ATMAE 50th Anniversary Annual Conference

“Constructing a Future for Tomorrow”
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The ATMAE 2017 Conference Presentation Abstracts and Proceedings Papers is the result of the work of many authors in technology, technology management, and applied engineering degree programs throughout the United States who gathered to share their work at the 2017 Annual ATMAE Conference in Cincinnati, Ohio November 1-3, 2017. The proceedings include all of the conference presentation abstracts that were accepted through the peer-review process and which were presented at the conference, and the Conference Proceedings Papers, based on accepted presentations, which were submitted and accepted through a secondary peer-referee process.

The reviews of presentation proposals and conference papers were led by ATMAE Division and Focus Group leaders. The proposals and papers were reviewed by a panel of ATMAE members with expertise in the topical area in a double-blind process. Review panelists evaluated the presentation abstract and papers pursuant to the review criteria, ranked each, and a cumulative rank-ordering system was used to help select the presentations and papers to be presented and published.

Many ATMAE members and leaders dedicated their time and expertise to review of all the Conference Presentation Proposal Abstracts, Conference Proceedings Papers, Student Research Competition Abstracts and Best Papers for the ATMAE 2017 conference. Without their time and efforts, ATMAE could not provide a thorough double-blind peer-referee process. Our thanks go to all of those dedicated ATMAE members:

**Conference Presentation Abstracts and Proceedings Paper Process:**

Dr. Yi-hsiang Isaac Chang, Illinois State University

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A comparative analysis of faculty compensation between ATMAE, ABET, and AACSB accredited programs

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Need: This presentation will compare the compensation models for different accrediting agencies and present the findings.

Overview: This presentation will provide a summary of the compensation models for different accrediting agencies.

Major Points:
- The effects of accreditation on faculty salaries and workload
- A list of the different accreditation agencies for baccalaureate programs
- CIP codes for different programs
- Compensation models for the different accreditation agencies

Summary: In the United States, many programs are nationally accredited by non-governmental, non-profit organizations such as ABET and AACSB. This presentation aims to provide attendees, the ATMAE faculty, with comparative data on faculty salaries in AACSB and ABET accredited programs. The presenters will share their findings on effects of different accreditation agencies on faculty salaries. We will also discuss ways of benchmarking ATMAE faculty salaries, teaching load, and scholarly requirements.
A comparative study of 2-year technology programs accredited by ATMAE and ETAC of ABET

Author(s)
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Need: Numerous 4-year, degree completion technology programs accept the entirety of the 2-year program graduate’s course work. The course work is generally credited in lieu of most if not all the first two years’ worth of the student’s 4-year program. But with which 2-year technology programs can students earn this dispensation? While there are ways to judge what is appropriate, a more objective means of doing so may be of value in helping programs determine whether a given 2-year technology program is appropriate for acceptance. As well, it will help programs interested in pursuing accreditation to select the appropriate accrediting body. As important it will assist other process stakeholders—ie parents, advisors, faculty, and the like, make decisions. Most importantly it will assist students negotiating the decision making process as they consider their pursuit of a bachelorette degree.

Overview: The presentation conveys to stakeholders an approach to more objectively exam the nature of 2-year technology programs and the families of those programs. Armed with this knowledge, instructional stakeholders will be better equipped to advise their charges with respect to their careers and their associate academic preparation.

Summary: A comparative study was conducted to examine the population of 2-year technology programs accredited by the Engineering Technology Accreditation Commission of the Accreditation Board for Engineering and Technology and the population of 2-year technology programs accredited by the Association of Technology, Management, and Applied Engineering. While the two accrediting bodies accredit many of the same types of programs, the data also suggest both accrediting bodies diverge from the core programs they accredit with ATMAE diverging to a greater extent than ETAC.
A Description Review of AACSB and ATMAE Accreditation Standards and their impact on faculty compensation

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Need: A descriptive comparison of the ATMAE and AACSB accreditation standards will provide insight on how ATMAE accredited programs benchmark their faculty compensation. The study will help the ATMAE administrators to focus on ways of recruiting and retaining qualified faculty members and administrators for the future.

Overview: This presentation outlines a comparative analysis of the AACSB and ATMAE Accreditation Standards to discuss how these standards affect faculty salaries. It will be of interest to ATMAE accredited programs administrates to focus on ways of recruiting and retaining qualified faculty members and administrators for the future.

Major Points:
- Review the ATMAE Outcome Based Accreditation Standards and AACSB Standards
- Present faculty salary data for ATAME and AASCB programs; based on their CIP code
- Compare faculty salaries of AACSB and ATMAE accredited programs
- Present a mechanism to benchmark ATMAE faculty salaries

Summary: This presentation outlines a comparative analysis of the AACSB and ATMAE Accreditation Standards to discuss how these standards affect faculty salaries. It will be of interest to ATMAE accredited programs administrates to focus on ways of recruiting and retaining qualified faculty members and administrators for the future.
A Marketing/Recruiting Strategy for your STEM Program

Author
Dr. James Smallwood, Indiana State University, Terre Haute, IN

Need: The United States has seen a slight increase in interest among young people toward STEM careers. This is a good sign and while high school students are becoming more interested there are many techniques that can promote and market your STEM programs. Utilizing these marketing/recruiting strategies will help students better understand your programs and help them to consider if STEM is a career path they might want to pursue.

Overview: The purpose of this presentation is to share information about some of the marketing/recruiting strategies with those in attendance, and in particular one strategy that includes developing audio/video materials. In the past it was very costly to produce a high quality recruiting video, but with today's hardware, editing software and knowledge of special techniques that appeal to the younger generation, it is much more affordable. A partnership has been established in Indiana among faculty at several universities, industry professionals, the Indiana Department of Education, and the Career and Technical Education Districts. These partners have created many audio/video materials for the Workplace Specialist (WSI) program and the materials are placed on YouTube and the WSI website and used for marketing, recruiting and retention. These materials use special techniques to appeal to high school students as well as non-traditional students who might be considering STEM as a career. The partnership will also be described in the presentation.

Major Points:
• Describe the education, industry , government agency partnership
• Explain the marketing/recruiting strategy
• Reveal the process involved in the development of the audio/video materials
• Discuss the potential impact on STEM related programs

Summary: A partnership in Indiana consisting of Indiana State University, Ball State University, IUPUI, industry professionals, the Indiana Association for Career and Technical Education Districts and the Indiana Department of Education has made a great effort to market and promote STEM careers among high school students.
Academic Outreach and Student Recruitment Programs to Attract Youth to STEM Programs through Mobile Renewable Energy Education

Author
Dr. Faruk Yildiz, Sam Houston State University, Huntsville, TX

Need: There are various ways to attract youth to STEM fields by presenting them with a wide variety of programs established through institutions, non-profit organizations, and funded state/federal agencies. One of the programs that is funded by the Department of Education is the Upward Bound TRIO program. The Upward Bound Math-Science program is one of three types of programs funded by the Upward Bound program, one of seven outreach and student services programs under the TRIO umbrella. The other programs are offered through a) educational opportunity centers; b) the Ronald E. McNair post-baccalaureate achievement awards; c) student support services; d) talent searches; e) training programs for federal TRIO programs; and f) veterans Upward Bound. In addition, institutional academic programs offer recruitment activities through their institutional marketing department, student clubs, summer camps, school visits, and by mailing brochures/flyers to potential K-12 students and their advisors. The Engineering Technology department faculty and university students also help recruit students to STEM fields with the mobile renewable energy workshops they conduct at school district locations.

Overview: Mobile Renewable Energy Education (MREE) is a long term project aimed to provide area (especially rural) K-12 students and teachers with an applied mathematics, engineering, and science curriculum package based on solar photovoltaic energy, wind power, energy conversion and conservation, energy safety and awareness, human power, global warming, and hydrogen fuel-cell fundamentals. The MREE project has established a partnership between the university and selected area schools for the improvement of students’ mathematical and scientific skill sets. The purpose of this program is to improve the K-12 students’ technological literacy by creating an environment where they are encouraged to understand that there are relationships between basic mathematics, science, and engineering technology. The students can then apply their new-found skills as they study renewable energy fields; the information they gain can help them grasp information from their studies effectively and gain a professional skill-set for successfully applying mathematics and science to technical projects with diverse teams throughout their careers. The students are introduced to the application of various types of renewable energy; they are also offered efficient energy-based hands-on projects such as a nationwide solar electric project which promotes mathematics and science for teachers and students. Students also learn more about energy- and science-related programs through this mobile education program.

Major Points:
• Outreach activities
• Recruitment
• Promoting STEM education through mobile energy education
• Familiarize the students with STEM fields
• Understand relationships between basic STEM fields as applied to renewable energy fields
• Create an environment where students understand and figure out relationships between basic mathematics, science and engineering technology applied to renewable energy fields
• Improve students’ mathematical and scientific skills
• Increase students’ technological literacy

Summary: Information about this successful mobile outreach program will be shared with academia; this information would include numbers of people and schools reached, feedbacks, materials, demographics, funding, results etc.
Thursday, November 3, 2017

Administration

Breaking Up Is Hard to Do: Leading through Unit Dissolution

Author
Dr. James Jones, Ball State University, Muncie, IN

Need: Organizational restructuring is commonplace in industry, and is also seemingly becoming more frequent within academe. Whether to save on administrative costs, foster collaboration, or in response to changing student enrollment, technology unit administrators may expect that organizational realignment will be at least considered at some point during their tenure. Realignment in general and unit or program dissolution in particular produces unique challenge for leadership during these periods of change.

Overview: This presentation examines leadership challenges during periods of unit dissolution as part of an organizational restructuring. The processes of developing a continuum of options for consideration, faculty involvement, courting new homes for programs and faculty, and other considerations will be detailed from technology administrator’s point of view.

Major Points:
- Rationale for realignment and dissolution
- Developing a continuum of options
- Faculty involvement
- Staff, resource, alumni, and other considerations
- Challenges and lessons learned
- Conclusions and recommendations

Summary: This presentation presents the leadership challenges encountered by a technology administrator during the dissolution of a college and departments, with programs realigning across multiple other colleges. Discussion includes the rationale behind the realignment, the development of options for consideration, the involvement of faculty in the process, and the implementation of the breakup. The leadership challenges encountered are detailed, including lessons learned, are detailed. After attending this presentation, technology administrators will be better prepared as to what to do – and what not to do – during a unit reorganization and dissolution.
Building Our Workforce for Tomorrow: The application of reverse curricular mapping to align employment expectations to education and training in the manufacturing sector

Author(s)
Dr. John Wyatt, Mississippi State University, Mississippi State, MS
Dr. Ryan Walker, Mississippi State University, Mississippi State, MS

Need:
Currently, our K-12 school system is deeply immersed in the era of standardized assessment (Atkin & Black, 2003), and efforts recently have been made to change the curricula and expected outcomes to align more closely with college and career readiness standards. However, once students complete a degree program, they are still faced with some difficult decisions. Graduates of four-year degrees typically earn more than those with only some college, but the range in earning potential for bachelor's degrees is so wide that graduates entering the workforce could be beginning a sustainable career or a life of struggle, poverty, and debt (Center on Education and the Workforce, 2016).

Overview:
Researchers have conducted backward curricular mapping of 202 successful graduates of the Industrial Technology BS degree program at Mississippi State University. These students held current employment with over 80 unique job titles. We linked the graduates' current job titles to archived manufacturing job postings in the Mississippi Works online employment system. The overarching category of Mechanical Engineering yielded 639 job postings with 34 job titles in common between the two data sets. Of the 639 job postings 55.4% represented 17 unique job occupations in the manufacturing sector of Mississippi's STEM based Economy (n=354). Our initial analysis reviewed these 354 job postings to identify common themes and or trends for employer expectations, minimum education/training and preferred qualifications. Results from this analysis established the ideal delivered curricula for individuals entering into the 17 targeted employment outcomes. This information was then compared to the delivered curriculum of the Industrial Tech program. Percent alignment for each position were calculated for each of the 17 career choices and recommendations made for the corresponding ideal planned curricula. A secondary analysis will be conducted to include the remaining 17 positions.

Major Points:
- Clusters of coursework (Modules) do align to employment expectations
- Descriptions of coursework and corresponding preferred qualifications will be presented
- Employer expectations revealed the importance of experience
- These data revealed a framework that links relevant industry experience to continued education (i.e. HS diploma+8 years = BS degree, or BS degree + 4 years = MS degree)
- Stackable credentials or continued education can provide for accelerated promotion within industry
- Unfortunately many of the academic credits earned in associates degrees do not transfer into BS programs
- Exceptions will be discussed
- Recommendations include the need for industry-supported assessments to validate skills verification of proposed modules, a process for institutions of higher learning to offer credit for work experience and the expansion of matriculation agreements to include more traditional AAS degrees.

Summary:
Researching curricular components along pathways that lead to the success of degree completers and their transition into STEM careers, we can better understand the preferred or ideal curricula for postsecondary education into the workforce. This research challenges the conventional wisdom or the perceived pathway to successful careers in manufacturing.
Community College and 4-Year School Partnerships

Author(s)
Dr. Sharon Rouse, East Carolina University, Greenville, NC
Dr. Robert Chin, East Carolina University, Greenville, NC

Need: There is general agreement that students interested in completing a bachelor's degree benefit by beginning their academic preparation at a community college. Key to helping students achieve their vision is grounded in the community colleges and 4-year schools working together to ensure that the coursework complement one another. This should result in a seamless transition that ensures students do not waste time or money taking class unnecessarily. While 4-year schools that host 2+2 and ATMAE accredited programs have made inroads, more can be done.

Overview: A Potpourri of options exists among 4-year schools that host 2+2 and ATMAE accredited programs with respect to the manner in which the 4-year schools administer 2+2 programs. Some are constrained by state or institutional directives and some by institutional or program values. That is, in 4-year programs, even among those that are ATMAE accredited, the number of 2-year degrees that are accepted for transfer into 2+2 programs range from one to several dozen. The focus of this presentation is on what is possible given the economic development value of facilitating the academic preparation of technology, management, and applied engineers with the aid of 2+2 programs.

Major Points:
- Types of programs and their value—2+2, bridge, degree completion
- General requirements for 2+2 programs
- Responsibilities
- Differences
- Beyond the scope
- Summary
- Conclusions and implications

Summary: The purpose was to identify practices that build upon the benefits students with an interest in completing a bachelor's degree by beginning their academic preparation at a community college derive. This finding suggests that, even among those programs accredited by ATMAE, differences exists with respect to what should comprise the first two years of technology, management and applied engineering programs.
Comparing enrollment trends in ATMAE accredited programs to projected workforce demand

Author(s)
Dr. Trevor Robinson, Utah State University, Logan, UT
Dr. Richard Miller, Ohio Northern University, Ada, OH
Dr. Feng Joa, Ohio Northern University, Ada, OH

Need: One goal of universities and colleges is to train and develop individuals to enter the workforce. Are programs accredited by ATAME developing graduates to enter fields of work that are growing or shrinking? Program enrollments assist in developing the workforce availability and future considerations for many programs. Are programs meeting the demand of industry or do certain programs need to be adjusted to meet future needs? Are there changes that could be adopted that could infuse growth into current programs?

Overview: A pilot study was completed in 2015 to identify the enrollment data trends for both manufacturing and construction programs accredited by ATMAE. In 2016, the study was expanded to include even more program. The most recent phase of the study included all four year programs related to manufacturing and construction that are accredited by ATMAE. Projected job numbers forecasted by the Department of Labor for areas related to these programs were compared to this enrollment numbers. This information will give practitioners in the manufacturing and construction majors an opportunity to forecast potential future considerations for their programs or departments.

Major Points:
Enrollment data for construction and manufacturing programs accredited by ATMAE from 2011-current year
Forecasting from the National Labor Statistics on construction and manufacturing jobs into 2025
Elevate awareness of opportunities for program growth in areas of specialization or existing majors
Continued development and use of a repeatable database for reference by ATMAE members

Summary: One goal of universities and colleges is to train and develop individuals to enter the workforce. Are programs accredited by ATAME developing graduates to enter fields of work that are growing or shrinking? This comparison will provide ideas and areas for potential growth in their majors and departments. Presenters will discuss possible changes that can be incorporated to assist in attracting students to their programs.
Curricula of ATMAE Accredited University Programs: Building a Composite

Author
Dr. Mark Doggett, Western Kentucky University, Bowling Green, KY

Need: ATMAE accredits various four-year manufacturing, industrial, construction, and information technology programs. To what degree are these accredited programs similar in content? Is there a typical convention of content for university courses?

Overview: The objectives of the research were to (a) determine the variety of ATMAE programs and their constituent courses and (b) identify a composite curriculum for ATMAE programs. Research was conducted using recent ATMAE accredited self-study reports of four-year programs in manufacturing, construction, computer technology, industrial technology, and engineering technology. Specifically, the study sought to answer the following questions:
  • What specific courses are self-reported by ATMAE accredited four-year programs?
  • What courses are reported by ATMAE accredited four-year programs to maintain the reasonable balance between practical and conceptual application as stated in the Accreditation Handbook?
  • Is there an identifiable composite curriculum for ATMAE accredited four-year programs?

Major Points:
  • Background and origins of the study
  • Methodology for data collection
  • Research findings
  • Summary and interpretation

Summary: This study evaluated recent ATMAE self-study reports of ATMAE accredited university program curricula. This information is useful for future program design and development while adding to the discipline's body of knowledge. In addition, the study provides a basis for further refinement of certification content, accreditation criteria, and role of 4-year programs in the professional association.
Thursday, November 2, 2017

Administration

Curriculum and Instruction Basics for the Engineering Technology Educator

Author(s)
Dr. Randell Peters, Indiana State University, Terre Haute, IN
Dr. Michael Hayden, Indiana State University, Terre Haute, IN

Need: Some engineering technology instructors lack a working knowledge of teaching basics that could help them improve their work load and job satisfaction while aiding student success, accreditation, and outcomes assessment.

Overview: To someone with a graduate degree in education, program and curriculum development, instructional strategies, course management, and student evaluation are simple. While it probably takes a few courses in education to have a good understanding, it only requires the grasp of a few core concepts to improve curriculum and instruction. The engineering technology instructor can apply a few key practices that will improve student success, facilitate accreditation and outcomes assessment, and ease the professor’s work load. Central among the principles is the alignment of program goals, course objectives, instruction, and evaluation.

Major Points:
- The hierarchy of faculty purview
- Putting education theory into practice
- The hierarchy of mission to course objectives
- The parts of an instructional objective
- The relationship of instruction and evaluation
- Instructional and evaluation schemes
- Alignment of outcomes assessment, accreditation, and other tasks
- Improving student success

Summary: The authors point out common blind spots that engineering technology instructors have concerning curriculum and instructions basics. The application of a few key curriculum and instruction principles can positively affect course management, student success, accreditation and outcomes assessment, the promotion and tenure process, and the instructor’s work load. Central among the principles is role of course instructional objectives in the alignment of program goals, instruction, and evaluation.
Developing a Successful Outcomes-Based Assessment Process

Authors(s)
Dr. James Jones, Ball State University, Muncie, IN
Dr. Tarek Mahfouz, Ball State University, Muncie, IN

Need: Accrediting agencies, institutions, and programs are moving away from input-based to outcomes-based assessment processes. Although these allow technology programs to demonstrate what their students are actually capable of performing, developing and implementing an outcomes-based process can be challenging and time-consuming.

Overview: This presentation examines the process that one technology program went through in order to maintain accreditation with an agency that changed to outcomes-based assessment. This presentation offers how the program leaders developed, refined, and implemented an entire assessment cycle in one year and was successfully reaccredited under the new standards. Completing the cycle, challenges, and lessons learned are offered for other administrators of technology programs making or considering making, a change to an outcomes-based assessment system.

Major Points:
• Input-based versus outcomes-based assessment
• Direct and indirect assessment processes
• Outcomes-course mapping
• Faculty buy-in
• Assessment tool development
• Data collection and analysis
• Closing the loop for continuous improvement
• Challenges and lessons learned

Summary: Attendees of this presentation will understand how one technology program successfully implemented a new outcomes-based assessment system. Differences between input-based and outcomes-based assessment systems and direct versus indirect assessment processes will be explained. The approaches taken by the program to map student learning outcomes to courses within the curriculum, gaining buy-in from faculty, and the data collection and analysis systems and tools used will be detailed. The program's model for continuous improvement utilizing this assessment approach will also be included, as well as challenges encountered and lessons learned.
Does offering certifications assist in the recruitment of undergraduate majors?

**Author(s)**
Dr. Mark Miller, University of Texas at Tyler, Tyler, TX  
Dr. Heshium Lawrence, University of Texas at Tyler, Tyler TX

**Need:** As the cost of a college education continues to escalate, it becomes more and more difficult for students to find the necessary resources to pay for it. Furthermore, as college graduates find it more difficult to find jobs, it becomes a challenge to entice new students to enroll in college programs. Therefore, strategies must be developed to ensure an adequate number of students continue to enroll in the program to maintain or improve its vitality.

**Overview:** The purpose of this study was to determine if the offering of technical certifications had any effect on the recruitment of undergraduate students to a Bachelor of Science in Industrial Technology program. All new undergraduate students to the program were surveyed to determine if certification was of any importance to their career goals and if it made any impact on their decision for choosing Industrial Technology as their major. This study was conducted previously with graduate students for the Master of Science in Industrial Management and the findings were considered significant enough to be applied to the undergraduate program.

**Major Points:**
- Overview of the proliferation of certifications
- Summary of programs offered at the university and enrollment trends
- Explanation of the creation of the survey instrument
- Findings generated from the survey instrument
- Summary of the implementation of the results generated from the study

**Summary:** As the enrollment of the undergraduate Industrial Technology stagnated, it was determined that a new direction was needed to increase its enrollment. Certifications were added to the program and within a few years the enrollment began to grow. The purpose of this study was to determine if certifications were important to undergraduate students and if so, was it a factor in an undergraduate’s student decision for selecting their major? Findings from this study will be shared and how its significance was used to implement a new departmental recruitment plan.
Thursday, November 2, 2017

Administration

Enabling a 100% Online Certificate Program in Quality: Benefits and Challenges

Author
Dr. John Earshen, SUNY/Buffalo State, Buffalo, NY

Need: Regional supervisory and non-supervisory workforce competency in the field of quality is in particularly short supply; online access to a certificate program in quality addresses strong demand

Overview: This presentation outlines an ongoing initiative to implement a 15 credit hour, portable, 100% online certificate program in quality that can be completed part-time in one calendar year.

Major Points:
- Structure, content and delivery methods for this certificate program in quality are examined
- Curriculum content is matched to the ATMAE Lean Six-sigma Body of Knowledge
- Discuss implications for the future - potential industry sponsorship in future years; deployment of the program on a state-wide basis

Summary: This presentation outlines an ongoing initiative to implement a portable, 100% online certificate program in quality.
Enterprise Risk Management: A Credible Approach for Integrating Risk Management into a Department of Technology

Author(s)
Dr. Jeenson Sheen, Norfolk State University, Norfolk, VA
Mr. Charles Hunt, Norfolk State University, Norfolk, VA
Dr. Munir Sulaiman, Norfolk State University, Norfolk, VA

Need: In the wake of an ever changing risk environment, it is critically important to deploy enterprise risk management in academic technology departments to contain threats and risks.

Overview: Enterprise risk management is a process and approach that prioritizes, monitors, and controls threats and risks that arise via normal operations, including opportunities that add value to administrative/management units. It represents a holistic approach for managing threats and risks throughout the organization, as opposed to individual silos. This presentation will illustrate a systematic, holistic approach that strategically/operationally integrates enterprise risk management into departmental organization. It will provide attendees with understanding and straightforward ideas for applying the concepts of enterprise management to address threats and risks to departmental value, effectiveness, and efficiency. Relevant issues, techniques and examples for alignment will be emphasized.

Major Points:
- Rationale and benefits of enterprise risk management
- Enterprise risk management context and process
- Categories and sources of risks
- Typical academic departmental risks
- Enterprise risk management implementation strategies and response measures

Summary: Today’s institutions of higher education are exposed to an increasing number of potential threats and risks. In the wake of an ever changing risk environment, there is a critical need to deploy enterprise risk management in academic, technology departments to contain threats and risks.
Four Pillars and Proposed B.S. Manufacturing Engineering Technology Program at SUNY/Buffalo State

Author
Dr. Mohan Devgun, SUNY/Buffalo State, Buffalo, NY

Need: Manufacturing is on a resurgence in western New York. Therefore, SUNY/Buffalo State is now developing a new program to meet increasing demand for manufacturing professionals.

Overview: This presentation details the new baccalaureate program in Manufacturing now under development at SUNY/Buffalo State. Careful attention has been paid to conformance with the four pillars of manufacturing as espoused by the Society of Manufacturing Engineers (SME).

Major Points:
- The need for a manufacturing engineering technology curriculum
- Required sequence of courses
- Analysis of conformity with the four pillars of manufacturing as espoused by SME
- Conclusions and recommendations regarding implementation and recruitment

Summary: In current global economy, both the manufacturers and educators are facing many challenges. This presentation will outline the identified competencies for manufacturing education by this group, and the recommended curriculum (based on 4-pillars of Manufacturing), for a 2-years and 4-years programs in Manufacturing Engineering/Technology. Finally, proposed B.S. in Manufacturing Engineering Technology program will be presented, outlining how it meets the recommended 4-pillars structure by the Society of Manufacturing Engineers.
Funding and Finance Strategies for ATMAE Student Chapters

Author(s)
Mr. Daniel Vazquez, Millersville University, Millersville, PA
Mr. Joseph Wright, Millersville University, Millersville, PA

Need: ATMAE student chapters have a growing need to acquire a financial source due to their participation in and travel to the annual ATMAE conference and even associated competitions. In the past, such teams have spent anywhere from hundreds to tens of thousands of dollars in both robotic platforms for competition and travel to the conference. Accumulating this magnitude of funds may not be easy for all student chapters, and the fields of donations and budgetary negotiations may be difficult to enter.

Overview: The purpose of the presentation is to provide options for accumulating funds for ATMAE Student Chapters and using known opportunities to expand the capabilities of such organizations.

Major Points:
- Financial Need + Budgeting
- Fundraising (Community-based)
- Donations (Organization-based)
- Allocations (Student Government-based)
- Marketing Chapter Activity

Summary: Funding processes vary for each ATMAE Student Chapter. Students may be able to pursue fundraising paths both on- and off-campus, donations from private groups, and budgeting plans with the on-campus student government. This presentation will not only focus on strategies to maximizing the visibility of each chapter on-campus, but also the actions and behaviors that could increase the viability of funding each group.
In Case of Emergency: How Technology Programs Can Help Develop the Next Generation of Emergency Management Professionals

Author
Dr. Jessica Murphy, Jackson State University, Jackson, MS

Need: Emergency Management (degree-granting) academic program are instrumental in enhancing competencies of current Emergency Managers and developing the next generation of highly proficient Emergency Managers. Moreover, the integration of Emergency Management into Technology programs serves as a key catalyst producing such highly qualified professionals.

Overview: The goals of emergency management are to save lives; prevent injuries; protect property and the environment. A hazard is a dangerous event or circumstance that has the potential to lead to disaster. In addition to natural and man-made incidents, technological incidents and hazards continue to escalate. Technological hazards are caused by the tools, machines, and substances we use in everyday life. However, these technological tools can be employed to prevent or properly forecast potential threats. Since Emergency Management professionals prepare plans and procedures for responding to natural disasters or other emergencies, this presentation describe how an Emergency Management concentration in a Technology program (at an urban institution), aids in developing the next generation of Emergency Managers to serve federal, state, and local agencies; private companies; hospitals; or nonprofit organizations.

Major Points:
• Define emergency management and state the need for well-trained emergency management professionals
• Indicate the need and demand for emergency management academic programs
• Describe the curriculum development, course objectives and core competencies for emergency management concentrations in technology programs
• Identify opportunities and challenges in the field of Emergency Management
• Discuss the importance in incorporating contemporary technology into Emergency Management
• Discuss Emergency Management program recruitment

Summary: This presentation will describes the program development of an Emergency Management concentration in the Technology discipline. Further details regarding course development, course objects, interactive training activities, and program recruitment will be provided to demonstrate the overall program direction and preparation of its students to become highly proficient Emergency Managers.
Thursday, November 2, 2017
Administration

Meeting the Future Educational Needs of Manufacturing Today

Author(s)
Mr. Jake Hildebrant, Murray State University, Murray, KY
Mr. Sidney Martin, Murray State University, Murray, KY

Need: There is a need to create baccalaureate degree manufacturing engineers. There is a pool of engineers who have associate level degrees. There is a need to help these 2 year degree engineers (and those in process) to become four-year degree recipients.

Overview: The presentation will outline the requirements for a Manufacturing Engineering Technology program which would include: programs that are based on on-line or hybrid learning opportunities; a curriculum that leads to and development of methods of working with nontraditional students to support lifelong learning. The manufacturing curricula utilizes faculty to provide degree programs that result in programs beneficial to manufacturing employees and the industry, and these higher education programs will collaborate with industry organizations that are offering credentialing to blend these traditional credits to be able to offer a degree to the student.

Major Points:
• Students will have a defined path from a two-year to four-year degree
• Students will be able to complete the degree online while working full time
• Matriculation problems and issues will be reduced
• The program can readily adapt to the needs of the manufacturers
• Resulting certifications could be readily administered by organizations such as ATMAE
• Readily reach underrepresented minority students

Summary: This paper outlines the requirements for a Manufacturing Engineering Technology program which would include: programs that are based on on-line or hybrid learning opportunities; a curriculum that leads to and development of methods of working with nontraditional students to support lifelong learning.
mLearning: Models and Policies for Adoption and Integration

Author(s)
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Dr. Edward Lazaros, Ball State University, Muncie, IN

Need: The adoption of mobile technology in the classroom is an increasing trend, despite the number of barriers that might exist (Mansureh, 2010). In technology education, there exists the expectation of cutting edge pedagogical technologies, which includes mobile devices. In an effort to meet this demand, a significant expenditure on technologies (infrastructure as well as client devices) is likely to occur. Additionally, other considerations such as personnel time, training, and support can consume much needed resources (monetary and otherwise). Strategies to address these challenges will be discussed during this poster presentation.

Overview: In this presentation, the authors will explore technology adoption best practices for educational institutions. Issues such as technology acquisition (build, buy, or borrow), security, models of jurisdiction, technology support, and training are discussed. Conference attendees will be able to share these strategies with their respective institutions. Examples from successful mobile technology implementations will be discussed.

Major Points:
- Several challenges facing schools/districts
- Expectations, responsibilities, and jurisdiction
- The best overall model to address these challenges was found to be a holistic model that addresses expectations, rights, and responsibilities for all stakeholders (i.e., students, teachers, and parents)
- Create a formal written document, commonly referred to as an Acceptable/Responsible Use Policy (A/RUP)
- Theft, security, technology support, and device utilization are common pitfalls
- Device roll-out (dissemination) is often complex and mismanaged

Summary: In this presentation, the authors will discuss mobile technology (mLearning) adoption. Challenges, issues, and best practices will be discussed. A holistic model of technology adoption will be presented along with policy items such as an Acceptable/Responsible Use Policy (A/RUP).
Thursday, November 2, 2017

Administration

Practice What You Teach

Author(s)
Dr. Randell Peters, Indiana State University, Terre Haute, IN
Dr. Michael Hayden, Indiana State University, Terre Haute, IN

Need: Some faculty members are like roofers whose own roof leaks; they do not practice what they teach! Many challenges facing faculty members and department chairs can be met by the faculty and administration practicing what it teaches.

Overview: The typical engineering technology department contains experts in area such as project planning, efficiency, quality, production control and planning, industrial supervision and management, cost-benefit and risk analysis, R&D, product and process design, research and statistics, and industrial organization and functions. Yet, many departments have daunting challenges (if not outright problems) with scheduling, planning, project completion, efficiency, quality, and other things that are part of the faculty’s body of knowledge. There are newer and traditional strategies to harness the faculty’s body of knowledge to not only meet departmental and personal challenges but to proactively improve success metrics and improve the work environment.

Major Points:
• Challenges and opportunities
• What we know that we might not know we know
• The Gurus, e.g., Deming, Fayol, and Taylor
• Tools for triage: management, problem solving, and other basics
• Getting the most bang for your buck: aligning teaching, scholarship, and service
• How to repair your own roof
• Setting a good example and mentoring colleagues

Summary: The authors summarize new and traditional strategies to harness the faculty’s body of knowledge to not only meet departmental and personal challenges but to proactively improve student and faculty success metrics such as SCH generation, student professional exam scores, and scholarly activity—while improving morale.
Friday, November 3, 2017
Administration

Project Managing Your Accreditation Processes Successfully and Smoothly

Author
Ms. Pamela McGee, Minnesota State University, Moorhead, MN

Need: An outcomes based accreditation process includes much more than writing a self study. You have to manage external experts, advisory boards, write the self study, gather data, engage stakeholders, manage risk, and much more. Because of the girth of an accreditation process, there is a need to stay on track, on time, with a high quality product. PMBOK 5 process groups and 10 Knowledge areas can help you stay on track, on time, within budget, utilizing scarce resources.

Overview: Although six years seems like a long time between accreditation visits, with an outcomes based accreditation process, the engagement of stakeholders, the closed loop validation with external experts, the continual improvement of general outcomes, student competency measures, and long and short term goal achievement requires a consistent, methodology and highly engaged advisory board, external expert representation, faculty, student and administration team throughout the six year accreditation cycle.

Major Points:
- Overview of how to apply the PMBOK 5 Process Areas and 10 Knowledge Areas to an Accreditation process
- Presentation of a MS Project Plan with pre-populated accreditation tasks, including pre-during-post activities and required activities under each standard.
- Key Learning’s from the Application of the Project Management Process to an Accreditation Cycle
- Example project plan, one note meeting agenda’s, and one drive folders
- Six Year Continuous Improvement Calendar of Activities

Summary: Attend this presentation to learn what they did to apply the PMBOK 5 process groups and the 10 knowledge areas to their accreditation, preview an actual project plan with pre-populated activities required for accreditation and learn how the faculty divided the work and organized the project plan with MS Project, One Drive, and One Note. Included in the presentation is a preview of a recommended project plan pre-populated with the many of the tasks required to complete an accreditation process, write the self study, and organize an onsite visit.
Providing real world experiences for students through collaborations with local non-profit organizations

Author(s)
Mrs. Janet Fick, Ball State University, Muncie, IN
Dr. James Jones, Ball State University, Muncie, IN
Ms. Jennifer Warrner, Ball State University, Muncie, IN

Need: Students are provided with hypothetical projects, but are not provided the opportunity to apply their knowledge to real world projects. Meanwhile, many local non-profit organizations need assistance, whether with their facilities or with connecting their younger students to their future possibilities. By pairing the two together, both can benefit.

Overview: This presentation discusses several immersive learning courses which have given students from construction management, architecture, interior design and other programs the opportunity to collaborate with each other while utilizing their skills and helping their local community. Non-profit organizations with which we have partnered include Habitat for Humanity, Boys and Girls Club, a local church which is rehabilitating houses, a local community center, and a local neighborhood association which is remodeling a building into a food bank. For most of these classes, the students analyze the facilities, work with local contractors to make recommendations and either complete construction drawings or complete design development drawings. Actual construction is not part of these classes. For an additional class, the university students work weekly with the K-12 students to explore future career possibilities in the construction industry.

Major Points:
• Finding the projects
• Introducing innovative teaching approaches that could be used at other institutions
• Exposing students to the challenges unique to real world projects
• Facilitating the interactions between students and the organizations
• Informing the students of the possibilities available to them with a future in construction
• Executing the course and implementing refinements in subsequent semesters

Summary: Attendees will familiarize themselves with this innovative teaching approach that could be used at their own institutions. Attendees will learn the value of combining an interdisciplinary team of students with a non-profit organization to complete real world projects. Attendees will comprehend the challenges and opportunities of coordinating the skills of the students with the needs of our partner organization.
Administration

Putting Military Skills to Good Use: Veterans in STEM

Authors:
Dr. Dominick Fazarro, University of Texas Tyler, Tyler, TX
Dr. Ivan Mosely, Tennessee State University, Nashville, TN

Need: The marketplace pillar encourages employees to think globally, but act locally in order to improve and sustain the company's niche to markets around the world. The talent pillar enforces efforts like including leveraging succession plans, enhancing selection rates for all and identifying the next generation of STEM professions (Diversity In Action, 2016/2017). The culture pillar serves to highlight the need of all employees to belong, to be seen, heard, valued and respected where employees live and work to build the next generation of STEM professions.

Overview: To attract and retain a first-rated workforce, “inclusion plays an intentional role in the way we come up with solutions”, says Dr. Elizabeth Sherwood-Randall, Deputy Secretary of Energy. “Inclusion makes our deliberations fuller and more complete, it keeps us from missing things that matter and it combines our talents and perspectives together to create better and richer solutions by using the many experiences of the workforce as an asset.” By creating inclusion, we gain the respect of employees, customers and our communities.

Major Points:
- Who We Are
- What We Do
- Where We Work
- When We Make Career Transitions
- How We Impact STEM Technology

Summary: Passage of the Post 9/11 G.I. Bill in 2009 brought a surge of new veteran enrollees. Many of these students are older. They have been out in the workforce or they have been in the military, so they are not like the traditional student who comes in directly after graduating from high school. And of course their needs are different and ought to be addressed. The more closely that a Veteran feels a connection to their fellow co-worker and the more they feel that where they work is representative of who they are as individuals, the more they are engaged.”
Author(s)
Dr. Trevor Robinson, Utah State University, Logan, UT
Mr. Steve Williams, Utah State University, Logan, UT
Mrs. Trina Nye, Utah State University, Logan, UT

Need: The jump from high school to college education is difficult for some students. Traditional college education in the freshman year typically consists of lecture based courses with larger number of students enrolled. There are a number of students who struggle with this approach, and are unable to successfully complete the traditional college experience. These students are often directed to an Applied Technical College (ATC) to obtain career training and credentials. The ATC model allows students to enroll in smaller classes where the content is taught mostly through a project-based hands-on approach.

Overview: Our University has partnered with the Applied Technical Colleges and local industry to provide a pathway for students and employees to step through their higher education. This program utilizes a “stackable credential” method, which allows the students to step through their degrees. The first credential to be stacked is a one year or 900-hour certificate from the applied technology college.

Major Points:
• This degree pathway is an alternate route for non-traditional students
• The degrees were developed through an industrial advisory committee
• Industry support through employee tuition reimbursement programs
• Partnerships with other academic institutions (i.e., ATCs)
• Available via distance education
• The degree programs have flexibility that meets the needs of students and working adults

Summary: The jump from high school to college education is difficult for some students. Traditional college education in the freshman year typically consists of lecture based courses with larger number of students enrolled. There are a number of students who struggle with this approach, and are unable to successfully complete the traditional college experience.
Stronger together: How developing a joint ATMAE accreditation report is streamlining individual program operations

Author(s)
Dr. Vigyan Chandra, Eastern Kentucky University, Richmond, KY
Dr. Dennis Field, Eastern Kentucky University, Richmond, KY
Dr. Ray Richardson, Eastern Kentucky University, Richmond, KY

Need: Creating a consolidated accreditation self-study document involving multiple programs can pose unique challenges to those involved in the process. There is a clear need for effective procedures: to disseminate information about accreditation guidelines and revisions; to set up departmental alumni and employer surveys; to mine data from units spread across campus; and to develop collaborative overlaps between the work of multiple authors. Getting the many stakeholders involved in the process on one page is critical to its success.

Overview: The presentation will document the transition process multiple programs housed within one Applied Engineering & Technology department used while developing a consolidated ATMAE self-study accreditation report in electronic form. The use of specific online tools which greatly assisted in this process will be highlighted along with ideas for reducing potential bottlenecks that may occur once the document authoring stage gets underway. While additional challenges need to be overcome for creating the combined accreditation document than one may encounter otherwise, the benefits far outweigh possible detriments. Our programs are stronger together, in large part, to this collaborative process.

Major Points:
• Managing the Matrix: Involving different program faculty, staff, students, and institutional units while authoring overlapping sections of the accreditation self-study report
• Use of secure online tools for collaborating effectively
• Writing well requires revising often: collaborators and co-reviewers
• Overcoming inertia and ideas for reducing procedural delays
• Tangible and intangible benefits of developing a joint self-study document
• A retrospective view of the accreditation process: what worked well and items that require closer attention earlier in future accreditation cycles

Summary: The joint development an accreditation self-study document in electronic format involving multiple stakeholders can be a challenge owing to considerations about shared authorship, online security, and time constraints. Effective sharing of both a big-picture view and one-the-ground specifics with related stakeholders involved in the process can help in the creation of processes that improve our programs, forging stronger connections, and constructing a better future for program graduates.
Thursday, November 2, 2017

Administration

Success factors for engineering technology transfers

Author
Dr. Gretchen Mosher, Iowa State University, Ames, IA

Need: This study investigated factors that influence successful outcomes for students who transfer into technology programs by examining variables such as High School GPA, standardized test scores, and other academic indicators. Information on the success factors for these students have implications for the recruitment of future graduate students and faculty in the field of technology.

Overview: The presentation will discuss the importance of integrating transfer students into the field of technology and challenges of doing so. Other items discussed will be the characteristics of students who transfer into technology fields from engineering and other majors. Factors influencing transfer student success in technology will be shared. The presentation will conclude with implications for technology department administrators and faculty.

Major Points:
- Importance of transitioning transfer students into the field of technology
- Needs of internal transfer students
- Factors influencing success

Summary: The presentation will discuss the importance of integrating transfer students into the field of technology and challenges of doing so. Other items discussed will be the characteristics of students who transfer into technology fields from engineering and other majors. Factors influencing transfer student success in technology will be shared. The presentation will conclude with implications for technology department administrators and faculty.
The Accidental Leader: Transitioning from Technology Faculty to Administration

Author(s)
Dr. Tarek Mahfouz, Ball State University, Muncie, IN
Dr. James Jones, Ball State University, Muncie, IN

Need: There exists a crucial need to learn from previous successful experiences of faculty transitioning into administrative and leadership positions to identify strengths, challenges, and proper mechanisms for facilitating such move for future faculty.

Overview: Like all aspects of life, college campuses are experiencing fast changes due to advancements in technology. Online education has revolutionized the education experience. This has forced faculty to find new ways about how to conduct their classes and provide a positive, rigor, and enjoyable experience to the students. However, other aspects like governance, budget, administration, enrollment, and promotions may force faculty to change their strategies regarding conducting their work especially when they transition into leadership positions. Thus, the focus of this presentation is to introduce the experience of two faculty members, in a Midwest University campus, as they transition into leadership positions at different levels.

Major Points:
- Definition and the role of leadership in a college campus
- Preparation mechanisms for a successful transition
- Challenges faced and lessons learned
- What to do and not to do in the future

Summary: The attendees will gain knowledge about (1) what leadership means and entail in a college campus, (2) how to transition into a leadership position, as well as (3) how to mitigate expected and unexpected challenges. They will gain from lessons learned and will be engaged in a lively discussion about the topic.”
BIM and Wearable Technologies: The Future of Construction Safety Management

**Author(s):**
Dr. James Stein, Eastern Michigan University, Ypsilanti, MI
Dr. Tolulope Borisade, Eastern Michigan University, Ypsilanti, MI

**Need:** The Bureau of Labor Statistics recorded 985 construction workplace fatalities in 2015. This is an increase from the 874 fatalities on construction projects across the United States in 2014. The success of every construction project is contingent on the safety of every worker on site. The need for a safer workplace cannot be over emphasized. Prevention is better than a cure, the saying goes. To reduce accidents, there is a dire need for new technology implementation for safety management. Wearable Technologies and Building Information Modeling (BIM) are powerful tools that are currently available to the industry. However, the potential of these tools are still primitively applied to safety management in the construction industry. This study explores how these technologies can be adapted for safety management in the construction industry.

**Overview:** The term “wearable technology” can refer to electronic devices that are incorporated into items of clothing and accessories which can comfortably be worn on the body. Wearable technology can be more sophisticated than handheld devices, it can provide sensory and scanning features, feedback and tracking functionalities. In this study we intend to explore the application of wearables in conjunction with BIM for solving safety issues on construction sites. A literature search was conducted to review current wearable products and their industrial applications. The information was then analyzed to determine how these technologies might be incorporated with BIM to manage safety on construction sites. Several recommendations for application are generated.

**Major Points:**
- Construction is a dangerous industry that needs new techniques and tools to manage safety
- Wearable technologies are currently available in the industrial marketplace
- BIM is fast becoming the choice for design and planning construction projects
- BIM and wearable technologies can provide real time input to manage safety on site
- There is great potential to implement BIM and wearable technologies to ensure safer construction worksites

**Summary:** At the rate at which technology is being introduced every day, we can presume that wearable technology will gain more prominence on jobsites in a few years’ time. The capability of wearable safety accessories can enhance communication between the workers on site as well as with the site office. The advent of this technology will presumably be actively embraced by the foreman, superintendents and project managers by making on site safety more manageable.
Building Performance and Human Health: A Study On Breathable Building Envelope and Intelligent Air Distribution Systems

Author(s)
Na Han, Eastern Michigan University, Ypsilanti, MI
Dr. Shinming Shyu, Eastern Michigan University, Ypsilanti, MI

Need: The building environment exerts significant impacts on human health and well-being of building occupants. To ensure healthy indoor air quality (IAQ), it is critical to examine the building performance considering both human factors and energy efficiency through intelligent air distribution systems.

Overview: Building's indoor conditions, including temperature, humidity, lighting, and air quality, collectively shape indoor environmental quality, which in turn modulate the performance and productivity of building users. The proposed research studies the correlation between human health and building performance with an emphasize on building envelop design and intelligent ventilation system to optimize indoor air quality and energy efficiency.

Major Points:
- The effects of building performance on human health
- Breathable building envelope, humidity, and thermal performance
- Intelligent ventilation systems and automatic demand control
- Energy recovery system and energy efficiency
- Requirements of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 62.1

Summary: The study investigates breathable building envelope design and its influences on interior air quality as well as occupants' health and productivity. To address the air distribution systems, the study looks into the ventilation requirements formulated by ASHRAE 62.1 and energy efficiency, which can be greatly enhanced by the introduction of intelligent demand control and energy recovery system.
Challenges and Lessons Learned for Smart City Development: A Guide to Success

Author(s)
Dr. Tarek Mahfouz, Ball State University, Muncie, IN
Dr. James Jones, Ball State University, Muncie, IN
Dr. Sherif Attallah, Ball State University, Muncie, IN

Need: There exists a great need to analyze success stories of Smart Cities worldwide and identify factors leading to their achievements as well as challenges faced and lessons learned in an effort to create guidelines for future projects.

Overview: With the current growth in population and resources consumption, new cities are playing an important role in defining living standards. This puts a larger mandate on public safety, equitable resource allocation, planning efforts, traffic management, among other parameters. Thus, in an attempt to develop a practice handbook and a set of guidelines governing smart cities development, the current research analysis best practices worldwide and drives associations between five sociological drivers; namely technologies, social structures, cultural drivers, economic drivers and governance; to the Intelligent Community Forum (ICF) indicators, which include broadband, knowledge workforce, innovation, digital equality, sustainability, and advocacy.

Major Points:
• Definition of Smart Cities
• Case studies of Smart Cities worldwide
• Identification of sociological factors underlining Smart Cities
• Intelligent Community Forum (ICF) indicators for Smart Cities
• Associations between the sociological factors and ICF indicators within the discussed case studies

Summary: The attendees will gain knowledge about (1) Smart Cities through analysis of successful examples worldwide, (2) parameters governing and challenges facing these cities, and (3) guidelines of Smart Cities development.
Effectiveness of Responsive Facade Systems in Improving Lighting Performance of Building

Author(s)
Mrs. Negar Heidari Matin, Eastern Michigan University, Ypsilanti, MI
Ali Eydgahi, Eastern Michigan University, Ypsilanti, MI
Dr. Shinming Shyu, Eastern Michigan University, Ypsilanti MI

Need: Based on U.S. Energy Information Administration, residential and commercial buildings are responsible for approximately 41% of all energy consumption and 72% of electricity usage per year. As 20% to 60% of all energy used in buildings is affected by design and construction of building envelope, considering sustainable strategies for energy efficiency of building envelope are very important.

Overview: The characteristics of traditional static façade systems are discussed to explore the limitations of these systems, which caused switching from static façade systems to responsive façade systems. To justify advantages of responsive façade systems in comparison with static traditional façade systems, the result of a responsive system simulation will be presented, which is simulated by an advanced daylighting and energy modeling plug-in for Rhinoceros.

Major Points:
- Traditional static façade systems
- Limitation of static facades
- Responsive façade systems
- Facade visual performance
- Glare discomfort effect
- Annual glare
- Interior daylight level
- Multifunctional façade system
- Control system
- Lighting energy efficiency
- Solar heat gain coefficient
- Visual comfort

Summary: The purpose of this study is to measure the visual performance of responsive façade systems in improving glare effect in comparison with static façade systems. The effect of adaptation time on annual glare and interior daylight level will be measured by using DIVA. DVIA is the most advanced daylighting and energy modeling plug-in for Rhinoceros, a NURBS modeling software.
Construction

Faculty Lead Student Competition: Designing and Building a Concrete Canoe

Author(s)
Dr. Ahmed Mohamed, Indiana State University, Terre Haute, IN
Dr. Michael Williamson, Indiana State University, Terre Haute, IN

Need: One of the most practical applications for civil engineering and civil engineering technology students is to participate in student competitions. Participation allows students to apply classroom knowledge to a real world environment. One such competition is the American Society of Civil Engineers (ASCE) National Concrete Canoe Competition.

Overview: This presentation discusses how students were able to develop an engineering design complete with analysis, and shows the steps for constructing and delivering a concrete canoe from Terre Haute, IN to Milwaukee, WI for participating in the ASCE National Concrete Canoe Competition.

Major Points:
- Major outcomes from participating
- Canoe design steps
- Material selection
- Mold design
- Construction of canoe
- Transporting the canoe
- Career readiness

Summary: The focus of this study is to provide insight into the concrete canoe design steps, material selection, mix design, specimen testing, mold design, pouring of the canoe, and transportation of the final product.”
Implementing a Student-Driven Solar Awareness

Author(s)
Dr. Sherif Attallah, Ball State University, Muncie, IN
Dr. James Jones, Ball State University, Muncie, IN
Mrs. Janet Fick, Ball State University, Muncie, IN

Need: Unsustainable energy sources are a concern in almost all societies worldwide especially in the last few decades due to both the increase of population and the unprecedented reliance on the electrical energy for human activities. Solar energy is one of the main renewable sources that are foreseen to play a role in addressing these energy concerns. However, among many factors, the lack of awareness of this critical energy source is still a hurdle on the way for full implementation. There is a continuous need for programs to increase awareness of the solar panel systems, how they work, the economics related to them and the main components. In addition, educational projects on universities campuses are also required to assist in providing college students with sufficient information and technical background on these vital systems.

Overview: Ball State University emphasizes the concept of immersive learning where the students work with their faculty advisers on projects in collaboration with partners outside the classroom. The objective of this presentation is to share how this immersive learning project has successfully been managed and what lessons are learned.

Major Points:
• Solar Panels
• Immersive Learning
• Team Work
• Managing Student Teams

Summary: The objective of this presentation is to share how this project has successfully been managed and what lessons are learned.
Thursday, November 2, 2017

Construction

Information-Seeking Behaviors of Construction Professionals

Author
Dr. James Jones, Ball State University, Muncie, IN

Need: Decisions in the modern construction industry should be based on factual information, and seeking this information can be a significant part of a constructor’s daily activities. However, this information-seeking behavior is often conducted without a conscious process and learned through trial and error, consequently being more difficult and less effective for personnel entering the industry.

Overview: This presentation reports the results of a study that examined this process and how constructors seek information efficiently and effectively. Specific strategies and techniques were identified in the process, as well as differentiations between novice and experienced construction professionals. The implications for construction educators are examined.

Major Points:
- Information-seeking in construction: How and why
- Strategies utilized
- Techniques for strategy implementation
- Accreditation issues
- Implications for educators
- Conclusions and recommendations

Summary: This study researched how and why construction professionals sought information in their everyday work lives. Attendees will come away with a better understanding of how information-seeking is an important part of the construction industry and how students can be better prepared with these skills.
On Building Automation System (BAS) and High-Performance Green Buildings

Author
Dr. Shuming Shyu, Eastern Michigan University, Ypsilanti, MI

Need: To optimize commercial building performance, reduce operational costs, and alleviate negative impacts on environment, it is crucial to monitor operation, detect fault, and control settings via building automation system (BAS).

Overview: A building automation system (BAS) functions as a centralized control using microprocessors to perform direct digital control (DDC) and data communication to integrate various energy-consuming systems, such as lighting, HVAC, plumbing, electrical, fire safety, and other building systems via conformance with communication protocol, such as BACnet, LonTalk, or Modbus. The lack of whole-building monitoring and control system results in significant energy waste. With drastic increase in computing power and lowered implementation cost, there are great opportunities for the building industry to create energy-efficient, high-performance green buildings with BAS.

Major Points:
- Building Automation System (BAS)
- Smart building system integration
- Direct Digital Control (DDC) and data communication
- BACnet – ANSI/ASHRAE standard 135-2008
- International Green Construction Code (IgCC)

Summary: This study probes into the interoperable characteristics of a BAS system, related industrial protocols and its environmental advantages.
Perception of Women Working in the Construction Industry

Author(s)
Ms. Jennifer Warrner, Ball State University, Muncie, IN
Dr. Sherif Attallah, Ball State University, Muncie, IN
Mr. Mike Mezo, Ball State University, Muncie, IN

Need: To address this, a better understanding of people's perception of the work of women and the reasons women decide to distant themselves from degrees that qualify them for construction jobs is required.

Overview: To develop a better understanding of the noticed shortage of women working in the construction industry, a survey was developed including Likert-scale questions on people's perception of the role of women in this critical industry and the type of challenges facing them. The objective of this presentation is to share information on the issue of the absence of women in construction and the results of the conducted survey and suggested actions within the construction programs to address this issue.

Major Points:
- Perception of Roles
- Challenges for Women in Construction

Summary: Attendees of this presentation will get insights on the survey conducted to better understand the reasons behind the shortage of women in the construction industry. Results of the survey will be shared along with suggestions on how construction programs can encourage more female students to join the industry.
Predicting Concrete Mechanical Properties via Computational Technique Approach

Author(s)
Dr. Ahmed Mohamed, Indiana State University, Terre Haute, IN
Dr. Randell Peters, Indiana State University, Terre Haute, IN

Need: Research will be presented in which a computational method of compression testing concrete has been developed accurately mimicking laboratory compression experiments. This computational method can help in the advancement of concrete design and improved selection of materials for the specific application.

Overview: Concrete (cement-based material) is the most widely used construction material on earth. The hydration reaction and the formation of CSH (Calcium Silicate Hydrate), which is the responsible component of the concrete strength, is still debatable until today. In this study, Molecular Dynamics (MD) computational simulations techniques were employed to obtain the mechanical properties for CSH (Calcium Silicate Hydrate) at the Nano-Scale level. From this simulation, stress – strain curve and modulus of elasticity were obtained and compared with laboratory literature results.

Major Points:
- Concrete as a Multiscale Material
- Introduction to Molecular Dynamics (MD) Method
- Simulation model parameters
- Obtaining the results for different model sizes
- Comparing the results with literature.

Summary: The focus of the research is to obtain the compression stress-strain curve and the modulus of elasticity of Calcium Silicate Hydrate (CSH). Using molecular dynamics (MD) computational simulations approach, the obtained results were in a very good agreement when compared with the available literature.”
Thursday, November 2, 2017

Construction

Scheduling Requirements for Civil versus Commercial Projects for CM Graduates

Author
Dr. John Reposa, Jr., Eastern Michigan University, Ypsilanti, MI

Need: In a pass study (Changing needs for Scheduling Software Proficiencies required for CM Graduates, ATMAE 2013) it was identified that 31% of the contractors are using Primavera software while another 39% was and/or using Microsoft Project. It was concluded from this study that 1) Construction management students need to be introduce to both Primavera and Microsoft Project software 2) It was also included that only projects over $1,000,000 should be evaluated and 3) needed to collected data from heavy-civil projects.

Overview: There has been a shift over the last couple of years in the use of scheduling software by construction companies. While larger projects are using Primavera there seems to be a shift to use Microsoft Project on smaller and Mid-size projects. The purpose of this study is to verify and recommend what scheduling software should CM students should be introduce to and what topics should be covered.

Major Points:
- Need of Construction Management students to be introduced to both Primavera and Microsoft Project software.
- Introduction resource loading to both Primavera
- Need of Construction management students to be introduced to both Primavera and Microsoft Project software.
- What software programs are common on Heavy-Civil Project?
- A comparison of Primavera to and Microsoft Project including both performance and cost of software.
- Determine the advantages and disadvantages of using Primavera in a network versus a standalone mode.

Summary: The purpose of this study is to verify and recommend what scheduling software should CM students should be introduce to and what topics should be covered for both Commercial and Civil Projects.
Construction

The Effect of Swine-Waste Biochar on the Early-Age Setting and Compressive Strength of Cement Pastes

Author(s)
Dr. Andrea Ofori-Boadu, North Carolina A & T State University, Greensboro, NC
Dr. Musibau Shofoluwe, North Carolina A & T State University, Greensboro, NC
Mr. Frederick Aryeetey, North Carolina A & T State University, Greensboro, NC

Need: Coupled with its negative impact on the environment, the costly and energy-intensive processes associated with the production of cement has spurred up the need to develop sustainable cement replacement materials. Preliminary research results have indicated that swine-waste biochar has cementitious characteristics and may be used as a partial cement replacement material. Considering, that swine-waste in hog-producing communities has resulted in environmental degradation, its application in cement pastes could have both economic and environmental benefits.

Overview: In this research study, the effect of swine-waste biochar on the setting and compressive strength of cement pastes are explored. Using a water/binder ratio of 0.28, cement pastes with varying proportions of swine-waste biochar were investigated using Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), RAMAN, setting and rebound hammer tests. Results indicated that swine-waste biochar accelerates the setting of cement pastes, while slightly reducing its compressive strengths. It has the potential to be used in rapid-setting concrete applications.

Major Points:
• Introduction
• Purpose of Study
• Review of Literature
• Methodology
• Results
• Conclusion and recommendations

Summary: In this research study, the effect of swine-waste biochar on the setting and compressive strength of cement pastes are examined.
The Effect of Swine-Waste Biochar on the Flow and Water Absorption Characteristics of Cement Pastes

Author(s)
Dr. Andrea Ofori-Boadu, North Carolina A & T State University, Greensboro, NC
Dr. Musibau Shofoluwe, North Carolina A & T State University, Greensboro, NC
Mr. Rico Kelley, North Carolina A & T State University, Greensboro, NC

Need: Coupled with its negative impact on the environment, the costly and energy-intensive processes associated with the production of cement has spurred up the need to develop sustainable cement replacement materials. Preliminary research results have indicated that swine-waste biochar has cementitious characteristics and may be used as a partial cement replacement material.

Overview: In this research study, the effect of swine-waste biochar on the flow and water absorption characteristics of cement pastes are investigated. Using a water/binder ratio of 0.28, cement pastes with varying proportions of swine-waste biochar were investigated using Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), RAMAN, flow and water absorption. Results indicated that swine-waste biochar reduces the flow of cement paste, while reducing its water absorption characteristics.

Major Points:
• Introduction
• Purpose of Study
• Review of Literature
• Methodology
• Results
• Conclusion and recommendations

Summary: In this research study, the effect of swine-waste biochar on the flow and water absorption characteristics of cement pastes are explored. Results indicated that swine-waste biochar reduces the flow and water absorption characteristics of cement pastes.
Thursday, November 2, 2017

Construction

Thermal Imaging and Infrared Applications in the Construction Industry

Author(s)
Dr. Sherif Attallah, Ball State University, Muncie, IN
Dr. Tarek Mahfouz, Ball State University, Muncie, IN
Mr. Gary Birk, Ball State University, Muncie, IN

Need: The construction industry is continuously evolving with advancement of technologies that find their ways to practical and economical applications in projects. Thermal imaging has become a full professional area of applied technology that has its shadows on various industries and arts including construction. In order for the construction industry to fully utilize the advances in the thermal imaging, there has to be a solid understanding of the technology as a guide to the proper utilization of its features and potential.

Overview: The objective of this presentation is to highlight the basic theory behind thermal imaging and the various ways of implementation in the construction projects. The applications range from infrared motion sensors to use of thermal cameras in the building diagnostics activities which involves inspections of the integrity of thermal insulation of the envelop, assessment of water damages and detection of faulty electrical connections. This technology is still evolving and further utilization in the construction industry is expected.

Major Points:
- Thermal Imaging
- Infrared
- Construction Projects
- Building Diagnostics

Summary: The objective of this presentation is to highlight the basic theory behind thermal imaging and the various ways of implementation in the construction projects. The objective is to provide insights on the thermal imaging technology along with the current and foreseen applications in the construction industry.
Thursday, November 2, 2017

Construction

Thirsty for a Solution: Using Waste Plastic Bottles as an Additive to Enhance Asphalt Characteristics in Roadway Design

Author(s)
Dr. Carol Lamb, Youngstown State University, Youngstown, OH
Ms. Hayley Marchio, Youngstown State University, Youngstown, OH

Need: The research is a meta-analysis of the efforts to reduce waste plastic while at the same time enhancing the characteristics of asphalt pavement.

Overview: Presentation of major research to date in the area of using waste plastic in asphalt design and discussion of where this research could be advanced.

Major Points:
- Current status of plastic waste and asphalt pavement
- Discussion of research on the use of plastic waste as an aggregate in asphalt pavement
- Discussion of results of research regarding the testing of the ‘plasphalt’
- Discussion of costs involved in production of ‘plasphalt’
- Discussion of where this research could be continued

Summary: This paper presents an informative interest focusing on the use of repurposed materials, more specifically, using waste plastic bottles in asphalt pavement design. The rationale is described behind the re-use of materials and details the environmental concerns, economic cost concerns, how the additive is made for the asphalt, and its general design.
Use of the fuzzy Delphi Method for a qualification-based contractor selection in the construction of bulk processing facilities

Author(s)
Ms. Nurhaizan Mohd Zainudin, Iowa State University, Ames, IA
Dr. Gretchen Mosher, Iowa State University, Ames, IA

Need: Construction projects for bulk commodity processing are complex. The selection of a contractor is one of the most important decisions influencing the successful completion of the construction project. Contractor selection involves the utilization of selection strategies and structured methodologies which need to be aligned with the owner’s requirements and project demands. The introduction of the Delphi method and fuzzy logic in the framework can potentially capture subjective selection criteria and transform them into quantifiable metrics.

Overview: This presentation will explain the qualification-based selection (QBS) and selection criteria for contractor with specific reference to bulk processing construction projects. Important elements of QBS, Delphi method and fuzzy logic will be discussed. Finally, a proposed framework for QBS by use of fuzzy Delphi method for bulk processing project will be presented.

Major Points:
• Unique nature of bulk processing construction projects
• Elements of qualification-based selection
• Reasons for incorporating Delphi method and fuzzy logic
• Framework as basis for decision-making in contractor selection process

Summary: The audience will understand the importance of contractor selection for bulk processing construction projects. Utilization of the Delphi fuzzy method in qualification-based selection (QBS) will be discussed as they relate to contractor selection and project decision-making.”
Using Explain Everything App for Creating Instructional Support Videos for Statics and Strengths of Materials Courses

Author
Dr. Denise Gravitt, Western Illinois University, Macomb, IL

Need: Students need support to overcome their poor mathematical preparation for Construction program courses. The Explain Everything App can be used to create instructional mini lessons with detailed mathematics demonstrations to support student learning at their own pace outside the classroom.

Overview: This presentation will demonstrate basic use of the Explain Everything App and some basic demonstration videos created for a Statics and Strengths of Materials course in a Construction Management program. A comparison of two semesters of student feedback for the same course will be shown where one semester students had access to the Explain Everything videos and the other semester didn’t have the instructional videos.

Major Points:
- Lower student mathematical ability in Construction Management program courses
- Potential cause of low student satisfaction scores
- Using Explain Everything App to create instructional videos
- Summary of student feedback from a course using support videos

Summary: This presentation will demonstrate the use of the Explain Everything App and some basic demonstration videos created for a Statics and Strengths of Materials course in a Construction Management Program.
100% Online versus The Classroom: The Optimal Pedagogical Strategy as Demonstrated through Higher Statistically-Significant Grade Performance by Undergraduate and Graduate Students Studying University-Level Quality Systems Engineering

Author(s):
Prof. Joe Long, University of Central Missouri, Warrensburg, MO
Prof. Troy Ollison, University of Central Missouri, Warrensburg, MO
Prof. Jeff Ulmer, University of Central Missouri, Warrensburg, MO

Need: The purpose of this presentation is to share with academics on a four-fold study to: 1) determine if 100% online students perform at a statistically-significant higher final course grade than face-to-face classroom students on the same course topic matter, 2) determine if undergraduate students perform at a statistically-significant higher final course grade level than graduate students (100% online or classroom), 3) determine if female students perform at a statistically-significant higher final course grade than male students (100% online or classroom), and 4) ascertain if higher grades are earned by student type (100% online or classroom) for certain topics (Total Quality Management, Quality Fundamentals, Statistics - Central Tendency, Statistics - Variance, and Process Capability).

Overview: The study supporting the presentation was conducted to explore the study, development, application, and evaluation of 100% online versus face-to-face classroom education delivery pedagogy. The study also provides statistical data on university-level, undergraduate and graduate, and student grade performance in Quality Systems Engineering topics of: Total Quality Management, Quality Fundamentals, Statistics - Central Tendency, Statistics - Variance, and Process Capability in relation to a final course grade.

Major Points:
• Advancements in technology is forcing higher education to meet students where they live and to be accommodating to special circumstances for each student
• Mobile learning using smartphones, tablets, laptops, and desktop computers are becoming more important to people being educated
• Unfortunately, technology problems do occur without a student having the knowledge to fix it and it is dependent upon a college or university to put measures in place to reduce negative technical issues
• A student’s technological understanding level is not dependent or directly correlated with their age, gender, or level of prior technology use
• While blended, or hybrid, courses use online learning as a supplement to face-to-face courses, 100% online students only communicate with others through technology

Summary: The purpose of this study was four-fold: 1) determine if 100% online students perform at a statistically-significant higher final course grade than face-to-face classroom students on the same course topic matter, 2) determine if undergraduate students perform at a statistically-significant higher final course grade level than graduate students (100% online or classroom), 3) determine if female students perform at a statistically-significant higher final course grade than male students (100% online or classroom), and 4) ascertain if higher grades are earned by student type (100% online or classroom) for certain topics (Total Quality Management, Quality Fundamentals, Statistics - Central Tendency, Statistics - Variance, and Process Capability).
A Quantitative Evaluation of Students’ Learning Outcomes in “Principles of Injury Prevention” Online Course

**Author(s)**
Ms. Fatemeh Davoudi Kakhki, Iowa State University, Ames, IA  
Dr. Steven Freeman, Iowa State University, Ames, IA  
Mr. Steven Bell, Iowa State University, Ames, IA

**Need:** Continuous improvement of course materials, teaching strategies, and course assessment tools is important in distance learning.

**Overview:** The main focus of the course is on the basic foundations of injury causation and prevention in home, motor vehicle, public, and work environments. The content of the course consists of two main modules: personal perspective module and management perspective. The personal perspective focuses on principles of injury prevention and industrial safety from safety analysis to stress management, home safety, and season safety. The management perspective module’s concentration is on the industry regulations, global issues in safety management, and general safety management in industry. The course is presented in the Fall semester 2017, with more than two hundred students coming from various academic backgrounds.

**Major Points:**
- Launching online survey for the online course participants (students)
- Analyzing survey results
- Figuring out the relationship between students’ demographics and their success rate in the course
- Figuring out the relationship between students’ course behavior and their success rate in the course
- Finding the balance in presenting various types of course materials (Personal Vs Managerial Perspective materials) from learners’ view point
- Finding out course success in changing students’ impression of the Principles of Injury Prevention and Industrialized Safety

**Summary:** The main focus of the course is on the basic foundations of injury causation and prevention in home, motor vehicle, public, and work environments. The content of the course consists of two main modules: personal perspective module and management perspective.
A Study to Determine the Pros and Cons of Effective Use of Respondus Lockdown

Author(s)
Dr. Cynthia Horta Martinez, University of Central Missouri, Warrensburg, MO
Mr. Reece Holcombe, University of Central Missouri, Warrensburg, MO

Need: When offering online programs, there is still a need to proctor some quizzes and/or exams. Respondus Lockdown Browser has been a great tool, however there is a need to adapt to the Respondus Lockdown Monitor and its effective use.

Overview: There has been concern in higher education about the validity of online testing. How can we be sure that students are not receiving help from others, using the textbook, or doing the test in teams? Each online proctoring university has developed its own approach; while some monitor live feeds, others record students and watch the recordings later. It is with this in mind that we intend to develop our own online proctoring approach.

Major Points:
- Technical Issues
- ID Requirements
- Authorized Materials
- Conduct and Academic Honesty

Summary: The study will be done with a small group of students enrolled in Engineering Economy and Legal Aspects of Industry at the University of Central Missouri. Information presented in this study will serve as a reference to help establish a base of pros and cons for universities that would like to engage in such technology.
Developing electronics curricula: Shifting from a traditional approach to project based distance approach

Author
Dr. Trevor Robinson, Utah State University, Bringham City, UT

Need: The electronics industry represents a large and growing sector in the global economy. This will require graduates from numerous programs to have an understanding of how electronics and electricity work. Electronics courses have traditionally been focused on the theory and math behind how electronic components and circuits work. Electronics theory as it has been traditionally taught with a disproportionate emphasis placed on the underlying mathematics can be disengaging for many students, especially when those students are familiar with learning through practical hands on applications and projects. Electronics course delivery needs to be reorganized and the approach to curricula needs to adapt to better prepare students to enter a world where familiarity with electronics will be a necessity. Also, with a growing demand for colleges and universities to offer more online and distance education courses, electronics courses should begin to become more accessible to a distance delivery methodology.

Overview: Over the past three years, there has been a collaborative effort between _____________________ University and ______________________ University to develop a more hands on and project based approach to delivering an electronics course. This approach utilized an occupational and task analysis to determine what skills and knowledge is needed for individuals entering industrial technology, technology and engineering education, manufacturing, construction, and related fields. The results of the analysis have led to the development of several hands on projects for students to complete while working through an electronics course. Two of these projects include the construction of a DC power supply, and building a working digital stopwatch. These new projects and curriculum have seen improved results in a face-to-face classroom, including better engagement, teamwork, and collaboration, as well was better understanding and retention of fundamental concepts. The success of this curricula over the past two years has led the instructors to adapt the curricula to be taught via a distance delivery method. During the most recent semester, the course was taught using a hybrid model. The hybrid method has also been a success.

Major Points:
• Need for improved approach to teach electronics
• Results of an occupation and task analysis for using electronics in the work force
• Development of a project based curriculum used to teach electronics
• Successes of a project based approach
• Adapting a face-to-face course into a hybrid course offered via distance education

Summary: The presenters have developed a more hands on and project based approach to delivering an electronics course.
Distance Learning

Distance Learning Technologies and the Virtual Classroom

Author(s)
Dr. Christopher Davison, Ball State University, Muncie, IN
Dr. David Hua, Ball State University, Muncie, IN
Dr. Biju Bajracharya, Ball State University, Muncie, IN

Need: Telepresence technologies facilitate the “virtual” classroom. Often, instructors are unavailable for office hours due to conferences and other academic responsibilities. However, students require assistance from their instructors. To address this need, a variety of telepresence technologies will be discussed. These will range from free technologies that support somewhat limited functionality to large-scale organizational telepresence technologies that support a number of features but have costs and subscriptions associated with them.

Overview: The objective of this presentation is to increase awareness of telepresence technologies that will assist instructors in hosting “virtual” office hours. Often, instructors are required to attend conferences (e.g., ATMAE 2017) or other activities while still expected to be available for student office hours. Telepresence technologies can provide convenient and often low to no cost solutions for instructors to host office hours. A variety of technologies such as Blackboard, WebEx, Google, and Yahoo will be explored.

Major Points:
- Research shows that office hours are highly correlated to student success
- Student advising moderates failure attribution (Bruan & Zolfagharian, 2016)
- Telepresence technologies serve as “virtual” office hours
- Costs for telepresence technologies range from free to subscription based

Summary: A review of the research literature indicates that student contact time and student advising are essential for student success. Light (2001) finds that student satisfaction with advising is important to the student’s successful college experience.
Thursday, November 2, 2017

Distance Learning

Enabling a 100% Online Certificate Program in Quality: Preparation of Distance Instructors

Author
Dr. John Earshen, SUNY/Buffalo State, Buffalo, NY

Need: Online access to a certificate program in quality requires special attention to instructor preparation and support.

Overview: This presentation outlines an approach to support the preparation of online instructors assigned to implement a 15 credit-hour, portable, 100% online certificate program in quality that can be completed part-time in one calendar year.

Major Points:
• Special training requirements for instructors of this 100% online certificate program in quality.
• Curriculum content is matched to the ATMAE Lean Six-sigma Body of Knowledge.
• Discuss implications for the future - potential industry sponsorship in future years; deployment of the program on a state-wide basis.

Summary: This presentation outlines the unique elements of instructor preparation to support an ongoing initiative to implement a portable, 100% online certificate program in quality. This 15 credit-hour program is being developed in response to strong regional demand for the development of workforce competency in quality.
Distance Learning

Increasing Student Satisfaction in Online Courses

Author
Dr. Edward Lazaros, Ball State University, Muncie, IN

Need: According to the BABSON Survey Research Group, data from Fall 2002 through Fall 2011 indicate that student online enrollments continue to rapidly increase. During 2010-2011, the total online enrollment increased to 6.7 million, a 9.3% growth rate in online enrollment. These astounding numbers, coupled with the expansion of degree completion programs, online general education transfer courses, and high school dual-enrollment and early college programs dictate that proper distance learning structure must exist in order to promote student satisfaction and enjoyment and maintain positive enrollment increases (Allen & Seaman, 2013).

Overview: This presentation will cover techniques to make online courses more enjoyable for students. First, it will cover the kinds of interactions the professor should have with the course, including how often to be online and available to assist students (Boettcher, 2011). Next, it will detail the importance of creating online community through dialogue (Pelikan, 1992) and delve into how setting expectations for students creates a positive learning environment. The presentation will then explore the different kinds of content to use in online courses, including group work (Hrastinski, 2008). It will then touch on student feedback and its importance and continue by explaining how to integrate proper discussion questions and prompts for maximum student involvement (Grogan, 2005). Lastly, the presentation will explain how to incorporate digital resources for students (Mardis, Everhart, Smith, Newsum & Baker, 2010) and ways to make online education as personalized as possible.

Major Points:
- Instructor presence
- Creating supportive online communities
- Setting explicit expectations for work
- Variety of large group, small group and independent exercises
- Opportunities for feedback
- Discussion posts that invite responses, questions, discussions and reflections
- Digital resources
- Customized and personalized learning

Summary: This presentation will cover details relating to how online courses can be improved to increase the satisfaction of students.
Need: With marketing online programs at universities often being difficult to fund, generating good prospects is paramount. Turning good prospects into applicants and eventually new students is of upmost importance. Unfortunately, many faculty are unaware of modern techniques that can be used to accomplish this. Faculty are often unaware of Google Ads, the importance of organic website placement, strategies for outpacing the competition, and strategies for connecting with prospects on a humanistic level.

Overview: This presentation will discuss online recruiting strategies that have resulted in success in the Midwest. Specifically, the use of Google Ads will be discussed.

Major Points:
- The importance of a web presence to remain competitive in an International marketplace of online graduate programs will be discussed
- The importance of pictures and video to connect with prospective students will be highlighted
- Once prospects express interest, advisor interaction techniques will be described

Summary: This presentation will highlight the success that one Midwestern university has had with online program recruiting.
Need: With a growing number of courses offered online and degrees offered through the Internet, there is a considerable interest in concerns and problems associated with online education, particularly as it relates to the quality of online instruction (Allen & Seaman, 2003). Instructors have many concerns about online education. Their primary concern is how online education changes their roles and responsibilities, and how they can adapt to this change (Yang & Cornelious, 2005).

Overview: This presentation begins by explaining the barriers, including different responsibilities, technology, and student interaction (Palloff & Pratt, 2000), and deterrents, such as lack of prestige and method of delivery (Yang & Cornelious, 2005), to being an online educator. Next, it outlines the roles of teachers and students in online education, emphasizing the responsibility of the learner to be a motivated participant in the educational community (Garrison, Cleveland-Innes, & Fung, 2004). It then details how teachers can facilitate the transition to these roles. Next, the presentation explores technologies like multimedia, audio and video, and instant messaging used in online education (McGreal & Elliott, 2004) and the nuances of new kinds of online learning and testing that may invite unwelcome plagiarism (Heberling, 2002). It continues by explaining performance assessments for online courses and how to create the most effective course possible. It finishes by touching on how to promote online community in order to enhance student outcomes through techniques such as online office hours (Serwatka, 1999). Finally, the presentation outlines how to face the overarching challenges of online education.

Major Points:
- Barriers and deterrents
- Understanding new roles for teachers and students
- Encouraging successful role transition
- Mastering technology
- Experimenting with new ways of learning and testing
- Establishing performance assessments
- Designing an effective online course
- Promoting online community
- Enhancing student outcomes
- Facing the challenge

Summary: This presentation will share information that can help prepare faculty for the online platform. Barriers and deterrents for online educators will be highlighted.
Recruiting Strategies for Online Programs

Author(s)
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Dr. Christopher Davison, Ball State University, Muncie, IN
Dr. David Hua, Ball State University, Muncie, IN

Need: Online is a medium that continues growing at a robust rate. A 2013 report from the Sloan Consortium, an organization that has tracked developments in online education in the United States for over a decade, found that “the number of students taking at least one online course has now surpassed 6.7 million.” Online enrollments continue growing at a robust rate, forcing many institutions to engage with the online space more vigorously, or perhaps for the first time. The same report indicated that nearly 70 percent of chief academic leaders say online learning is critical to their long-term strategy.

Overview: This presentation will begin by explaining the typical demographic of an online student (Flowers, 2005) and how to target the correct audience for recruitment. It will then detail how to promote the positives of online education versus the most common perceptions (Smallwood & Zargari, 2000). Next, the presentation will explain methods of online advertising, including social media marketing (Barnes & Lescault, 2012). It will then continue by emphasizing the importance of proper accreditation for online schools (Sheehy, 2012) and encourage recruiting through excellent job placement opportunities and a solid graduation record (Cook & Hartle, 2011). The presentation will finish by revealing how institutions should allow credit transfer in order to become more appealing to students.

Major Points:
- Addressing the Demographic
- Changing Perceptions
- Online Advertising
- Social Media Presence
- Focus on Accreditation
- Highlight Job Placement
- Emphasize Graduation Rates
- Allow Transfer Credits

Summary: The presentation will highlight strategies for online program recruiting success, specifically ways to target demographics that align with those who typically gravitate toward online education.
Stakeholder reactions to using e-learning as an alternative to snow day

Author(s)
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Dr. Edward Lazaros, Ball State University, Muncie, IN
Dr. Christopher Davison, Ball State University, Muncie, IN

Need: E-learning can be defined as a method to establish teaching and learning process [sic] through the use of Internet and information technology devices” (Pardamean & Suparyanto, 2014). The teaching and learning process is also known as virtual learning. This paper covers these processes in regard to make-up days for inclement weather for public schools, such as snow days or hurricane days. Most state or local implementations of virtual learning days are quite recent: within the last five years. Therefore, the extent of research is limited, and available reports on schools’ decision to implement alternative learning styles are scarce. However, online classes have existed since the Internet grew in popularity among the general population, and various studies and research have been conducted and are integrated here.

Overview: The purpose of this presentation is to highlight a recent study investigating how virtual learning days have impacted students, parents, teachers, and school administrators. In areas where inclement weather results in school cancellations, virtual learning days provide an alternative that allows for continued instruction on those days. The Indiana Department of Education has established a policy that sets requirements for what can be considered an approved virtual learning day. This presentation will provide an overview of a recent study that surveyed superintendents throughout Indiana to determine the impact virtual learning days have had on their stakeholders. The perceived benefits and challenges of virtual learning days expressed by each of the stakeholders will be presented. The general finding of the survey was that stakeholders support the use of virtual learning days as an alternative to declaring “snow days”.

Major Points:
• Discussion of the impact of school cancellations due to inclement weather
• Describe the Indiana virtual learning day policy
• Provide the results from a survey of stakeholders in school districts that have adopted virtual learning day policies
• Discuss the implications of the results on the growth of virtual learning day policy adoption by school districts

Summary: This presentation will provide insights into how students, parents, teachers, and school administrators have responded in school districts that have adopted virtual learning day policies.
Thursday, November 2, 2017

Distance Learning

Synchronous and Asynchronous content delivery in online and hybrid courses

Author(s)
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Need: Education can be considered to be labor-intensive industry and as costs per student has risen faster than the rate of inflation, innovations that lower costs are constantly being sought (Baum, Kurose, & McPherson, 2013). The makers and curators of Learning Management Systems (LMS) (Blackboard, Moodle, Sakai) have sought to enhance student engagement opportunities on their platforms by partnering with video capture software makers who cater to synchronous or asynchronous content delivery. One innovator that purports to upend the single content delivery system is Yuja which does both synchronous and asynchronous content delivery and an assessment of such systems and their effectiveness needs to be done.

Overview: The purpose of this presentation is to share information on various techniques for incorporating audio/video lectures into your online and hybrid courses. These techniques are deployed through the use of software such as Yuja, Tegrity and Collaborate, which are add-ons to the Blackboard course management software. Currently, this is the high end of the audio/video delivery for online courses. However, there are other more affordable and in some cases free software that are available to help supplement an instructors online and hybrid courses. Several of these various techniques will be discussed.

Major Points:
- Share information on various techniques for incorporating audio/video lectures
- Discuss Tegrity, Collaborate, Yuja and other software and associated hardware
- Present current research on delivering online audio/video lectures
- Discuss advantages and disadvantages of these delivery methods
- Explain how this can fit into your online and hybrid courses

Summary: Many Universities and Community Colleges have made the delivery of course content online a top priority due to the cost pressures associated with costing of education in its traditional mode of delivery (Deming, Goldin, Katz, & Yuchtman, 2015). This presentation aims to share some of these content delivery systems with colleagues in the field.
Thursday, November 2, 2017

Distance Learning

Using Mobile Devices in Online Education

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Need: Mobile technologies are playing an increasingly important role in college students’ academic lives. Devices such as smartphones, tablets, and e-book readers connect users to the world instantly, heightening access to information and enabling interactivity with others. Applications that run on these devices let users not only consume but also discover and produce content. As such, they continue to transform how college students learn, as well as influence their learning preferences, both within and outside the classroom (Chen & deNoyelles, 2013).

Overview: This presentation will begin by exploring the prevalence of mobile devices among the student population, including phones and tablets (Dahlstrom, 2012). It will then discuss the benefits of mobile devices in education and detail the fact that student attitudes toward mobile learning are overwhelmingly positive (Ally, 2009). Next, this presentation will cover the skills and support necessary for proper mobile technology use and explain how instructors can adapt properly (Chen & deNoyelles, 2013). The presentation will then analyze what mobile technology is currently being used for and its potential, including the use and creation of apps (Vázquez-Cano, 2014). Finally, the presentation will cover the future of mobile learning and its effects beyond the course (Berge & Mulienberg, 2013).

Major Points:

- Prevalence of Mobile Technology
- Benefits
- Student Attitudes
- Skills and Support
- Instructor Training
- Current Device Use
- Academic Possibilities
- App Utilization and Creation
- Beyond the Classroom

Summary: During this presentation, information regarding technology advances that allow for mobile device integration into the online classroom will be discussed. The benefits of mobile learning, such as flexibility and the use of apps will be highlighted.
Virtualization: Implementation and Growth, Policies and Management

Author(s)
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Need: A practicum assessment is a hands-on laboratory assignment meant to evaluate mastery of concepts, learning outcomes, and students' ability to apply knowledge. Virtualization and virtual technologies can enable practicum assessments for IT education. Newhouse (2013) considers IT pedagogy without virtual assessment technologies “primitive” (p. 263) in nature. Practicum assessments are often found in health-care (Jukkala, Greenwood, Motes, & Block, 2013), education (Wyss, Siebert, & Dowling, 2012), and even in online education (Chao, Hung, & Chen, 2012).

Overview: Virtual technologies are a relatively easily implemented assessment tool for educators. Technical education environments can be enhanced with these tools with a low impact on existing infrastructures. Educators attending this presentation will take away tools and strategies to implement virtual technologies. Participants will be informed of the challenges that arise in the computer systems technical education environment with regard to teaching systems administration. The research presented clearly demonstrates that virtual technologies are viable solutions. Another important concept emerging in this presentation is that virtual technologies are often the best compromise between school administration policies on computer security and the students’ need to demonstrate knowledge of systems administration concepts. Additionally, the participants will learn specific virtualization strategies, including cost (from open source to expensive enterprise solutions) and the computational resource requirements necessary to implement the virtualization strategies.

Major Points:
• Increase awareness of easily obtained and implemented virtual technologies to ameliorate system security conflicts, systems configuration management conflicts
• Practical assessments as an alternative to traditional examinations in a technical education environment
• Virtualization technologies are common and range in cost from free to expensive enterprise level infrastructure software

Summary: In this presentation, several virtualization technologies will be presented. These different technologies range from free and open source, to more expensive enterprise level virtualization.
A Low Cost Control System Laboratory for Engineering Management and Technology (ETM) Students

Author
Dr. Curtis Cohenour, Ohio University, Athens, OH

Need: Engineering Management and Technology (ETM) students with an understanding of control systems are better prepared for today’s job market. ETM students are not required to take the math classes need to support a traditional analysis of control systems in either the frequency domain, or the time domain. ETM students are well prepared for a course that provides a practical understanding of control systems.

Overview: An inexpensive servo from the radio control hobby market is modified to support a laboratory experiment in controls. The experiment is part of an electronics course based on the Arduino. The servo controller is removed and the two motor leads, and the three potentiometer leads are brought outside of the case. Two Pulse Width Modulation (PWM) Arduino outputs are used to form a proportional reversing motor drive. This provides a low cost “plant” for the laboratory. Other Arduino IO includes, potentiometers for gain and reference, pushbuttons for auto / manual, manual inputs, and indicating lights.

Major Points:
- What is process control
- Types of controllers from dead band control to Proportional Integral Derivative (PID) control
- Common pitfalls in software based controllers
- The servo modifications for the lab
- The controls lab
- Student outcomes
- Student feedback
- Conclusions

Summary: Attendees will learn how one university developed a controls lab for ETM students.
Accelerating Tomorrow’s Robotic Applications through visualization: Experiential learning using Visionary Render

Author
Mr. Jesus Pagan, Ohio University, Athens, OH

Need: Using virtual reality in and out of the classroom could increase student engagement. Not only these technologies are mature, but they can be implemented in new ways to provide students access to new learning experiences.

Overview: The presentation will focus on creating the necessary elements needed for the implementation of a virtual reality experience using Visionary Render from Virtalis. We will showcase the process of collecting the data and manipulating it so that it can be used as an alternative learning tool for a robotics course at Ohio University.

Major Points:
• CAD data import
• Out of the box VR devices
• Tools for creating annotations and snapshots

Summary: This presentation focuses on the areas of robotics and automation specially in the implementation of new material handling robotic cells being incorporated at Ohio University.
Building a 20/20 view of the network: Open-source tools for mapping the system and traffic flow

Author
Dr. Vigyan Chandra, Eastern Kentucky University, Richmond, KY

Need: Owing to the amorphous nature of the modern computer network, which is in parts hardwired and wireless, local and remote, the task of tracking down issues related to performance, quality of service, or security can be a challenge. Traditional computer/network and security tools require investigation of log files and error messages in order to track down issues. These may no longer be sufficient to isolate and remedy issues with minimal latency. There is the need for graphical tools to aid network administrators and analysts maintain an always-on, secure, high-availability system.

Overview: With multiple applications being simultaneously accessed over hardwired and mobile devices, remotely and on-site, the size of the network landscape is increasing non-linearly, even exponentially. Along with this increase in the network perimeter comes the potential for cascading points vulnerabilities users may inadvertently have been created. The presentation will provide alternative ways of observing computer network system traffic and thus of securing these. Open-source tools for network monitoring and management, highlighting the visual display of information, will be shared with the audience.

Major Points:
- Before we can manage, we must observe: cataloging the network landscape
- Spotting data trends and anomalies using log and files
- Visuals of computer/network systems data: Monochrome vs Color and Tables vs Graphs
- Seeing with parade of wireless and wired network traffic with new eyes
- Open-source graphical tools for polling information about network devices
- Who’s on First: Leaving interpretation regarding the “data of interest” to the admin

Summary: The implications of visually depicting this information from a computer and network systems/security standpoint will be discussed.
Thursday, November 2, 2017

Electricity, Electronics, Computer Technology & Energy Issues

Building a Solar Charged Electric Go-Kart

Author(s)
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Need: Growing energy demands have led to increased use of fossil based fuels. The increasing population and polluting nature of fossil based fuels is leading to a detrimental growth in the global pollution levels. Also, global warming is increasing steadily giving rise to irregular climate patterns all over the world. All these factors are hazardous to humanity’s survival and consensus is therefore to look for alternate sources of energy and modes to use it. Transportation has been a major contributor to the global energy mix (28%) and has been using predominantly fossil fuels. This project aims to demonstrate the use of solar energy to power a go-kart and showcase the viability of solar energy as a practical source of energy.

Overview: A solar vehicle is a mode of transportation that utilizes solar energy absorbed by solar arrays which is then stored by a bank of batteries. This energy stored in the batteries is then converted to mechanical energy using a motor which drives a chain sprocket. The chain sprocket is what drives the wheels of the kart. This simple yet effective circuit can be made efficient enough to use solar energy as the ultimate source of energy for an electric vehicle. The range and the efficiency being the biggest challenges in a solar based vehicle are the main considerations of this research. With new advancements in the battery technology, present day batteries have become more efficient and lighter than before. The main objective of this research is to explore ways to construct a safe, green, efficient and practical vehicle. Further work on the go-kart is to be on the lines of the regenerative braking system which uses the motors reverse EMF to charge the batteries for extended range. Also, with the onset on smart-grids incorporation of an electric vehicle into the grid will be researched as well.

Major Points:
- Environment conservation
- Solar Energy
- Range and Efficiency
- Fabrication of the frame
- Battery Storage

Summary:
In this presentation, the design and engineering aspects of a solar electric go-kart will be discussed.
Building Affordable Laboratory Equipment to Conduct Energy Experiments for Alternative Energy Classes

Author(s)
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Dr. Faruk Yildiz, Sam Houston State University, Huntsville, TX

Need: Engineering Technology (ET) degrees are more applied than the more theoretical science-based engineering degrees. The technical courses in ET programs as well as those in math and other sciences are taught with more applications and less theory than the related engineering courses. ET courses generally have labs associated with the courses that require applied or hands-on concept applications that strengthen the students’ knowledge base. Lab sections of most ET course curricula are important because they introduce concepts of the subjects which are then applied to daily life and industrial activities. Due to budget limitations, it becomes an issue to keep labs up to date and to upgrade the existing equipment to offer students new technology challenges. To overcome this challenge, academic programs invest in individual components instead of fully operational laboratory equipment in order to build units in-house; this allows them the ability to pay less for equipment.

Overview: Faculty and senior students in an Engineering Technology program have been designing, building, and testing energy-related laboratory equipment to conduct lab experiments for energy-related courses and workshops. Engineering Technology students are very interested in design and production process of training equipment and their participation provide major help to faculty. Students gain valuable experience during this process and learn how to manage projects with limited resources. Since 2010, over forty students (mostly undergraduate) were involved in a variety of projects either as volunteers or by enrolling in independent study courses. Some of the projects are listed under major points.

Major Points:
- Mobile solar thermal water heating system
- Mobile solar thermal air heating system
- Mobile photovoltaic laboratory equipment
- Wind energy training systems
- Battery testing system
- Electric vehicle unit
- Hydrogen fuel cell system
- Weather station for measurements
- Hybrid wind/solar power house
- Solar powered LED lighting
- Geothermal energy training unit

Summary: In this study, information will be detailed which are related to the various student feedback, the students’ previous educational coursework backgrounds, details of the each project (funding resources, time, number of students, cost, materials/material specs and vendors, and associated lab workbooks), quantitative data regarding student feedback (like GPA, subsequent career path followed or not followed by the students), high impact (from students’ perspective) that projects related to alternative energy projects and their ranks related to other projects will be detailed.
Characterization of AuBe Ohmic Contact with the p-GaAs Base Used for Heterojunction Bipolar Transistors

Author(s)
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Dr. Qingzhou Xu, Morehead State University, Morehead, KY

Need: Compound semiconductor heterojunction bipolar transistors (HBTs) are promising devices for RF power amplifiers and other high-frequency applications because of their good linearity. HBTs utilize heavily doped bases without compromising their current gains due to the energy band discontinuity. With a decrease in the base intrinsic resistance, the extrinsic resistance of the ohmic contacts becomes a significant part of the total base resistance that limits HBTs’ high-frequency, high-power, and low-noise performances. HBTs typically use an n-p-n structure to take advantage of much higher electron mobility. The thickness of the p-type base layers of modern HBTs is reduced below 1000 Å to increase both cutoff and maximum oscillation frequencies. For such thin layers, narrow interface reaction regions become important for device manufacturing. The thin base layers place severe geometrical constraint on the construction of ohmic contacts on the base. Achieving high-quality ohmic contacts on the thin p-type bases of modern HBTs remains a challenge in actual device manufacturing. This presentation reports an effort to solve the actual fabrication problems arising when an Au-1 wt% Be alloy is used as a contact material and to develop high-quality ohmic contacts on the thin p-GaAs bases of AlGaAs/GaAs and InGaP/GaAs HBTs.

Overview: This presentation will first review the electrical characteristics of heterojunction bipolar transistors (HBTs), their stacking-layer structures and the challenge that thin p-type base layers pose on actual device manufacturing. It will then introduce the experimental methods to make, treat and characterize the ohmic contacts with three different barrier metals. Then, the presentation will introduce the measured results, and discuss and compare the results. The I-V characteristics of the HBTs fabricated by the optimized ohmic contact will also be presented. Finally, the conclusions of this research will be introduced.

Major Points:
• The remarkable electrical characteristics of heterojunction bipolar transistors (HBTs) make them the devices of choice in the applications of RF power amplifiers and high-frequency communications.
• Thin base layers play an essential role at achieving high-performance HBTs in terms of cutoff and maximum oscillation frequencies.
• Thin base layers cause a significant challenge to actual fabricating HBTs.
• Annealing temperatures are important in realizing low contact resistance.
• A proper barrier layer is critical for the electrical stability and geometrical integrity of the ohmic contacts.
• The HBTs fabricated by the optimized ohmic contacts exhibit excellent electrical performance.

Summary: This presentation reports a research on realizing high-quality ohmic contacts on the thin base layers of heterojunction bipolar transistors (HBTs).
Customize the robotic end effector by CAD modeling and simulation

**Author(s)**
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Dr. Yuqiu You, Ohio University, Athens, OH  
Dr. Sanghyun Lee, Morehead State University, Morehead, KY

**Need:** Robotics becomes more and more prevalent in industrial automation and manufacturing. Customizing the robotic end effector for various situations, sizes, shapes etc. is very critical to the application of next generation of robots. Computer Aided Design (CAD) on robotic end effector could contribute significantly to the customization and make the process more efficient.  

**Overview:** The presentation will provide an overview of computer aided design on robotic end effector utilized in some industrial manufacturing. Some examples will be selected to demonstrate how SolidWorks modeling and simulating improves the motion of end effectors and make the customization efficient.

**Major Points:**
- Introduction of current end effectors in industrial robotic applications  
- Review the principles of mechanisms  
- modeling the end effectors using SolidWorks  
- Simulation of end effectors using Motion Stud  
- Future work: automation control

**Summary:** Robotics is adopted in various automated manufacturing processes. The customized design on its end effector is becoming more and more prevalent to fit different applications. This presentation will demonstrate how to apply mechanical mechanisms on robotic end effectors’ design and show related CAD modeling and simulation using SolidWorks. Attendees will gain understanding on the procedures of computer aided design in industrial robotics.
Thursday, November 2, 2017

Electricity, Electronics, Computer Technology & Energy Issues

Cyber Security Testing Framework of Internet of Things Devices

Author(s)
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Dr. Edward Lazaro, Ball State University, Muncie, IN
Dr. Christopher Davison, Ball State University, Muncie, IN

Need: The proliferation of IoT technologies has created a broad array of products and services designed to make life easier. It is anticipated that there will be 20 – 30 billion IoT devices deployed globally by 2020. These technologies will become an increasing part of our lives as intelligence is incorporated into an expanding number of items. There have been many examples of how the privacy and security of the information that these devices collect and transmit have been compromised by hackers. These devices have also been hijacked by hackers who have used them as “zombies” or “bots” to engage in distributed denial of service (DDOS) attacks. Many manufacturers have failed to incorporate appropriate levels of security into their devices as a result of their rush to market. At this time there is no standard that defines minimum security measures that must be implemented before a device is allowed to go to market. These vulnerabilities places individuals, organizations, and society at risk.

Overview: The Internet of Things will bring about a new generation of products and services through the use of embedded systems. Embedded systems is what enables previously mundane items with sensory, computing, and communication capabilities. These capabilities have presented a broad array of consumer products. The rush to market of these items has seen a number of products whose security features were not fully developed. To address this issue, the IoTNet project seeks to develop an applied framework for testing the security of IoT devices. The goal of the project is to provide manufacturers with a service that will subject their devices to a battery of security tests. The manufacturer would then receive a report detailing any vulnerabilities that were discovered. The manufacturer will then be able to remediate those vulnerabilities before going to market with the device. Attendees will learn about IoT technologies, the potential privacy and security risks associates with IoT technologies, and how these issues can be addressed through the development of a security testing framework.

Major Points:
• Introduce the concept of the Internet of Things and its component parts
• Identify the potential risks associated with using IoT technologies
• Define the attack vectors associated with IoT devices
• Describe the development of a security testing framework for IoT devices
• Discuss the implications of the study

Summary: This presentation will discuss the development of a project that will allow IoT manufacturers to have their products undergo a battery of cyber security tests before their products go to market.
Thursday, November 2, 2017

Electricity, Electronics, Computer Technology & Energy Issues

Data Hiding Method in Digital Image Steganography

Author(s)
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Dr. Christopher Davison, Ball State University, Muncie, IN

Need: In the realm of digital communications and information sharing media, the game of cops and robbers between cyber intelligence namely government, military, educators, researchers etc and criminal cyber intelligence namely hackers, spammers, malvertisers, terrorists etc. is on. There is continuous and ongoing efforts made by both intelligence to communicate and exchange secret information between their intended partners in ever expanding cyber space. The secured communications and exchange of information occurs via sophisticated, hardened security devices and protected media such as firewalls, intrusion detection/prevention systems, virtual private networks, and antivirus. Despite these efforts, information still falls into the hands of unauthorized people. This results in data breaching, information leaking, copyright infringement, hacking, eavesdropping etc. One of the technologies used by cyber intelligence and criminal cyber intelligence is steganography. Steganography is a method of concealing information within other common information carriers like image, video, audio, and text without exposing its presence to the intermediate devices or media. This is a preferred technique over a cryptographic technique that explicitly exposes its presence. Because of its ability to bypass most security systems without revealing its presence, steganography is becoming an important topic in the field of cyber security.

Overview: The objective of this presentation is to discuss steganography, a science of data hiding, methods used in digital images, its scope and challenges. Steganography technologies are used to transfer secret information between intended sender and receiver without revealing its presence to any third parties between them thus providing privacy and secrecy while they traverse on cyber space. These methods are used by both cyber intelligence and criminal cyber intelligence. Cyber intelligence uses these methods for secrecy and privacy while criminal cyber intelligence uses these methods for data infringements, data leaking, copyright violations, and malware distributions. Opportunities and threats posed by these methods will be explored in this presentation.

Major Points:
- Discussion of digital image steganography methods, their scope, and challenges
- Describe mathematical measurement of image quality and data hiding capacity to minimize any suspicion of hidden information
- Describe how to increasing data hiding capacity impacts image quality

Summary: This presentation will discuss data hiding technique that can be used for transmitting secret hidden messages to the intended recipient by using digital image as carrier of information while traversing across cyber space.
Design of a Hybrid Solar Photovoltaic and Thermal Unit to Analyze Weather Effects on Solar Cell Power Output

Author(s)
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Dr. Keith Coogler, Sam Houston State University, Huntsville, TX

Need: There has been increased worldwide interest in developing technology that will improve the applications of renewable energy systems. Solar photovoltaic technology, in particular, has experienced added attention recently, and by the end of the decade, solar photovoltaic systems are expected to be cost-competitive compared to retail electricity prices in a significant portion of the world, even without subsidies. The academic community began developing solar photovoltaic-related curricula in order to respond to industry needs by producing qualified graduates who are familiar with solar photovoltaic systems. Technology and engineering programs in many higher education institutions are developing alternative energy-related curricula in classes, projects, training, and certification programs. RE teaching systems and projects help students to comprehend complex concepts in a more complete way by including a renewable energy project or series of laboratory experiments. Energy knowledge and renewable energy-based projects are important in order to prepare students to be competitive for careers in the growing fields of energy related engineering, science, and technology.

Overview: Current and voltage output of a solar photovoltaic (PV) panel is affected by changing weather conditions. Temperatures affect the voltage, and solar irradiation affects the current outputs of a solar PV module. It is important to characterize the response of the system to changes in power characteristics so the equipment associated with the solar PV panel can be sized appropriately. The average operating voltage and current of a PV system is important to consider for safety concerns, equipment capabilities and choices, and in order to minimize the amount of wire required for construction. Typically, historical temperature, solar irradiation data, and weather data are used to estimate solar PV outputs. It is critical that students explore how the efficiency of a solar PV panel is affected by the ambient temperature and solar insolation. For this purpose, engineering technology students and faculty developed a mobile training unit so that student can study weather effects on solar PV modules. The unit includes two solar panels, instrumentation devices (temperature and solar irradiation sensors), a charge controller, inverter, measuring equipment, etc. This new, completely portable unit is merged with an existing solar thermal air heating unit for natural heating of the solar panels to study temperature effects. Polarized plexiglass and high efficiency light bulbs were installed to study the effects of solar irradiation. The unit was completely designed and built in Engineering Technology laboratories by students and faculty. The available lab equipment is used in lab sections of two renewable energy courses offered in the program.

Major Points:
• How weather affects Solar PV
• Solar PV power characteristics
• Solar photovoltaic curriculum development
• Laboratory experiments
• Multidisciplinary curricular activities

Summary: This research describes the design and development of a hybrid solar photovoltaic laboratory unit using instrumentation tools to study power characteristics based on weather changes. All the steps of the design process and curriculum development will be shared with academia.
Thursday, November 2, 2017  
Electricity, Electronics, Computer Technology & Energy Issues

Designing and Testing Sensors to Assist in Coral Restoration

Author  
Dr. Gary Mahoney, Berea College. Berea, KY

Need: Coral reefs are one of the most diverse ecosystems on the planet. Reefs are essential to numerous marine species’ life cycle. However, reefs are experiencing massive die-outs. Global climate change is considered one of the biggest culprits affecting 50-70% of the coral reefs. Organizations such as the Coral Restoration Foundation Bonaire have been working to restore the shallow water Elkhorn and Staghorn populations along the coast of Bonaire and Klein Bonaire. While their open source process has been successful in restoring reefs they would like to collect additional data to better understand and predict the process.

Overview: This project will explore the design and testing of off the shelf and/or open source sensors to be used to document coral restorations in Bonaire. It is expected that O2, CO2 and temperature sensors will be paired with Arduinos to log data to help better describe the restoration process. Design of the cases or housings will be a major part of the project.

Major Points:
- Case Design
- Coral Restoration
- Global Climate Change
- O2, CO2 and Temperature sensors
- Arduinos
- Data logging

Summary: This project involves working with the Coral Restoration Foundation Bonaire to design low cost, off the shelf/open source sensing devices to monitor O2, CO2 and temperature on their ongoing reef restoration projects.
Electricity, Electronics, Computer Technology & Energy Issues

Enacting Active Compliant Visual Robotic Control: Setup, Configuration, and Applications

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Overview: The purpose of the presentation is to provide instruction on how to integrate a vision system with an industrial robotic arm. Configuration of the hardware and software will be discussed, along with some sample applications for enacting active compliant visual robotic control.

Major Points:
- Hardware Setup (Cognex In-Sight Micro, Local Area Network, & a Mitsubishi SCARA 4-axis Industrial Robot)
- Software Setup (In-Sight Explorer & RT Tool Box2)
- Sample Applications / Video Demonstrations of Work

Summary: The presentation will focus on the integration of a premier vision system with a typical industrial robotic arm. Configuration of the hardware and software will be discussed, along with some sample applications for enacting active compliant visual robotic control.
Author(s)
Mr. Lucas Poynter, Eastern Kentucky University, Richmond, KY
Dr. Ni Wang, Eastern Kentucky University, Richmond, KY
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Need: An engraving machine is designed to make use of a sharpened carbide stylus to etch (engrave) part numbers into a piece of material. While quite versatile, this machine only operates in X and Y axis. The only way to adjust the Z movement in the machine is to loosen a screw and adjust the engraving machine by hand. This measurement is difficult to achieve when using both hands to adjust the height of the machine. This project is to design and build a more precise and accurate way to adjust the height of this machine to more efficiently engrave part numbers in the finished products.

Overview: The presentation will provide an overview of procedures for improved design of an engraving machine to add the adjustment feature in Z direction. Model of Computer Aided Design (CAD) and final product will be presented. This work will show real-world experience on CAD tools mastered by the college student under the supervision of student mentor in applied engineering and technology discipline.

Major Points:
• Describe a real industrial problem
• Solution approach: improve the machine by adding adjustment in Z direction
• Re-design of machine by using computer aided design
• Manufacturing: build a new machine

Summary: This study will re-design an engraving machine to improve its performance by adding adjustment in Z direction. The presentation will emphasize the results of modeling and manufacturing. Attendees will gain understanding of the computer aided design and manufacturing and get first-hand experience on CAD tools.
Experimental Projects to Demonstrate Reliability and Viability of Potential Renewable Energy Sources

Author(s)
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Dr. Faruk Yildiz, Sam Houston State University, Huntsville, TX
Dr. Mehmet Goksu, Millersville University, Millersville, PA

Need: The availability of sufficient energy is the foundation for economic growth and social progress. Along with economic advances and the increasing energy demand from business, government, and individuals, the shortage of fossil fuel as well as its environmental pollution has brought about serious problems related to energy security, environmental protection, and economic development. Renewable energy, characterized as sustainable and environmentally friendly, is the inevitable choice to satisfy increasing energy demands, to improve the energy structure, decrease environmental pollution, and promote sustainable development. Renewable energy comes from resources such as sunlight, wind, rain, tides, and geothermal heat which are naturally replenished. The energy output from these resources may be abundant or limited, depending on weather and geographic locations. For example, solar energy may be a viable way to produce electric energy in a specific location, such as Arizona, whereas in West Texas, wind energy would be well-suited in terms of energy generation. There are a variety of ways to assess which renewable energy system fits in a specific location. In academia, students who study energy systems are required to complete laboratory experiments or projects to learn about the applicability of the energy sources.

Overview: A detailed literature review is conducted to compare the reliability and viability of potential renewable energy sources. Advantages and disadvantages of renewable energy sources as opposed to conventional sources (especially fossil fuel) are explained with detailed recent scientific research data. Cost of installations, site specific analysis, seasonal variations, running costs, noise, reliability, capital cost, and deployment characteristics, etc., are investigated and described in detail for each renewable energy source. Furthermore, affordable site-specific surveying equipment and software packages are introduced to learn if specific energy system is viable at a specific location.

Major Points:
• Describe the nature and scope of alternative energy technologies
• Describe the application and operation of different non-electric energy systems
• Describe viable energy conservation techniques
• Compare different methods of generating electricity
• Compare different techniques for storage systems
• Identify ways to better manage energy consumption through courses offered
• Discuss how to convert a building’s energy supply to an RE system

Summary: This extensive study gives detailed information about sustainable energy sources for academic faculty, program coordinators, administrative people, and the public. The purpose of the study is to provide a reliable source of information on research and instruction about renewable energy systems, their cost, possible installation issues, and the techniques required for their implementation.
Factors Affect Students’ Adoption of Digital Technology in Learning Process

Author
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Need: Increasing numbers of higher education institutions are integrating innovative digital technologies as instructional tools to enhance implementation of learning objectives. Today’s undergraduate students are using innovative digital technology extensively in their everyday lives primarily for socializing and entertainment. They are the generation with extensive experience in using digital technology as they are spending much of their time using interactive multimedia, social media, etc. But, students’ use of digital technology in their academic learning is still relatively low. Therefore it is important to study the factors that affect undergraduate students’ intention to use digital technology in their academic learning. This study intended better understanding of the issues by focusing on the human factors that may have effect on undergraduate students’ intention to use digital technology in their academic learning.

Overview: The findings of an empirical research will be presented. The purpose of this research was to assess the human factors that may have effect on undergraduate students’ adoption of digital technology in their academic learning. Based on the research findings and theoretical models in existing literature, this research investigated the contribution of two specific human factors on the undergraduate students’ adoption of digital technology in their academic learning.

Major Points:
- What influence undergraduate students’ adoption of digital technology in their academic learning?
- Effect of students’ computer self-efficacy
- Effect of students’ attitude toward digital technology

Summary: The results from this study will provide educators and administrators in higher educational institutions a better understanding about the undergraduate students’ adoption of digital technology in their learning process.
Thursday, November 2, 2017

Electricity, Electronics, Computer Technology & Energy Issues

Gardens & interactive elements in Hospital Pediatric Units: Parental Affective Perceptions

Author
Mrs. Gidaa Alamry, Eastern Michigan University, Southfield, MI

Need: The importance of the presentation consists on identifying which elements in gardens produce the best parental affective perceptions in an attempt to create a less stressful environment and more positive parental attitude from which the sick child can benefit.

Overview: The presentation will cover the significance of the problem, the research methods, and the observations and data analysis.

Major Points:
- Introduction
- Problem Study
- Significance of the study
- Purpose of the study
- Research questions and hypothesis
- Methods
- Data collection and analysis
- Results & Conclusion

Summary: The attendees will be shown the importance of gardens and interactive elements (lights, audio-visual displays of cartoons) in providing a parental positive perception. Furthermore; the research aims to obtain the best parental affective perceptions to create a less stressful environment and the optimistic parental attitude from which the sick child can benefit.
Need: Due to the energy dilemmas society encounters today, there is a demand for alternative energy sources. Atmospheric and excess man made electromagnetic radiation in the atmosphere carries energy that is currently being wasted. Utilizing that energy by harvesting the electromagnetic radiation and converting its photons into useable electricity could reduce the problems our current energy consumption practices are causing.

Overview: The presentation will start with an explanation of electromagnetic radiation, such as the spectrum of frequencies that exist, how it works, its sources, its purposes, and its potential as an alternative energy source and solution to environmental harm. The experimentation done to harvest it will then be provided, depending on what is accomplished by November. That may include the use of a spectrum analyzer to determine the frequencies present in the area, comparing antenna designs for maximum harvesting capabilities, and building various collection devices in order to charge a battery using electromagnetic radiant energy. Any findings and progress from the experimentation will be provided followed by what further research needs to be conducted and the ultimate goals of the project.

Major Points:
- Today’s energy dilemmas require alternative energy solutions
- Electromagnetic radiation has great potential to be a source of renewable energy
- Doing so would utilize wasted energy in excess electromagnetic radiation in the atmosphere
- The harvested energy could be used to power the lighting needs of residential homes

Summary: Most energy consumed today comes from nonrenewable resources, which puts us at risk of running out of consumable energy, causing environmental damage, and encountering energy security issues. In an effort to reduce those risks, we are attempting to harvest excess electromagnetic radiant energy, which consists of all radiation on the electromagnetic spectrum.
**Increasing the Efficiency of a Wind Turbine**

**Author(s)**
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Dr. Faruk Yildiz, Sam Houston State University, Huntsville, TX

**Need:** It is clear that fossil fuel resources are finite and depletion will happen sooner or later. If the current level of fossil fuel energy consumption continues, the entire world's fossil fuel energy reserve will be depleted in about 100 years [1]. Fossil fuel resources will eventually be replaced by renewable energy sources, especially by solar energy and wind turbine. Currently, only a small portion of the world's energy consumption is produced by renewable energy. There is an increasing demand for clean, renewable energy as the world's fossil fuel reserves continue to diminish. Scientists and engineers are trying to make renewable energy a more viable and cost-effective method of generating electricity in an effort to partially fulfill the world's energy needs.

**Overview:** We will present a theoretical calculation for a wind turbine to show how to increase its efficiency in any environment condition. Our calculation is based on wind turbines with rectangular blades for simplification. We separately obtained both turbine parameters and generator parameters that could be used for control parameters for maximum power generation. We will demonstrate how matching these parameters guarantees more power extraction from the wind turbine. Also, this theory could be easily implemented in any maximum power point (MPP) controller device to operate the wind turbine at the MPP under varying weather conditions.

**Major Points:**
- Basics of Wind Turbines
- Design and analysis of Wind Turbine
- Wind Turbine's matching parameters for maximum power
- A new algorithm for MPP controller device
- Importance of torque versus angular velocity curve of a Wind Turbine
- Conclusion and suggestions

**Summary:** This presentation is focused on theoretical calculation of a simplified version of a wind turbine to extract maximum power. This calculation could be extended to a wind turbine with different blade geometry. Also, we present a new algorithm in the calculation that could be easily implemented in any maximum power point (MPP) controller device to operate the wind turbine at the MPP under varying weather conditions.
In-situ Integration of MEMS Switches to Realize Reconfigurable Multifunctional Antennas

Author
Dr. Qingzhou Xu, Morehead State University, Morehead.KY

Need: Communications in both commercial and military applications are increasingly moving to small, light-weight, and high-frequency systems with increased functionality and reduced power consumption. This presentation reports the latest efforts of the researcher to tackle the issues that hinder currently the broad applications of RF MEMS switches.

Overview: This presentation will first review the challenges that are faced by modern high-frequency communications, the reasons why the challenge cannot be effectively solved by semiconductor devices and why RF MEMS switches are needed, the advantages of RF MEMS switches to address the challenges, and the current difficulties in developing RF MEMS switches. It will then introduce the approaches and experimental methods of the researcher to solve the difficulties in developing RF MEMS switches. Following that, the presentation will present the researcher’s research results, MEMS switches of various geometries and two MEMS switch-integrated multifunctional reconfigurable antennas. High-resistance bias lines that are used to actuate MEMS switches will also be introduced. Finally, this presentation will give a few concluding remarks drawn from this research.

Major Points:
- There are urgent needs in both commercial and military communications to move to small, light-weight, and high-frequency systems with increased functionality and reduced power consumption
- Reliable, new-type switches with very high isolation, very low insertion loss, very high linearity and low energy consumption are required. MEMS switches are the devices to meet the contemporary needs
- The thin-film stress and stress gradient can be purposely tailored to repeatedly and reliably achieve curving or non-curving metallic membranes by using different metal layers that are made by different methods or different processing parameters. MEMS switches of various geometries have been successfully fabricated by using the developed methods
- High-resistance bias lines are needed to actuate MEMS switches while minimizing deleterious electromagnetic coupling between DC lines and RF elements to ensure the in-situ integration of MEMS switches with RF components
- Reconfigurable multifunctional antennas and other RF devices can be realized by the methods developed in this research
- The monolithic integration of MEMS switches with RF components is the most effective way to achieve reconfigurable multifunctional structures

Summary: This presentation demonstrates that the thin-film stress and stress gradient can be purposely tailored to achieve curving or non-curving membranes by using different layers that are made by different methods or different processing parameters.
Electricity, Electronics, Computer Technology & Energy Issues

Machine Ethics: Challenges and Importance for Educators

Author(s)
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Dr. David Hua, Ball State University, Muncie, IN
Dr. Edward Lazaros, Ball State University, Muncie, IN

Need: Machine ethics is a relatively new domain. It comprises the domains of computer science, computer engineering, and psychology. There is a growing concern over the dangers of AI among scientists and celebrities such as Bill Gates and Elon Musk. Increasingly, computational systems are involved in decision making without human intervention. Many of those decision have ethical implications. As science makes steady progress toward Strong AI, Machine Ethics becomes more important.

Overview: In this presentation, the authors will define ethics and the branches of human ethics. Then, machine ethics will be introduced and compared with the branches of human ethics. Following that discussion, the importance of Machine Ethics will be discussed with the attendees. Finally, selected classroom exercises and activities will ensue as time allows.

Major Points:
- Branches of human ethics
- Metaethics
- Applied ethics
- Normative ethics
- Machine Ethics (Artificial Moral Agents)
- Can we and should we?
- The Digital Soul
- Problems of implementation
- Complexity
- Scalability
- Algorithmic Instantiation
- Importance of Machine Ethics
- Exercises in Human vs. Machine Ethics

Summary: In this presentation, the Why, How, and If of Machine Ethics as well as the concept of the “Digital Soul” will be explored.
Thursday, November 2, 2017  
**Electricity, Electronics, Computer Technology & Energy Issues**

**Multi-Layer Behavioral Motion for Complex Robotic Control with >10 DoF**

**Author(s)**
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Dr. John Wright, Millersville University, Millersville, PA

**Need:** The future for robotics in the United States is clear. We must automate our manufacturing processes to remain competitive in the global marketplace. Robotics is an important part of that automation. Humanoids have a host of capabilities that may reveal potential new uses in industry.

**Overview:** The purpose of the presentation is to provide instruction on how to develop advanced motion control using a control layering technique called Timeline. Prior presentations have focused on relatively simple motion control combined with sensory perception including vision. The focus of this work is to show NAO users how to control multiple axes or Degrees of Freedom (DoF) with a custom block of code known as Timeline. The need for this type of control will apply to more sophisticated industrial and humanoid robot users where the DoF exceeds 10 or more. The NAO platform utilizes 25 DoF.

**Major Points:**
- Introduction custom movement programming
- Instruction on Timeline development
- Demonstration of NAO’s capabilities for parallel execution of independently taught motions (independent layers)

**Summary.** As society continues to advance with automation, so does the need to develop the talent pipeline. Control techniques taught in today’s applied engineering programs need to cover those that are widely deployed in industry, as well as, those that are fundamental to future advances that are on the horizon.
Objective Evaluation of Mobile Robot Trajectories using Multiple View Geometry

Author
Dr. Sangho Park, Central Connecticut State University, New Britain, CT

Need: Development of new mobile robot platforms and algorithms needs objective evaluation of navigation performance by analyzing the position, velocity, and acceleration in the navigating patterns.

Overview: In STEM (Science, Technology, Engineering and Mathematics) education, mobile robot development and competition has become very popular. Mobile robot is an effective platform for stimulating student motivation at K-12 as well as college-level institutions. Objective estimation of mobile robot movements is critical in effective design and development of mobile robots.

We present a computer vision-based evaluation testbed for mobile robot navigation. The current testbed uses two synchronized cameras, and they can be mounted in versatile manner: i.e., at arbitrary oblique viewing positions depending on user need. Multiple-view geometry merges the camera views to a view-independent orthographic projection map to provide a virtual top-down view regardless of actual camera positions. Individual trajectory points of the robot are time-stamped, and the calculation of the position, velocity, and acceleration provides the full description of the robot movements. The testbed has an intuitive graphical user interface (GUI) with which students can run the system easily.

Major Points:
• The proposed method uses two cameras for simultaneous capture of mobile robot navigation
• The cameras can be positioned in a versatile manner: i.e., arbitrary oblique viewing angles on demand
• Multiple-view geometry generates a virtual top-down view of the robot footage on a registered world coordinate system
• Time-stamped trajectory points on the world coordinate system enables the calculation of position, velocity, and acceleration for the full description of the robot movements
• The shape analysis of the robot footage on the world coordinate system provides the orientation information of the robot.

Summary: Objective estimation of mobile robot trajectory is critical in navigation performance evaluation.
Thursday, November 2, 2017

Electricity, Electronics, Computer Technology & Energy Issues

Optimization of a Solar Power Plant Using an Automated Control System

Author(s)
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Need: This presentation will provide an example of how automating a solar thermal power plant eliminates human error and maximizes operational efficiencies.

Overview: A project was completed to automate a solar thermal power plant by forcing the plant’s control system devices and field instruments to talk to each other. The power plant operates based on the time of day and present weather conditions. Human error is no longer a factor in the operation of the power plant. The project improved both the operational efficiency of the power plant as well as the efficiency at which electricity is generated.

Major Points:
- In order to resolve a safety issue, the power plant’s control system devices and field instruments needed to talk to each other
- The power plant’s control system was integrated with an instrument that measures available the sunlight and another instrument that collects weather data
- Real-time system efficiencies measure the power plant’s performance
- While monitoring the system efficiency calculations, adjustments are made to the power plant to reduce tracking error and optimize system efficiency
- The power plant is a fully automated system that generates electricity whenever there is available sunlight
- In adverse weather conditions, the power plant turns off and moves into a position that will prevent wind damage

Summary: The project improved both the operational efficiency of the power plant as well as the efficiency at which electricity is generated.
Performance Analysis for Time-of-Flight Ranging Sensor

Author(s)
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Need: In the robotic field, identifying the distance between a robot and surrounding objects in the environment is a challenging task. Many types of sensors can be used to perform this task including ultrasonic sensor, infrared (IR) sensor, and traditional laser sensor. Recently, time-of-flight (ToF) ranging technology sensor which measures the distance based on the time that is taken by the light to travel has become popular in robotic range finder applications. This study evaluates the performance of VL53L0X, one of the ToF range finder sensors in the market.

Overview: A time-of-flight (ToF) ranging technology computes the distance by measuring the time it takes for the light to travel back and forth from the sensor to the object or obstacle. The time-of-flight laser sensor utilized in this study uses laser light to measure the distance. However, the effectiveness of this ranging sensor in different scenarios should be tested as the accuracy of this sensor may vary when the light collides with different material surfaces. The purpose of this study is to analyze the sensor’s effectiveness in different environments in which the sensor may be operated. Different materials are used to simulate various types of objects in the study.

Major Points:
- Basic concepts of time-of-flight (ToF) ranging technology
- Usability of ToF sensors in different environments
- Experimental process for determining effectiveness of ToF sensor (VL53L0X)
- Revealing the worst-case scenario where the sensor should not be operated

Summary: The results from this study will help students and hobbyists to implement this sensor in their projects, and also help researchers and manufacturers to decide whether the sensors can meet their requirements.
Thursday, November 2, 2017

Electricity, Electronics, Computer Technology & Energy Issues

Performance Analysis of Stand-Alone Hybrid Energy Systems in Rowan County KY

Author(s)
Mr. Femi Oyeniran, Morehead State University, Morehead, KY
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Dr. Hans Chapman, Morehead State University, Morehead, KY
Dr. Nilesh Joshi, Morehead State University, Morehead, KY

Need: The aim of the energy performance analysis presented in this research is to help guide government policy makers, businesses and community in making decisions on the future of energy consumption in Rowan County and the Commonwealth of Kentucky

Overview: The research emphasized on the operational efficiency of a hybrid energy system in Rowan County Kentucky, that will sufficiently replace the conventional fossil source energy system. By performing computational analysis on the simulated hybrid system configuration, the efficiency, reliability, and comparable operating cost is obtained in optimizing the hybrid system use.

- Major Points:
  - Renewable Energy
  - Hybrid System
  - Standalone
  - Performance Analysis
  - MatLab Simulation

Summary: The key objective is to develop an autonomous energy supply capable of replacing existing coal-generated, non-renewable energy source in the county."
Satellite Tracking Control Implemented in Matlab®

**Author**
Dr. Curtis Cohenour, Ohio University, Athena, OH

**Need:** A control system to track GPS and other navigational satellites is required to support advanced research in satellite navigation. A high gain parabolic dish is used to collect Radio Frequency (RF) data, and low noise receiver measurements. A commercial off the shelf (COTS) antenna rotator is used to position the dish. The position command and calibration are performed using a Matlab® Graphical User Interface (GUI). The Matlab® control allows for field calibration, and remote tracking, features not available in other dish positioning software.

**Overview:** “A 1.9 meter parabolic dish is used to collect data from GPS and other navigational satellites. The signal is well below the thermal noise floor. To compensate for this, the spread spectrum signal is correlated over a one millisecond interval to bring the de-spread noise level above the noise floor. This process is adequate for navigation, but for research it is desired to examine the signal directly. Using a high gain antenna allows the data to be collected above the noise floor. Data can be collected directly by recording the Radio Frequency (RF) data, or using the processed low noise data from a receiver.

**Major Points:**
- How the Global Positioning System (GPS) works
- The high gain antenna and rotator
- The Matlab® Graphical User Interface
- Issues with calibration
- Calibration procedures
- Results

**Summary:** The fundamentals of GPS, and need for high gain data are discussed. The GUI is discussed in detail along with the rudiments of calibration, and finally results.”
Need: Residential loads form an integral part of the electrical grid. There are high fluctuations in power usage patterns which have adverse effects on the grid. Steady load with gradual increase in peak helps to maintain the reliability of the grid. This would enable utility companies to efficiently respond to the increase demand. This practice is cost-effective and in return is helpful for the consumers as utility companies charge higher at peak loads. This is one of the reasons the utility companies want to monitor residential loads and engage consumers to keep a steady load on the system. From consumers’ perspective, utilities charge higher during peak hours and lower during off-peak hours. If consumers are made aware as the load on the system is increasing, they can adjust their usage cycles to match the rates to reduce their electricity bill and ultimately help the utilities have a stable system. Those practices and technologies by energy suppliers or consumers were made possible by smart electrical grid and smart home.

Overview: In this presentation, different home energy management (HEM) systems and devices will be discussed, which are enabled by the smart electrical grid. Those systems and devices will be integrated to form a smart home. Examples will be provided based upon the available products currently in the market.

Major Points:
- Overview of smart grid and smart home integration.
- Different home energy devices available on the market.
- Integration of different components to form a smart home system.
- Overview of different communication protocols used in smart homes.

Summary: The presentation will also explain different protocols that form the home area network and compare their capabilities. These systems and devices can be integrated with the smart electrical grid to form a smart home.
Thursday, November 2, 2017

Electricity, Electronics, Computer Technology & Energy Issue

Teaching Finite State Machines (FSMs) as Part of a Programmable Logic Control (PLC) Course

Author
Dr. Curtis Cohenour, Ohio University, Athens, OH

Need: Engineering Management and Technology (ETM) students can increase their employability with Programmable Logic Controller (PLC) skills. To meet these needs an undergraduate senior elective in PLCs is offered. The course has long been offered without any specific training in sequences. In the fall of 2015 the course was modified to include Finite State Machines (FSMs). With this change students are now trained to recognize the difference between combinational logic and state logic. Combinational logic is logic that is derived exclusively from current inputs and does not depend on previous inputs. State logic includes memory of previous events specifically embodied in the “states.”

Overview: Combinational logic also known as time-independent logic is PLC logic that depends only on the current inputs. Ladder logic is solved cyclically per IEC 61131-3. Combinational logic depends only on logic that is solved earlier in the cycle. If the logic depends on information from a previous cycle (memory), it is state logic. State logic is common in PLCs but is often implemented with little formal analysis. This leads to overly complicated logic that is difficult to understand, troubleshoot, and maintain.

Major Points:
- What is a PLC and how is it programmed
- What is combinational logic
- What is state logic and what is a Finite State Machine (FSM)
- Why is the distinction important
- Writing sequences
- The generic state
- Creating outputs from states
- In class results
- Conclusions

Summary: Industrial control courses in Engineering Technology and Management (ETM) include programming of Programmable Logic Controllers (PLCs). Text books are available to support these courses but few provide any content on Finite State Machines (FSMs). This is unfortunate because a great deal of PLC applications in industry involve sequence logic which lends itself to the FSM.
The Feasibility Study of Photovoltaics in Eastern Kentucky: The implementation of Microprocessor Powered Adaptive Photovoltaic Tracking Systems with MATLAB

Author(s)
Dr. Yuqiu You, Ohio University, Athens, OH
Dr. Ni Wang, Eastern Kentucky University, Richmond, KY

Need: We will present Microprocessor powered solar tracking systems is cost effective and efficient energy harnessing system in Eastern Kentucky, specially Morehead, KY.

Overview: Attendees will gain the knowledge of how to harness solar energy with solar cells with the case study of Eastern Kentucky, specially Morehead, KY. Furthermore, we will be presenting how to utilize the microprocessor to control tracking systems with MATLAB.

Major Points:
- Feasibility study of Solar Cells in Eastern Kentucky for the first time
- Microprocessor powered tracking system
- Knowledge about how to communicate with Microprocessor and tracking system using MATLAB

Summary: In the present work, we systematically studied about renewable energy resources, in particular, solar energy for the application of Microprocessor powered photovoltaic panels in Eastern Kentucky.
Electricity, Electronics, Computer Technology & Energy Issues

Three-dimensional RGB-D Camera Sensor Usage for Industrial Robotics Applications

Author
Dr. Wutthigrai Boonsuk, Eastern Illinois University, Charleston, IL

Need: Recent advances in sensing technology bring the possibility of using the new generation of Red, Green, Blue plus Depth (RGB-D) cameras for industrial applications. However, a major challenge is to determine whether these newer cameras can meet industrial standards for machine vision systems. The present study investigates the effectiveness of RGB-D camera for industrial robotics applications such as automatic inspection and robotic guidance.

Overview: Industrial robotics applications, specifically automatic inspection and robotic guidance, require advanced image processing and analysis of data captured from vision systems. Automatic inspection is a visual examination which a camera autonomously inspects parts for quality defects (e.g. missing or misalignment of components). Robotic guidance uses a camera's sensor to determine positions of obstacles and to identify and locate workpieces. This study explores the capability of recent RGB-D camera, Intel RealSense (SR300) sensor, for industrial robotics applications. The depth information from the camera is used to remove image background and to measure and examine the workpieces. Accuracy in different ranges, repeatability rate, and processing time are recorded and analyzed.

Major Points:
- Concepts of 3D RGB-D camera sensor
- Practicality of 3D RGB-D camera for industrial robotics applications
- Principles of image segmentation and analysis
- Basic concepts of automatic inspection and robotic guidance in industrial applications
- Evaluation of 3D RGB-D Camera (Intel RealSense) for Industrial Application

Summary: This study explores the effectiveness of 3D RGB-D camera (Intel RealSense) for industrial robotics applications such as automatic inspection and robotic guidance. The results from this study not only benefit researchers or industries who are interested in implementing RGB-D camera in their applications, but also serve as initial feedback for bridging the gap between consumer products and industrial applications.
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Electricity, Electronics, Computer Technology & Energy Issues

Using Cognex Vision for Part ID and Analysis: Tutorials, Labs, and YouTube

Author(s)
Mr. Michael Wiles, Millersville University, Millersville, PA
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Dr. John Wright, Millersville University, Millersville, PA
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Mr. Kevin Wagner, Millersville University, Millersville, PA

Need: Modern vision systems are critical for part identification and analysis. ATMAE’s automation programs and faculty should require instruction on contemporary machine vision systems to keep their students current and relevant.

Overview: The purpose of the presentation is to provide instruction on how to program/configure a vision system for part identification and analysis. Applications for enacting active compliant visual robotic control using a Cognex In-Sight vision system will be discussed. Sample laboratory experiments, tutorials, and YouTube videos will be shared with the audience to help those new to using a Cognex In-Sight Micro platform.

Major Points:
- Overview to Cognex In-Sight
- Part Identification Techniques and Analysis
- Sample Laboratory Experiments, Tutorials, and YouTube Resources

Summary: The purpose of the presentation is to provide instruction on how to program/configure a contemporary vision system. The presentation will focus on the dissemination of hands-on laboratory experiments, tutorials, and helpful YouTube video instruction modules to assist new users of the Cognex In-Sight vision system platform. Various techniques will be discussed.
Using Device Level Ring Topology to Increase Network Reliability in Mission Critical Industrial Control Systems

Author(s)
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Mrs. Edith Wittenmyer, Indiana State University, Terre Haute, IN

Need: A mission critical system is a one that is essential to the survival of an enterprise. It cannot be allowed to become inoperable without substantial consequences. Mission critical distributed control systems are found throughout manufacturing and infrastructure operations. If the network connecting the operational technology together fails the system collapses. As operators of infrastructure and manufacturing facilities struggle to maintain the reliability of control systems against a variety of threats, they seek methods of creating resilient networking structures.

Overview: Specifically, this presentation will examine how device level ring topology can be implemented using the popular Allen-Bradley ControlLogix and CompactLogix programmable automation controller platforms interconnected through an EtherNet/IP network. Where to obtain technical data useful to inform system operators in industry of installation procedures; and inform technical educators who wish to introduce the topic into their classrooms will be provided. Benefits and difficulties of implementing and running device level ring networks for mission critical applications will be discussed.

Major Points:
What is device level ring topology, and how does it differ in design from other industrial networking topologies?
What are the advantages and disadvantages of using device level ring topology in mission critical industrial networks?
What is the outlook for the use of device level ring topology from equipment vendors and users in industrial control systems?

Summary: This presentation provides an overview of how device level ring topology is implemented in an Ethernet/IP network; and why its use has gained rapid acceptance in industry. Examples of a device level ring network suitable for use in classroom instruction and laboratory projects will also be presented.
Virtual commissioning for Industrial Automation

Need: The building of industrial plants poses various challenges in the area of automation. Two of the most significant ones are the time consumed during commissioning and start-up and the availability of industrial equipment to adjust the sequences through the optimization of programs in the PLCs.

Overview: This presentation addresses the possibility of virtual commissioning for industrial automatized plants. Virtual commissioning can help improve software and save time. The total engineering time and prototype waste are reduced and errors are less expensive to correct since they are detected earlier.

Major Points:
- Problem Statement
- Solution Approach
- Virtual Commissioning of software simulation (Virtual Scenarios UNITY 3D, C#)
- Programming (Arduino, PLC)
- Hardware Wiring connections (PLCs, Arduino, Relays, DAQ board)
- Future technological Advancements
- Benefits of Virtual Commissioning
- Examples

Summary: Virtual commissioning for industrial automation is specifically engineered to develop and program the sequences and automation of industrial plants in a virtual environment.
Thursday, November 2, 2017

Graphics

A Microsoft Kinect-based Gesture System to Enhance 3D Visual Communication in Virtual Collaboration

Author(s)
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Ms. Narda Hamilton, University of North Dakota, Grand Forks, ND
Dr. Dave Yearwood, University of North Dakota, Grand Forks, ND

Need: The existing technology for synchronous online conferencing is not adequate for effective 3D visual communication in a multi-disciplinary, team-based collaboration setting. Individual collaborators' spatial cognition ability and prior experience were not considered in designing such systems.

Overview: Attendees will be informed about how two-hand gestures designed for the Microsoft Kinect-based virtual environment can serve as an intuitive user interface to manipulate 3D objects, thus improve visual communication in collaborative product and process development. We will also discuss how similar mixed reality systems can be used for such purposes, and the possible challenges to deploy the full potential of these systems.

Major Points:
• The characteristics of synchronous virtual collaboration
• 3D visual communication issues of current conferencing technology
• Microsoft Kinect v2 as a multi-user collaboration platform
• Gesture as the natural user interface for object manipulation
• Limitation and future work

Summary: We will present an ongoing research project investigating the effectiveness of 3D visual communication through a gesture-based interface in mixed reality systems for virtual collaboration.
Augmented Reality in the Classroom: Development of a stationary bicycle with virtual environment for new learners

Author(s)
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Dr. Farzin Heidari, Texas A&M University-Kingsville, Kingsville, TX
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Need: One of the most common types of bicycle crash in new learners is the inaccurate interpretation of traffic participants' intents at intersections (Haworth & Debnath, 2013). Proper experiential training for the new bicycle learners must be developed to improve bicycle-learning as well as safe riding habits. One of the safe riding habits is coordination between the handlebars and the pedaling before balancing on the bicycle. Current study reports on the development of a stationary bicycle with augmented reality to provide safe riding experience for new learners. Researchers will construct a stationary bicycle and develop a virtual environment with the bicycle to simulate the real world.

Overview: A group of graduate students in technology management course will develop a virtual environment in 3D studio max and Unity software to incorporate the environment into the virtual reality. Additionally, the students will construct a stationary "trainer" bicycle to interact with the virtual environment. The students will collect the pedaling velocity to transfer real-time data to the virtual environment for acceleration. The learner can practice correct posture, pedal rotation – acceleration ratio, bicycle riding skills and etiquette on the road, and traffic rules at intersections.

Major Points:
- Construct a stationary bicycle within risk management course
- Connect bicycle’s rear tire to a computer to register tire’s revolution per minute (rpm)
- Develop a virtual road map for the rider
- Develop virtual instructions to safely operate the bicycle step by step
- Provide feedback on the completion success rate at the end of the training session
- Report student feedback on the outcome of the project in the form of presentations, articles etc

Summary: The audience may benefit from the incorporation of augmented reality technology into the classroom environment. The ATMAE community may benefit from the student feedback and post study assessment on how the project may motivate student engagement in a technology management courses.

Author
Dr. H. Naik Dharavath, Central Connecticut State University, Great Britain, CT

Need: The graphics and print media industry is in a constant technological flux, and industry input is needed to make sound curricular decisions for technology-based educational programs.

Overview: The presentation will be based on the survey results for a Graphics Technology curriculum at a post-secondary institution. Employer’s expectations are an integral part of Graphics Technology curriculum in order to prepare future graduates for jobs in a constantly evolving printing industry. The graphic arts industry is constantly changing because of technological advancements, necessitating a more educated, skilled and technically competent workforce. The presentation will be of interest to educators in the graphics technology programs who are considering or planning to revise the curriculum or improve the student competency levels.

Major Points:
- What type of technical competencies in the production segments Print Management, Digital Prepress, Digital Cross Media, Digital Printing Production, Bindery and Distribution, Color Management, and Digital Workflow Management areas are expected by the employers in the graphics and print media industry in the NES region?
- Who are the largest sources of workforce supply for the graphic and print media industry?
- Graduates with what level of educational (or type of degree) background would graphic and print media industry prefer to hire?

Summary: The purpose of this research is to determine the expectations of graphic and print media employers of the New England States (NES) region, who are employing graduates of graphic related education for entry-level technical positions.
Exploring the Benefits of Collaborative Design using Onshape: A Full-Cloud, 3D CAD That Runs on a Web Browser

Author
Dr. Doug Koch, University of Central Missouri, Warrensburg, MO

Need: As design processes change and budgets tighten up, educators and companies need productive, reliable, and collaborative CAD solutions that run on multiple platforms and devices. Software are now allowing designers to work simultaneously on the same model or assembly. Being able to have multiple students working on a model or assembly at the same time is a new concept with many advantages.

Overview: This presentation will cover some of the advantages of being able to design collaboratively and demonstrate some of the basic functionality of Onshape. It will cover what it means to be able to fully model in a web browser and/or on your phone or tablet, and how multiple users can work on a model at the same time. The presentation will facilitate open discussion on its benefits and drawbacks as it relates to use in your classrooms and labs.

Major Points:
• The benefits of collaborative design
• Collaborative design workflow
• Employing Onshape in the classroom
• Basic functionality of Onshape
• Compatible browsers, phones, and tablets

Summary: The focus of this presentation is on providing its participants a brief overview of new collaborative design (CAD) tools and how these tools can and should be employed in the classroom to better prepare students for the environments they will face in industry. Onshape will be the primary CAD platform discussed and demonstrated as an example of some of the changes and capabilities currently available.
Gamification: Increase student engagement by gamifying your classroom

Author
Dr. Carl Blue, University of Southern Maine, Gorham, ME

Need: Gamification is the use of game design and gaming mechanics to enhance non-game contexts. It is the application of distinctive fundamentals of game-playing like scoring, competition, and rules of engagement to applicable areas of teaming and other inter-human activities.

Overview: In this presentation, several significant and proven aspects of Gamification will be offered. Games increase motivation through engagement. Nowhere else is this more important than education. Nothing demonstrates a general lack of student motivation than the documented retention and graduation rates at the college level as presented in a Harvard Graduate School of Education study, “Pathways to Prosperity” reported that 56 percent of college students complete four-year degrees within six years; and only 29 percent of those who start two-year degrees finish them within three years. As part of this presentation, research on best practices on gamifying other services will be presented that have demonstrated improvement in retention and provided incentives for degree completion.

Major Points:
• Implementing an “experience points” system where students’ letter grades are determined by the amount of points they have accumulated at the end of the course.
• For each assignment completed, award students with badges to indicate mastery of specific process or topic.
• The use of games allows students to fail, overcome, and persevere. It’s not about failing. It’s about learning.

Summary: In this presentation, several significant and proven aspects of Gamification will be offered. Games increase motivation through engagement.
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**Graphics**

**Modeling and Improvement of Transmission**

**Author(s)**
Mr. Elliott Davis, Eastern Kentucky University, Richmond, KY
Dr. Ni Wang, Eastern Kentucky University, Richmond, KY

**Need:** This presentation will allow students to understand the importance of understanding a 3D modeling system and how to properly scale it into 3D printed part(s).

**Overview:** This presentation will be able modeling and improvement of a 1958 Super 99 Oliver tractors transmission. The use of SolidWorks in designing the original transmission, along with an improved transmission, and performing a motion analysis on both designs at similar revolutions per minute (RPM) will be shown. How much time went into creating the project and the history of the concept of a tractor’s transmission.

**Major Points:**

- SolidWorks Creation
- Motion Analysis
- 3D Printing of Parts

**Summary:** Making sure the parts are in correct scale, the 3D modeling will allow for a clearer picture as to how the gears move and what action takes place when they are moving in either clockwise or counter-clockwise motions.
UX Design: A Sample Lesson Plan for the Graphics Curriculum

Author
Dr. Hope Carroll, UW-Stout, Menomonie, WI

Need: With user experience (UX) design jobs on the rise, this presentation offers a unique approach to incorporating UX design concepts into a web development course.

Overview: With a growing need for students to be skilled in user experience design, educators need to find innovative ways to implement UX concepts into current web design and development courses. Attendees will be offered a unique approach to incorporating UX design into a web development course. A course outline with sample usability and user experience assignments will be provided.

Major Points:
- What is UX design?
- Usability and user research (personas)
- Connecting usability to UX design
- Connecting UX design to web design
- Usability testing

Summary: This presentation offers a unique approach to incorporating user experience design concepts in a skill-based web development course.
A decision analysis of a six monthly distribution program for food grains in Punjab

Author(s)
Mr. Abhay Grover, Iowa State University, Ames, IA
Dr. Shweta Chopra, Iowa State University, Ames IA
Dr. Caroline Krejci, Iowa State University, Ames, IA

Need: The presentation provides a comparative assessment of different feasible alternatives for food distribution policy in the state of Punjab and will further provide policymakers and researchers with a unique approach to decision analysis in food policy evaluation.

Overview: The authors will present the application of Multi-Attribute Utility Theory (MAUT) to identify an objectives hierarchy for a public distribution system with measurable goals. In this presentation, the authors will establish single-measure utility functions and derive comparative weights for multiple different sub-objectives, based on stakeholder inputs and empirical data collected from the survey of 300 beneficiary households. A multi-measure utility function (MUF) will be used to identify best solution among multiple different alternatives. A sensitivity analysis will then be used to assess whether the most-preferred alternative is sensitive or robust for each measure.

Major Points:
- Develop objective hierarchy for public distribution system
- Establish and identify various alternatives to six monthly distribution system of food grains
- Perform a MAUT analysis to determine the alternative which provides the highest overall stakeholder utility
- Conduct a sensitivity analysis to establish robustness of the solution with respect to each measure

Summary: The audience will gain insight into the principles of multi-criteria decision analysis as applied to the particular case of the public food distribution system in Indian Punjab.
Absolutely the best platform skills workshop ever: How to use your people presence and PowerPoint to reach Millennials and Homelanders

Author
Dr. Kimberley Gordon, University of Arkansas, Ft. Smith, AR

Need: Use visual aids to keep your students engaged rather than putting them to sleep

Overview: Platform skills are woefully absent in conference sessions and classrooms alike. Attendees and students who are accustomed to engaging handheld devices find breakout sessions as well as classrooms infinitely boring because the presenter lacks enough sufficient platform skill to hold the students' interest. Dare we say that a highly educated individual doesn't a charismatic presenter make! This session introduces Gordon's Platform Model intended for anyone who needs to boost their platform skills in the classroom, the boardroom, or both.

Summary: Attendees will review the golden Corporate American Platform Rubric (CAPR) -- a tailored rubric used to teach new academics, emerging leaders and boards of directors how to conduct critical presentations such as course instruction, press conferences and shareholder meetings.
Management

Analysis of Efficiency Ratios and Profitability of US Food Processing Industry: An Empirical Study

Author
Dr. Nilesh Joshi, Morehead State University, Morehead, KY

Need: According to USDA’s Economic Research Service (ERS), food manufacturing is an important sector of U.S. economy accounting for 14 percent of all U.S. manufacturing employees. Thus, it is imperative to examine how working capital management efficiencies have evolved over the years in U.S. food processing industry and how they have impacted overall profitability of the industry.

Overview: This research provides an overview of historical trends in efficiency ratios and profitability of U.S. food processing industry. Further, the relationship between the two is explored using Pearson correlation and multiple regression models.

Major Points:
• Overview of the U.S. food processing industry.
• Data collection for a selected group of food companies for the last ten years.
• Historic trends in efficiency ratios and profitability metrics.
• Formulation of Pearson correlation and multiple regression analysis models.
• Presentation and analysis of results.

Summary: In this research, we examine historical trends in operational efficiencies and profitability metrics of food and beverage companies in U.S. The data is collected from annual reports of the last ten years for a selected group of food companies.
Application of Statistical Process Control to a University Website

Author(s)
Dr. Eli Aba, Pittsburg State University, Pittsburg, KS
Mr. Praveen Guraja, Pittsburg State University, Pittsburg, KS

Need: Statistical Process Control (SPC) is a statistical method that separates special cause variation from common cause variation. The presentation aims to critically discuss how SPC has been applied to a university website.

Overview: Statistical Process Control helps to eliminate special causes. SPC enables process improvement by establishing and maintaining consistency in the process. It is in the spirit of continual improvement to keep eliminating special causes. SPC enhances predictability of processes and elimination of waste. Eventually, by SPC, the total quality of products and services is enhanced to the satisfaction of the customer. The presentation discusses how SPC has been used to separate special cause variation from common cause variation.

Major Points:
- Importance of SPC to optimizing and controlling processes
- Benefits of SPC
- Pareto chart employed as part of SPC
- The use of SPC for separating special cause variation from common cause variation

Summary: Attendees will understand how to use SPC in conjunction with other quality tools for continual improvement. The findings may help users of SPC to be in the position to know more about SPC and adopt it.”
Assessing Complexity as a Critical Factor in Managing Technology Projects

Author
Mr. Curtis Stock, Indiana State University, Terre Haute, IN

Need: Complexity in technology projects can create obstacles that are not surmountable by standard project management tools and techniques. Complex projects require the application of different frameworks and tools.

Overview: Complexity in technology projects can add unexpected challenges for project teams. Having an awareness of factors that cause complexity as well as tools to properly assess and evaluate complex projects can be invaluable for project team working in complex environments.

Major Points:
• Complexity challenges the effectiveness of traditional project management systems
• Complexity can be identified across many dimensions of technology projects
• There are several approaches to assessing project complexity: complexity science, chaos theory, complex adaptive systems
• Emergent frameworks provide structures for analyzing and evaluating complexity in projects

Summary: A comparison of these frameworks is drawn to offer insights into implications of project complexity to stakeholders and ultimate success or failure for technology project initiatives. Final conclusions are drawn as well as prospects for further research into this area.
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Management

Data Analysis Using Statistical Process Control: A Case for a Cold Rolled Coil

Author(s)
Dr. Eli Aba, Pittsburg State University, Pittsburg, KS
Mr. Yuga Sunkarasetti, Pittsburg State University, Pittsburg, KS

Need: Statistical Process Control (SPC) uses statistical methods to distinguish between special cause and common cause variations. The presentation aims to critically discuss how SPC has been applied to a cold rolled coil.

Overview: Statistical Process Control uses statistical techniques such as control charts to analyze a work process or its outputs. SPC identifies special causes, so that appropriate action can be taken to maintain a state of SPC and to improve the capability and stability of the process. The presentation discusses how SPC has been used to separate special cause variation from common cause variation in the case of a cold rolled coil.

Major Points:
• Types of defects found in a cold rolled coil
• Benefits and importance of SPC
• Pareto chart and cause-and-effect diagram employed as part of SPC
• Control chart for monitoring variation

Summary: Attendees will understand how to use SPC in conjunction with other quality tools for data analysis. The findings may help users of SPC tools to be in the position to know more about the use of SPC and other quality tools for data analysis.
Digitalization and automation of global supply chains for risk mitigation.

Author(s)
Mr. Gaganpreet Singh Hundal, Purdue University, West Lafayette, IN
Mr. Akshay Gupta, Purdue University, West Lafayette, IN

Need: Global supply chain risk mitigation is a challenging issue confronting myriad organizations engaged in global trade, outsourcing or offshoring and 3PL international logistics. Natural disasters, terrorist activities, political instability, economic recession, technology changes and change in consumer needs are some of the contributing factors increasing vulnerability of global supply chains.

Overview: Following presentation revolves around a big Question: How digitalization and automation of global supply chains can be done by various technologies linked with supply chain network. It is suggested that integrative technologies like machine learning algorithms, Unmanned Aerial Vehicles (Drones), Global Positioning system, Information technology and 3-D printing may be a robust solution to the proposed question.

Major Points:
- There are five integrative technologies cited below which can be linked to global supply chain network for mitigating risks due to disruptive events
  - Machine Learning Algorithm
  - Unmanned Aerial Vehicles
  - Global Positioning System
  - 3-D Printing
  - Information Technology

Summary: Integrative technologies like machine learning algorithm, Unmanned Aerial Vehicles(Drones), Global Position System, robust Information Technology infrastructure and 3-D printing can digitize and automate global supply chains for risk mitigation.
Implementation of KaiNexus tool for lean healthcare in Mary Greeley Medical Center: Employee perspective

Author(s)
Miss Bhagyashri Parab, Iowa State University, Ames, IA
Dr. Shweta Chopra, Iowa State University, Ames, IA
Dr. Sree Nilakanta, Iowa State University, Ames, IA

Need: The implementation of lean in healthcare domain has increased in the last 15 years. The adoption of lean methodology is expected to not only reduce waste but also increase financial gains, and employee satisfaction. The purpose of the research is to explore the impact of lean implementation on employee satisfaction within the healthcare organisation.

Overview: Lean methodology is a collection of philosophies and practices when applied together creates maximum value by reducing waste. Since implementing the KaiNexus tool for lean, the Mary Greely Medical Center has experienced increased profits. Though a critical part of organisation, employees and their opinions have not been studied. The study seeks to explore employees' perception of the implemented lean methodology.

Major Points

- Explain lean methodology, its benefits, and its implementation in the healthcare domain
- Identify employees that are directly involved in the process and interact with the tool frequently
- Analyse the survey data to identify patterns and insights
- Document the findings for future research, and offer suggestions to human resource management department for further strategies or initiatives.

Summary: The audience will gain information about lean methodology and its application in the healthcare domain. The value added by the lean will be discussed. Overview of the data collected will be shared.
Improvement of Supply Chain Transactions by Applying Lean

Author(s)
Dr. Kanchan Das, East Carolina University, Greenville, NC
Dr. P. Rao, University of Northern Iowa, Cedar Falls, IA

Need: Supply chain functions for procurement, production, distribution and marketing are continuously involved in various types of transactions. Yet managers, business experts, and entrepreneurs seldom emphasize or care regarding improvement of transactions. Question is, should they need to care? Or are they caring the transactions anyway when trying to improve production and services systems.

Overview: The research will present a new approach of defining and evaluating application of lean to improve transactions and by that overall business performance. It will facilitate supply chains to be confident on their customer services, delegation of work, and creating partnering relation with the suppliers for overall business growth. The research will provide step by step procedure for applying the method in a generic system setting.

Major Points:
- Importance of transactions and its quality in the current global market
- Identifications and explanations of supply chain operational attributes that solely depends on transactional quality
- Methodology for measuring transactional quality and performance
- A case or model based system to include transaction in a business planning
- Explore what if analysis to understand factors that are precondition for superior performance

Summary: This research will outline how transactions can influence performances in manufacturing, education, and other services industries. The research will consider multi-dimensional factors/attributes that may be considered driver or preconditions for transactional quality and performance. It will explore applicability of existing quality improvement or quality management systems to improve transactional quality and performance. The research aims to establish some fundamental basis for understating the transactions and how a supply chain can apply it for its overall performance improvement.
Thursday, November 2, 2017

Management

Introduction to the Johnson & Johnson Operating System

Author
Dr. David Hoffa, Johnson & Johnson, Monument, CO

Need: This presentation will be important to all educators and practitioners of advanced manufacturing systems, such as Lean and Six Sigma, who want to learn about the most current developments within the practice of continual improvement.

Overview: This presentation will introduce the Johnson & Johnson Operating System (JJOS), a novel approach to continual improvement, which is designed to maximize organizational commitment, accountability, and impact. Instead of the traditional DMAIC flow, the JJOS follows a process of Diagnostic, Confirm, Design, Plan, and Implement, and uses a dedicated, synchronized team instead of a number of practitioners working asynchronously.

Major Points:
- Define the Johnson & Johnson Operating System
- Explain the structure, phases, and stages
- Comparisons to DMAIC
- Detail the financial, cultural, and people development impacts
- Introduction to the Johnson & Johnson Operating System

Summary: The Johnson & Johnson Operating System (JJOS) is a novel approach to continual improvement that incorporates the best ideas from several of the corporation’s former quality and improvement programs, and departs from the traditional DMAIC improvement process in favor of a new structure, which consists of five stages: Diagnostic, Confirm, Design, Plan, and Implement.
Re-evaluating traditional paths to market for industrial products

Author(s)
Dr. Rod Flanigan, University of Nebraska-Kearney, Kearney, NE
Dr. Jacob Bishop, University of Nebraska-Kearney, Kearney, NE

Need: In the world of industrial products, the traditional path to market is in the midst of a slow evolution. For several decades, manufacturers engaged in the power transmission industry took their industrial products (i.e., gearing, bearings, chain, couplings, etc.) to market via a strong network of industrial distributors. This channel, based upon very strong relationships between manufacturers/distributors/end users, was finely tuned and handed down from generation to generation. Over time, however, threats to this age-old industrial business model have emerged and caused most major manufacturers in the industry to rethink how they take their products to market.

Overview: Recently, colleagues from industry asked if the authors would conduct some in-depth research on channel selectivity, exclusivity, and changing business models in the power transmission industry. The industry faces significant threats to their traditional business models; millennials in the workplace, technology, global competition, corporate mergers and acquisitions, Amazon Business/Alibaba, and any number of other factors that affect how companies sell their products, and how the B2B marketplace acquires products. This research will explore best practices in a wide range of industries, including; electrical, fluid power, power transmission, and construction related products.

Major Points:
- Provide a quick review of how the current business model was established, and how it has served the needs of the industrial marketplace.
- Understand how industrial manufacturers can leverage ecommerce sales without marginalizing their traditional industrial distributors.
- A quick look at how the millennial generation is influencing the marketing of industrial products.
- Will provide an analysis of how Amazon Business and/or Alibaba are influencing the industrial market.

Summary: It is one thing to be able to efficiently manufacture an industrial product, but it is an entirely different set of problems when considering how to get these products into the hands of the end user. The traditional paths to market are changing quickly, and most industrial manufacturers are struggling trying to determine current best practices for the distribution of their products. This research explores current practices of industrial distributors, current threats to these practices, and provides a look to the future of industrial product distribution.
User acceptance of new technology in mandatory adoption scenario: Understanding the effect of users’ internal traits and technology characteristics

Author(s)
Mr. Varun Chhabra, Iowa State University, Ames, IA
Dr. Shweta Chopra, Iowa State University, Ames, IA
Dr. Prashant Rajan, Iowa State University, Ames, IA

Need: The purpose of this study is to investigate the effects of users’ internal traits and technology characteristics on intermediary users’ technology adoption behavior in mandatory adoption scenario. The results of this study will help researchers to understand the factors affecting technology adoption for the users who are mandated to use the provided technology. Furthermore, policy makers and government agencies will be able to use the findings of this study to better analyze the technology acceptance by users which in turn can be used to develop more appropriate technologies leading to easier adoption and ultimately to provide better services to beneficiaries.

Overview: The internal traits of technology users include their emotional response to the introduced technology such as technology anxiety and their personal convictions such as trust in internet and resistance to change. Technology characteristics comprise of system characteristics like relevance and interface characteristics such as screen design and terminology. A questionnaire based survey was conducted among the fair price shop salespersons who were mandated to use android tablets and their responses were analyzed using partial least square structural equation modeling (PLS-SEM).

Major Points:
• Heightened use of information and communications technology to provide better services to citizens through e-governance initiatives
• Understanding factors influencing technology adoption in mandatory adoption scenario
• Understanding the users’ internal traits and their effect of technology adoption
• Understanding various characteristics of technology that effect its adoption by intermediary users
• Introducing a model that can be used by researchers to further study the technology adoption behavior under mandatory adoption scenario

Summary: The attendees will get an in-depth information of factors that affect technology adoption behavior of users’ of introduced technological advancements. Application of PLS-SEM to act as a vital tool to analyze current and future research on information systems will be discussed. Implications of work on new e-governance technology introduction will be shared.
Thursday, November 2, 2017

Manufacturing

Best Practices in Sustainable Supply Chain Management

Author
Dr. James Smallwood, Indiana State University, Terre Haute, IN

Need: It is important to include information regarding best practices of Sustainable Supply Chain Management (SSCM) in Industrial Technology and Engineering Technology programs. There is an international growing concern for the environment. Consumer demand for greener processes and products are driving markets toward sustainability. As a result, more companies than ever before are re-structuring their processes up and down the supply chain so that profitability can be enhanced while environmental impacts are reduced.

Overview: This presentation will reveal the results of a research study of manufacturing companies regarding best practices of Sustainable Supply Chain Management (SSCM). Several supply chain management experts from large international companies were interviewed to determine this information. Experts from Sony, Taghleef, ThyssenKrupp Presta, and Bemis were interviewed. In addition, experts from smaller local companies were also interviewed. As for best practices, there are many things all of these companies are doing and some things specific to each company. This information will be shared with those in attendance.

Major Points:
• Reveal the results of a research study of best practices in SSCM
• Describe SSCM strategies/practices used by many of the companies in the study
• Discuss SSCM practices specific to some of these companies
• Explain how this information can be useful to Industrial Technology and Engineering Technology programs

Summary: The research study will be discussed as well as the results. It is believed this information will be very useful to faculty teaching in Industrial Technology and Engineering Technology programs.
Thursday, November 2, 2017

Manufacturing

Implementation of Advanced Technology Training for the Manufacturing Workforce

Author(s)
Dr. Farzin Heidari, Texas A&M University-Kingsville, Kingsville, TX
Dr. Ulan Dakeev, Texas A&M University-Kingsville, Kingsville, TX

Need: Modern manufacturing workers require advanced academic and technical skills to enable their employees to stay competitive.

Overview: Advanced manufacturing involves the use of technology to improve/upgrade the existing process, with relevant technology being described as innovative/cutting edge. The use of advanced technology and advanced manufacturing concepts should be implemented for the training of the manufacturing workforce. This can be achieved by providing teaching materials, faculty workshop, appropriate software, needed equipment and online training in order to perform well in high-tech manufacturing positions.

Major Points:
- Introduce advanced manufacturing processes to manufacturing workforce
- Provide a foundation for training and demonstrative teaching at the University to promote manufacturing careers
- Create and implement curriculum such as design, 3D modeling/simulation, robotics and CAD/CAM/CNC process for innovative application of technologies, processes and method of production

Summary: The essence of technology in the manufacturing industry is to improve the market dynamics and remain competitive, change the workforce demographic, and add more skills needed to work in the advanced manufacturing environment. As a result of new technology implementation in the manufacturing industry, the manufacturing sections require workers with advanced academic competency and technical skills.
Implementing 3D Printer to Produce Parts for Medical Applications

Author
Dr. Gholam Massiha, University of Louisiana at Lafayette, Lafayette, LA

Need: A 3D printer can create a temporary medical equipment or even part of human organ that can take the place of the broken one until another, more permanent; one can be produced or ordered.

Overview: 3D printing has seen much growth in the past decade. There are many different methods and materials that can be used, depending on what the type of prototype is needed. There has been much research into different application for different fields. The focus of this paper is to consider the application of a 3D printer for use in the industrial sector, specifically for use in the creation of temporary parts, prototypes and molds. The application of this paper will focus on a pump impeller used in the Heartmate II to increase blood supply from the left side of a human heart.

Major Points:
• The need for integration of 3D manufacturing and medical technology
• Print temporary parts of good quality that replace normal parts for a limited time
• Print parts that are able to conform to required specifications
• Print molds that can be used to cure epoxy for required applications

Summary: Students learn to integrate 3D printers into manufacturing, medical technology and even environmental technology applications. Industrial technology students involved in medical technology and 3D manufacturing may have a strong advantage in medical technology jobs fields."
Friday, November 3, 2017

Manufacturing

Learning Requirements for Manufacturing Organizations

Author(s)
Dr. Teresa Clark, Murray State University, Murray, KY
Mr. Sidney Martin, III, Murray State University, Murray, KS

Need: There is an importance that manufacturing organizations focus on the learning requirements of the organization. Organized continuous improvement cannot happen unless a learning plan is developed. Organizations must understand that having training meetings does not address the organizations learning needs.

Overview: This talk will provide a learning action plan for a manufacturing organization. The presentation will start with a summary of why the organization needs to address learning. A review of the state of the literature will be provided. A review of the areas which the manufacturing organization can address learning improvements and innovation will be made. Finally, areas for future research will be provided.

Major Points:
• Mastering the learning requirements of the organization
• Increasing productivity in manufacturing
• The role of learning and the relationship to continuous improvement
• Gaining back market share through addressing learning requirements
• The need to emphasize learning, innovation, and knowledge

Summary: This article will provide a guide for future research to increase the potential for this organized research effort will occur to improve the transfer of knowledge to the manufacturing industry.
Teaching Process Simulations in Manufacturing and Technology Programs

Author
Prof. Samuel Obi, San Jose State University, San Jose, CA

Overview: This presentation will provide an overview of the role and applications of simulation in manufacturing systems. It will then describe a case example developed at San Jose State University in the fall of 2015, to illustrate an example for programs that may need to employ these techniques. A popular software called SIMPROCESS is used in the case example. This presentation will emphasize the need and importance of simulation to the United States’ manufacturing industry. It will explain its major benefits, limitations and applications. It will then employ the tool used at San Jose State University’s manufacturing program to demonstrate its components, how it is designed and how to implement it in a manufacturing curriculum.

Major Points:
• Simulation-related challenges facing U.S. manufacturing industry
• Description of simulation
• Overview of benefits of simulation
• Demonstration of simulation
• Review of steps in designing a simulation
• Using simulation in manufacturing curriculum
Thursday, November 2, 2017

Manufacturing

The Future of Human/Machine Interaction: Collaborative Robotics

Author(s)
Dr. William Clyburn, Indiana State University, Terre Haute, IN
Mr. Oscar Henriquez, Indiana State University, Terre Haute, IN

Need: Manufacturers are always concerned with new technology that will increase productivity, quality, and save production costs. The use of robots in manufacturing has become an accepted fixture in most manufacturing environments to accomplish these objectives. However, one issue regarding the use of robots in the manufacturing environment has been the safe interaction of human workers with robots. Robots have the speed and power to cause grievous injury, or death, to the unlucky, or unwary, worker who runs afoul of the robot’s automated operations. The result is that manufacturers must meet stringent safety regulations, and install safeguards for human worker safety that add to operating costs.

Overview: This presentation will provide an introduction to what design features are being used to create a class of collaborative robots. The benefits to manufacturers from the use of collaborative robots are reviewed, along with what adaptations are necessary to upgrade existing facilities and labor operations to utilize collaborative robotics to its best advantage.

Major Points:
What design features create robots which are classified as collaborative
What are the incentives to manufacturers to invest in the use of collaborative robots
What changes to the manufacturing environment are created by the use of collaborative robots

Summary: are investing in this technology as they view it as the wave of industrial robotics for the future. This presentation will introduce the audience to what design features are used to make robots collaborative with human workers; and how they can be best used to advantage in the manufacturing environment to enhance safety, increase productivity, and reduce production costs.
Author(s)
Dr. Randell Peters, Indiana State University, Terre Haute, IN
Dr. Michael Hayden, Indiana State University, Terre Haute, IN

Need: The number of new materials is rapidly increasing. For older and recent materials, new methods of production and new applications are being developed. New methods of testing have led to previously unknown properties. Is your program keeping pace?

Overview: Materials topics are more important to engineering technology programs than ever. The authors will present an overview of trends in materials and in the teaching of those materials (both content and instructional method). Most material topics are increasing in instructional emphasis. Dedicated materials courses are increasing, while materials topics embedded in other courses are still widely used. Strategies for a program to keep current on materials topics are presented.

Major Points:
• Materials
• methods of investigating and testing
• properties
• Increased importance of materials topics such as safety and environmental concerns
• The basics vs cutting edge
• False dichotomies
• lab vs lecture
• dedicated materials course vs materials topics dispersed in various courses

Summary: The authors summarize recent advancements in the science and application of materials. The number of new materials is rapidly increasing.
What manufacturing and service businesses can learn from the airline industry!

Author
Dr. Merwan Mehta, East Carolina University, Greenville, NC

Need:
A best practice in one industry can be successfully adapted into another industry to become a novel innovation. The airline industry has done a great job in being efficient and safe over the past few decades, and it behooves manufacturing and service businesses to learn from these lessons.

Overview: All businesses want to be as productive and profitable as they can be but the airline industry, apart from wanting to be that has to also be extremely safety conscious, as disorganization and mistakes can be fatal for the crew and customers. How standard work, checklists, and quick team formation through the airline industry’s crew resource management or cockpit resource management (CRM) system is accomplished will be presented in this presentation. CRM is a training method to minimize the effects of human error that can have devastating effects on a process. CRM focuses on air safety, interpersonal communication, leadership, and decision making in the cockpit. CRM is also becoming popular with air traffic control, ship management, firefighting, and operating rooms.”

Major Points:
- Airline industry’s early accident-prone days
- Evolution of safety standards in the airline industry
- Adoption of standard operating procedures
- Incorporation of checklists
- Tackling the issue of leadership in the front of the aircraft using CRM
- How manufacturing and service businesses can benefit from these concepts

Summary: Many good pilot teams and passengers have died due to simple errors, and it is high time other businesses benefit from what was learned as the reason for the failures. In this presentation, a detail discussion on standard work, checklists and the CRM will be conducted to learn from.
**Micro/Nanotechnology**

**Bulk Mechanically Alloyed Oxide Dispersed Copper for Solid-State Foaming**

**Author(s)**
Mr. Joseph Wright, Millersville University, Millersville, PA  
Mr. Roger Welsh, Millersville University, Millersville, PA  
Dr. Mark Atwater, Millersville University, Millersville, PA

**Need:** Modern powder metallurgy and porosity creation requires a high volume of alloyed powder for repeated trials when creating new micro- and nanoscale pores. Conventional high-energy ball milling provides an efficient method to produce alloys for powder metallurgy, yet is only able to mill several grams of powder per vial. Planetary mills feature vials multiple times the volume of conventional ball mills, allowing for large-scale production of alloy powder. In order to scale the production of solid-state metal foams by this method, the feasibility of larger production volumes must be assessed.

**Overview:** The purpose of the presentation is to provide comparison and research data from high-energy ball milling in conventional and planetary milling processes to increase the feasibility of producing solid-state metal foam alloys.

**Major Points:**
- Understanding General Ball-Milling (Conventional)  
- Mechanical Differences in Planetary Milling  
- Alloy Results (Visually & Post Particle Expansion)  
- Varying Impact Energy and Milling Ratios

**Summary:** This presentation offers an in-depth exploration into the usage of planetary milling techniques and the impact they have on porosity in copper and copper alloys. The differences in conventional ball-milling and planetary, both impact energy-wise and mechanically, will be discussed.
**Nano-Scale Level Simulation Model for Quasi-Static Laboratory Compression Test**

**Author(s)**
Dr. Ahmed Mohamed, Indiana State University, Terre Haute, IN  
Prof. Randell Peters, Indiana State University, Terre Haute, IN

**Need:** Rapid growth in the computational power in the last few decades has enabled Engineers and researchers to create non-destructive methods to study and improve existing materials properties.

**Overview:** In this study, Molecular Dynamics (MD) computational simulations methodology was developed to model and simulate the quasi-static compression laboratory test at the Nano-Scale level.

**Major Points:**
- Different Length Scales  
- Nano Scale Level  
- Molecular Dynamics Method  
- Laboratory Compression Test  
- Computational Model Parameters

**Summary:** The focus of this research is to develop an accurate computational model for the laboratory compression test. The main idea of the computational model is to apply deformation strain and obtain the corresponding stress. With this technique, the use of computational simulations can replace, or work congruently with laboratory experiments.”
**Predicting Elastic, Bulk, and Shear Modulus for Cement Clinkers under Varying Pressure Conditions**

**Author(s)**
Dr. Ahmed Mohamed, Indiana State University, Terre Haute, IN  
Dr. Ali Shahhosseini, Indiana State University, Terre Haute, IN

**Need:** In this research, the mechanical properties such as Elastic, Bulk, Shear Modulus, and Poisson’s Ratio for cement clinkers, under different pressures, was predicted using computational simulation approach.

**Overview:** Cement is the most widely used construction material worldwide. Cement consists of different clinkers with Nano-scale sizes. In this study, Molecular Dynamics (MD) computational simulations techniques were employed to predict the Elastic, Bulk, Shear Modulus, and Poisson’s Ratio for Cement Clinkers at the Nano-Scale level. The effect of applying different hydrostatic pressures on the properties and structure configuration was studied.

**Major Points:**
- Cement Clinkers  
- Computational model experiment and parameters  
- Obtaining the results for different Hydrostatic pressures  
- Study of the effect of varying pressures on the mechanical properties  
- Study of the effect of varying pressures on the structure configuration

**Summary:** The focus of the research is to obtain the Elastic, Bulk, and Shear Modulus for the major cement clinkers using molecular dynamics (MD) computational simulations approach. Analysis of obtained results was done and effect of varying pressure conditions on the mechanical properties was studied.
RepRap 2.0: Moving from Filament to Resin

Author(s)
Dr. Yi-hsiang Chang, Illinois State University, Normal, IL
Mr. William Walker, University of North Dakota, Grand Forks, ND
Mr. Zackary Vacura, University of North Dakota, Grand Forks, ND
Ms. Shae Bonifacio, University of North Dakota, Grand Forks, ND

Need: In contrast to its open-source FDM-based sibling, the documentation of know-hows is lacking for the resin-based 3D printer. Despite of its high print quality, the cost of ownership for this type of printers is still high as there are no solid examples available online.

Overview: We will present a research project intending to accelerate the open-source resin 3D printer's development by replicating the RepRap approach. A working model of the resin 3D printer and its prints will be presented. The proposed product hierarchy of this printer which standardizes the module interface will be discussed. We will conclude the presentation with the outlook of this open-sourced resin 3D printer project.

Major Points:
- Overview of open-sourced RepRap history
- The difference between resin and FDM 3D printers
- Generic platform performance and limitation
- Modular hierarchy of the resin 3D printer
- Open-source document and community management

Summary: We will present an ongoing research project with the intention to start the next wave of open-source 3D printers by replicating the RepRap history. The project rationale will be discussed and the design-to-manufacturing process of resin 3D printers will be illustrated.
Air Quality and Noise Assessment in Confinement Livestock Facilities

Author(s)
Mr. Alexander McDaniel, Indiana State University, Terre Haute, IN
Dr. Ernest Sheldon, Indiana State University, Terre Haute, IN

Need: The workers’ health can be effected by improper ventilation due to hydrogen sulfide, ammonia, and methane as well as noise and humidity.

Overview: This presentation will consist of a discussion of methods used to obtain air quality and noise exposure data for a large central Indiana swine farm. Air sampling will be conducted for hydrogen sulfide, ammonia, and methane concentrations. A noise dosimeter will be utilized to monitor noise exposure, and air velocity and humidity measurements will be made. Sampling is being done every two months for a full year, and ultimately a detailed summary with recommendations will be provided to the farm. Data collected up until the ATMAE conference will be summarized in this presentation.

Major Points:
- Air sampling will be made with a four gas monitor that tests for hydrogen sulfide, ammonia, and methane concentrations.
- A noise dosimeter will be utilized to monitor noise exposure.
- Air velocity and humidity measurements will be made.

Summary: This presentation will be a status report of my project that will help an Indiana swine farm obtain an acceptable safety level for its employees and livestock. After contacting the owner of the facility to set up a time and date, data will be collected from the multiple areas within the facility.
Thursday, November 2, 2017

**Safety**

**Applying Traction/Friction to Prevent Injuries via Slips, Trips, and Falls: Practical and Sustainable Solutions**

**Author(s)**
Mr. Charles Hunt, Norfolk State University, Norfolk, VA
Dr. Jeenson Sheen, Norfolk State University, Norfolk, VA
Dr. Munir Sulaiman, Norfolk State University, Norfolk, VA

**Need:** Workers who experience a slip, trip or fall suffer considerable pain from a resulting injury. These persons’ lives may be changed forever from a disability.

**Overview:** This presentation will highlight some practical solutions for minimizing slips, trips, and falls in the manufacturing workplace. Attendees will gain insight on the mechanism regarding slips and trips, together with scientific-technology principles of traction/friction, momentum, and gravity. Relevant issues, techniques, and examples will be shared.

**Major Points:**
- Rationale and benefits of slip, trip, and fall prevention
- OSHA’s new walking-working surfaces rule
- Definitions and common causes of slips, trips, and falls
- Injuries occurring via slips, trips, and falls
- The costs of slips, trips, and falls
- Human factors and conditions that increase the risk of slips, and trips
- Scientific principles of traction/friction, momentum and gravity

**Summary:** According to OSHA, 15% of all workplace fatalities are the result of slips, trips, and falls. Furthermore, according to OSHA, 65% of falls happen on the same level resulting from slips, and trips.
Assessment of the Condition of Power-Take-Off Guarding Systems on Farm Machinery

Author(s)
Miss Joy Sheldon, Indiana State University, Terre Haute, IN
Dr. Ernest Sheldon, Indiana State University, Terre Haute, IN

Need: Modern agricultural equipment uses state-of-the-art guarding systems that can effectively prevent people from coming into contact with dangerous rotating Power-Take-Off (PTO) shafts. However, as machinery ages the condition of those guarding systems often deteriorates, creating hazards that may lead to disastrous consequences. For various reasons, farmers remove or modify the shielding systems on equipment without restoring them to their original functionality.

Overview: We have designed a rubric that has been distributed to farmers in the state of Indiana. The rubric has a list of parts that make up a Power Take-Off driveline shaft and its guarding system, it then gives different conditions that the farmer can select reflecting the condition of the various components of the PTO driveline and its guards. This information gives us an idea of how many farmers are working with equipment that is not in the proper operating condition.

Major Points:
• Entanglement with farm machinery is consistently one of the primary causes of serious injury or death on U.S. farms.
• Due to increased prices on modern machinery it is easier for farmers to purchase older equipment, however the older equipment may have ineffective, damaged or missing guarding systems.
• Excuses for poor maintenance of machinery are varied and often creative, but seldom adequate for explaining severe injuries or loss of life.

Summary: This presentation will go more into depth on how we were able to get the rubrics out and returned, as well as what our findings were. Attendees will take with them an understanding of the scope of the problem involving the condition of PTO guarding systems on many, if not most farms.
Characterizing number of days away from work (DAFW) using information in workers’ compensation claims database

**Author(s)**
Dr. Sai Ramaswamy, Wenatchee Valley College, Wenatchee, WA
Dr. Gretchen Mosher, Iowa State University, Ames, IA

**Need:** The number of days away from work (DAFW) is an important indicator used to estimate injury severity, evaluate injury risks, and identify problem areas. However, very little research has characterized the DAFW based on individual, occupational and industry factors. Recently, several researchers recommended the use of workers’ compensation (WC) claims as an excellent data source to address existing informational gaps about safety incidents and injuries in the workplace. This study characterized the number of DAFW using information stored in WC claims such as injured employee age, tenure, and type of job, nature, and cause of injury.

**Overview:** Occupational injuries continue to be a major issue in several industries. This presentation will discuss how data from a workers’ compensation claims database was utilized to characterize the DAFW and the relationship between DAFW and several components of injury data. An improved understanding of injury risk enables safety professionals and insurance companies to plan and evaluate injury prevention efforts effectively.

**Major Points:**
- Importance of characterizing the DAFW using workers’ compensation claims data
- Application of multivariate analysis for measuring the relationship of DAFW with several factors influencing worker safety
- Importance of findings to the industry and scope of future work

**Summary:** Attendees will understand the importance of workers’ compensation claims data to address informational gaps existing in occupational safety research. The importance of the DAFW as an indicator of injury severity and the factors that influence this important indicator will also be discussed.”
Critical thinking and decision making integration into fluid power laboratory safety training

Author(s)
Mr. Saxon Ryan, Iowa State University, Ames, IA
Dr. Gretchen Mosher, Iowa State University, Ames, IA

Need: Many college level laboratory courses across the United States incorporate safety training into their courses. This training is intended to ensure students aware of the hazards and know how to handle them appropriately. Critical thinking and decision making are integral parts to safety when handling complex fluid power systems. This work focuses on the exploration of including critical thinking and decision making in laboratory fluid power safety training. The goal of this work is to increase the effectiveness of the safety training so that students make safety oriented decision in the lab and in the future outside of the lab.

Overview: This work reviews the fluid power laboratory environment along with various equipment and the hazards of the equipment. Decision scenarios were developed based on the environment for students to determine what they believe is the most safety oriented decision. The scenarios were written with the intention of eliciting answers from the students that could be examined for critical thinking aspects. These scenarios will be used to determine if the safety training is effective at training the students to choose a safety oriented decision and to determine if students are using critical thinking.

Major Points:
- Need for safety training in fluid power laboratory
- Integration of critical thinking and decision-making aspects into laboratory safety training
- Creation of test case for use in assessment of fluid power safety training
- Implications for student assessment in safety-sensitive laboratories

Summary: The audience will learn about the importance of fluid power safety in a laboratory setting and its application outside of the lab. The relationship of decision scenarios, critical thinking, and fluid power training will be shared. Methods of writing decision scenarios in a way that assists in fluid power training will be discussed. Finally, Implications for assessing students on the topic of safety with critical thinking and decision making will be presented."
Thursday, November 2, 2017

Safety

Developing and Testing an Authentic Safety Assessment

Mr. Wesley Chang, Iowa State University, Ames, IA
Dr. Gretchen Mosher, Iowa State University, Ames, IA

Need: The primary focus of the presentation is to describe the development and use of an authentic assessment designed to measure an individual’s decision process after they have participated in a training session on combustible dust explosion hazards.

Overview: This presentation will discuss authentic assessment and the use of these assessments in safety. Key benefits of authentic assessment will also be discussed as they relate to combustible dust hazards. Implications for industry professionals and researchers will conclude the presentation.

Major Points:

- Definition of an authentic assessment
- Authentic assessment in safety
- Benefits of an authentic assessment with combustible dust hazards
- Implications for researchers and industry professionals

Summary: The audience will learn the role authentic assessment plays in safety training, advantages of using authentic assessment in safety training, and implications of use in industry and research organizations.”
Does geographic variation influence occupational injury trends? Evidence from research literature

Author(s)
Dr. Sai Ramaswamy, Wenatchee Valley college, Wenatchee, WA
Dr. Charles Schwab, Iowa State University, Ames, IA
Dr. Gretchen Mosher, Iowa State University, Ames, IA

Need: Past studies suggest that occupational injury trends have a significant association with several individual, work-related, and industry factors. Characterizing the relationship between these factors and occupational injuries can help identify at-risk groups so prevention efforts can be customized for maximum impact and mitigate injuries. The purpose of this study is to summarize the evidence in the research literature to characterize the relationship between worker’s geographic location and occupational injury. Specifically, investigate if the trend of occupational injuries varies by region after controlling for industry type, occupation, and worker demographic factors.

Overview: Occupational safety is a multidisciplinary field encompassing areas such as engineering, industrial technology, psychology, and economics. Therefore, research literature published in occupational safety distributed across various disciplines must be identified, integrated, and interpreted to provide evidence supporting a specific research hypothesis. This presentation will discuss the impact or lack thereof of geographic variations on occupational injury trends based on the existing evidence in the research literature.

Major Points:
• Overview of factors associated with occupational injury
• Importance of past incident analysis and identification of at-risk groups in occupational safety
• Summary of existing research literature about influence of geographic variation on occupational injury trends
• Potential application of this study to the industry and scope of future work

Summary: Attendees will gain knowledge about the influence of geographic variation on occupational injury trends. Furthermore, they will gain an appreciation for the importance of characterizing the relationship between injury factors and injury trends for mitigating future occurrences.”
Thursday, November 2, 2017

Safety

Firefighter Fall Notification System: Design and Development

Author(s)
Dr. David Hua, Ball State University, Muncie, IN
Dr. Christopher Davison, Ball State University, Muncie, IN

Need: According to statistics from the National Fire Protection Association (NFPA), 6% of the fatalities reported in 2015-2016 were due to personnel falling. The outcome of such falls can be impacted by the time it takes for others to respond to the fallen fire fighter. The fire captain on scene needs to be alerted as soon as a fall occurs in order to send others to retrieve the fallen fire fighter.

Overview: The presentation will describe the design and implementation of a system that alerts when a fire fighter has fallen a prescribed distance. We are developing an app which uses smartphone gyroscopes or accelerometers to predict the sudden changes in height when personnel are on scene at a fire. The system would generate an alert when there is a change in height of more than 8 feet within a 2-4 second period. This would initiate an alert/alarm that the fire captain would receive so they know one of their fire fighters might be in danger and in need of assistance.

Major Points:
- Describe the need for an alert system for fire personnel.
- Identify problem areas in real time monitoring of changes in height.
- Describe the functioning of the application.
- Demonstrate the application.

Summary: This presentation will showcase our effort to develop a notification system in the event of a fire fighter fall. It will describe the design and development of the system components. The audience will also be provided a demonstration of the alert system in action.
Safety

Potential Health Impact of Radiofrequency Radiation on Humans

Author(s)
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Dr. Eli Aba, Pittsburg State University, Pittsburg, KS
Ms. Janaki Koppolum, Pittsburg State University, Pittsburg, KS
Mrs. Marina Fligor, HANAU Health Group, West Lafayette, IN

Need: In today’s world, technologies based on transmission of radio frequencies, such as Wi-Fi, have multiple applications in many sectors of industry, science, medicine, and military. However, multiple studies report that those new discoveries have potential negative effects on biological processes in human bodies, as well as brain activity, and even emotional state. The presentation focuses on the potential health effects of Wi-Fi technologies on humans.

Overview: This article is devoted to analysis of controversial opinions about impacts of Wi-Fi technologies, electromagnetic field, and cell phone radiation on human health conditions. Attendees will appreciate learning about potential harmful effects of longtime exposure to Wi-Fi and some preventive ways to safeguard human bodies. This may also help attendees to begin looking into how to fill the knowledge gap in this area by carrying out research to add to the body of knowledge.

Major Points:
• Brief explanation of radiofrequency principles used in Wi-Fi technologies
• Major potential side effects of longtime exposure to EMF
• Some practical preventive ways of minimizing the potential negative effects of Wi-Fi signals

Summary: This paper is organized as a literature review of multiple academic sources with the purpose of creating awareness for a large audience of Wi-Fi and mobile phone users.”
Safety

The Prediction and Classification of Occupational Incidents Severity Using Workers’ Compensation Data

Author(s)
Ms. Fatemeh Davoudi Kakhki, Iowa State University, Ames, IA
Dr. Steven Freeman, Iowa State University, Ames, IA
Dr. Gretchen Mosher, Iowa State University, Ames, IA

Need: Explaining the occupational incidents scenarios that lead to severe injuries will contribute to figuring out more hazardous underlying factors leading to such injuries as well as reviewing and developing necessary safety measurements in such work environments.

Overview: In this study, we will classify the underlying factors leading to injuries in food processing and feed mill industries in Midwest USA. The data is collected from an insurance company and reports more than 4000 incidents between 2008 and 2016. Three classification methods will be applied: Naïve Bayes, K-Nearest Neighbor, and CHAID decision tree (Chi-square Automatic Interaction Detector). The misclassification error rate and predictive accuracy rate will be compared to find the optimum model. Finally, various factors that lead into severe, less severe, and non-severe incident scenarios will be classified for future application for insurance financial modeling purposes, and review of safety measurement considerations for the employers of the field.

Major Points:
• Primarily selecting most significant features affecting the severity of the occupational incidents
• Classifying main features via Naïve Bayes and K-NN algorithms
• Classifying main features via CHAID Decision Tree technique
• Comparing predictive accuracy rate, and misclassification error rate for all three models
• Figuring out the optimum predictive model fitting the data
• Presenting classification results for adopting better safety measures at work environment in food processing and feed mill sectors

Summary: The focus of the study is to build a predictive model which could classify the occupational incidents scenarios in food processing and feed mill industry.
Friday, November 3, 2017

Safety

Understanding human performance modes in occupational safety

Author
Mr. Daniel Borkowski, Indiana State University, Terre Haute, IN

Need: In the occupational workforce it had been determined 80-90% of injuries or illness are attributed to Human Performance Factors. Human Performance is a set of concepts and principles linked with a performance model that illustrates the organizational framework of human performance.

Overview: The model shows that human performance is a system connecting a network of elements and factors that work together to create repeatable outcomes. The system is comprised of organizational factors, job-site conditions, individual behavior, and results.

Major Points:
- Defining human error
- Breakdown of different mental modes and how they’re relatable to incidents in the workplace
- Factors that can influence continuous improvement of human performance in the workplace

Summary: This presentation will define Human Performance, Human Error, and explain how mental mode affects workers in the workplace.”
A study to develop a four-week instructional workshop in Organizational Dynamics and a model for assessing and forecasting potential enrichment opportunities in technology leadership

Author(s)
Dr. Cynthia Horta-Martinez, University of Central Missouri, Warrensburg, MO
Dr. Ronald Woolsey, University of Central Missouri, Warrensburg, MO

Need: Individuals and Organizations are in need of a four-week instructional workshop in Organizational Dynamics and a model for assessing and forecasting potential enrichment opportunities in technology leadership.

Overview: The cost of making bad hiring decisions have led many employers to use personality tests as part of their hiring process. Understanding demographics, personalities, own emotional intelligence and being ready for technology in this generation is a given. However, we still have individuals and organizations that can't or will not take the time to understand these concepts and is important to know how to address it.

Major Points:
- Demographics
- Individuals and Organizations
- Personality Profile
- Kiersey Temperament Sorter, Myers Briggs Personality test,
  Herman Brain Dominance, Smalley Personality Types Inventory
- Emotional Intelligence
- Eysenck's Personality Inventory, Five factor model
- Technology Potential
- Technology Readiness Index, Technology Adoption Score

Summary: With this workshop individuals and organizations will get an understanding of their personality, emotional intelligence and technology potential strengths and weaknesses and be able to work on them in an effectively way, in order to be more productive and efficient. The final goal is short course opportunities, professional development training, academic grants, and journal publications.
Thursday, November 2, 2017

Teaching Innovations

A Virtual Environment for Learning Radiation Emergency Response

Author(s)
Dr. HuiRu Shih, Jackson State University, Jackson, MS
Miss Kawandrea Spann, Jackson State University, Jackson, MS
Miss Ebony Davis, Jackson State University, Jackson, MS

Need: The greatest challenge facing emergency response personnel is the ability to train effectively. An interactive and virtual training paradigm shows promise towards achieving training goals.

Overview: Emergency situations may occur in a broad range of scenarios. First responder training should include realistic scenarios. Virtual environments can create an emergency situation that could not otherwise be experienced. What virtual reality can do is to create experiences that help students become better equipped to handle real-life situations.

Major Points:
- A virtual environment platform can provide students with a higher level of immersion and realism
- Virtual environment can be used to enhance the learning in emergency response and management
- The virtual environment platform can allow for greater flexibility regarding different emergency scenarios

Summary: This study showed the feasibility of using virtual reality for the development of a tool for teaching students the basics of nuclear emergency preparedness and response. Virtual reality is also being studied and used in different ways in emergency management."
Analysis of Students’ Perspectives on Success Factors in Engineering Technology Majors

Author
Mr. Todd Alberts, Indiana State University, Terre Haute, IN

Need: The presentation addresses the issue of successful recruiting and retaining students in technology majors. The authors will present the research data that validates the importance of introductory classes and support network for STEM students that would help them successfully pursue their major.

Overview: The presenters will share the quantitative results of the research that compares the students’ perceptions of the factors pertinent to successful completion of the chosen program to the factors that were identified by independent research as indicative of students’ success in STEM areas.

Major Points:

• students’ perceptions about what is important for successful completion of the Technology degree program differs from the factors identified by other research
• students ranked the confidence in one’s math skills and faculty support as two major variables of success in STEM majors
• students tend to underestimate the importance of social support from peers and family
• the logistic regression analysis showed a significant correlation between having a high GPA and ranking math skills high on a scale of important success factors

Summary: The goal of this study was to evaluate students’ perspectives on what they consider important for a successful completion of a STEM-related degree program and carry out a comparative analysis of their perceptions and the data obtained through other research on students’ success factors in STEM majors.
Automatic Identification Data Capture towards Robust Material Handling, 
a Key Learning Pedagogy for Warehousing Class

Author
Dr. Mohammed Ali, University of Texas at Tyler, Tyler, TX

Need: Bar coding is ubiquitous. Automatic Identification Data Capture (AIDC) and Radio-frequency Identification (RFID) technologies are everywhere from manufacturing, distribution, retail, healthcare, financial to military. The material handling operation in a warehouse is the vital part among other operations. The industrial technology graduates may have employment opportunities in these industries. Therefore, it is clearly necessary for them to have theoretical and hands-on learning of these technologies as part of the warehousing class.

Overview: This paper reports incorporation of RFID and AIDC in the TECH 4348 – Warehousing course curriculum. Businesses without AIDC will be out of business over night. Accurate, timely and confidence in data are key on decision making. Inventory management, item documentation in receiving, packaging, shipping and material handling requires processing of those data. As a result, data becomes the driving force for planning and control of these activities. The AIDC and RFID technologies can provide a boost to the warehouse course curriculum. The implementation of these techniques from designing, coding and scanning of bar code to readability in automated material handling system will be discussed in the presentation.

Major Points:
- Although, the first use of bar code scan started in 1979, today there are ten billion UPC/EAN scans taking place every day in retail industry
- A survey to 320 mid-level management professionals of 10 industries was conducted by the SAP
- Study results revealed that 59% of inventory management and 64% of shipping/receiving activities require the implementation of AIDC and RFID technologies
- Both activities are an integral part of a robust material handling system in the warehouse
- Warehousing is often an undergraduate level course of industrial technology curriculum
- Learning pedagogy in warehousing course by implementing of AIDC and RFID technologies is the demand of present time

Summary: The implementation of these techniques from designing, coding and scanning of bar code to readability in automated material handling system will be discussed in the presentation.
Author(s)
Dr. Sophia Scott, Southeast Missouri State University, Cape Girardeau, MO
Ms. Aarya Khanal, Southeast Missouri State University, Cape Girardeau, MO

Need: The future technical work environment requires students who can effectively communicate and solve technical problems. Technology students need to be proficient in both problem solving and communication. Each individual has an approach or style he or she prefers in communicating problems. The goal of the university is to prepare students for their future by teaching them to communicate with individuals from diverse backgrounds. Two important skills that students need to enter the future workforce are effective team communication and problem solving. Little research has been done on communication styles effect on team performance.

Overview: Involving students in a fun activity can help to engage them in technical problem solving and communication. The purpose of this research is to assess the communication style of students to see if their style affects success in problem solving using a puzzle activity. The proposed subjects of the research are students enrolled in a technology program at a Midwestern university. Participants will be asked to complete an instrument to assess his or her communication style. In addition, the students will be given a problem to solve. The presentation will provide the results of this study.

Major Points:
- Identifying communication styles of technology students
- Results of the study will be presented
- Tips and techniques for communication styles to help students in team problem solving

Summary: This presentation will show an assessment of communication styles of technology students in selected classes. Based on the communication styles, the students will then work together in a team to solve a puzzle.
Constructing the Open Road: Teaching with IoT and Ambient Internet Technologies

**Author(s)**
Dr. Vigyan Chandra, Eastern Kentucky University, Richmond, KY  
Dr. Ni Wang, Eastern Kentucky University, Richmond, KY  
Dr. Sergio Sgro, Eastern Kentucky University, Richmond, KY

**Need:** Technologists in the near future will need to extract actionable information and make decisions based on data harvested from multiple interacting “smart” devices. Students in ATMAE programs should be provided with learning opportunities for becoming familiar with the upcoming Internet of Things (IoT) which will use the information infrastructure for controlling device operations everywhere.

**Overview:** The presentation will provide an overview of IoT and the Ambient Internet (4.0) for potential use in the technology curriculum. These technologies will soon make it possible for users to dynamically configure the environments based on historical data collected by sensors and prior user responses. Suggestions of open source IoT applications in the classroom, the use of ambient computing, and projects utilizing real time responses will be shared during the session.

**Major Points:**
- Intersection of the Internet of Things (IoT) and the Ambient Internet  
- IoT, manufacturing, and smart-everything  
- Open source apps for familiarizing students with IoT systems  
- Classroom/lab activities using ambient computing and mobile devices  
- Capstone projects configured for live sensor and actuator responses  
- Promise of the open road, speed bumps and all -- Enjoying the challenges while adopting IoT enabling technologies in the curriculum

**Summary:** Attendees of the session will learn about using IoT applications and some of the next generation Ambient Internet technologies in their classrooms. IoT provides opportunities for increasing student engagement in learning by integrating mobile devices within an academic setting. Meaningful ways of using IoT and ambient computing technologies within the classroom will make applying these in the workplace easier.
Thursday, November 2, 2017

Teaching Innovations

Developing Effective Visual Representation Schemes to Improve and Measure Student Skills in Circuit Analysis Education

Author
Dr. Sangho Park, Central Connecticut State University, New Britain, CT

Need: Developing analytical skills for student success in electrical engineering is challenging and requires considerable amount of student effort and instructional support.

Overview: We developed a new training/assessment software for enhancing students’ analysis skills. The new tool integrates circuit simulation, multi-level visual representation, pedagogical procedure for assessment in a single package written in Java.

Major Points:
- The proposed software tool provides instructor with versatile pedagogical control options
- Pedagogical design involving pre-test, simulation, and post-test is easily configured and modified by instructor
- Students can repeat practices multiple times with automatically-randomized values of parameter variables
- Instantaneous feedback to student answer is provided to her/him to motivate further endeavor
- Grades on student performance and improvements over time are automatically measured

Summary: The software’s instantaneous feedback regarding student performance is expected to motivate student to master analytical skills and support instructor with empirical data.”
Development of an Interdisciplinary Cybersecurity Laboratory for Information Technology and Automation & Controls Engineering Technology Programs

Author(s)
Dr. William Clyburn, Indiana State University, Terre Haute, IN
Dr. Xiaolong Li, Indiana State University, Terre Haute, IN

Need: This presentation presents the results of a response to this call through the development of an interdisciplinary laboratory to train technology students in creating, operating, maintaining, and defending networked systems in commercial, infrastructure, and industrial control applications.

Overview: This paper presents an overview of the development cycle of the project to create the laboratory and to develop curricular materials.

Major Points:
• What are the cybersecurity workforce skills needed by IT and ACET students?
• Where can curricular materials & training be obtained by educators to prepare them to effectively deliver these skills to their students?
• An overview of the materials and designs used at ISU to develop a networked laboratory to provide hands-on experiential learning in cybersecurity for IT and ACET applications.

Summary: This presentation provides a review and formative evaluation of the results of the process of this laboratory development to serve as a model for other institutions seeking to include Cybersecurity in their own programs. The focus of the presentation will be curriculum development and equipment needs, as well educator preparation needs.
Thursday, November 2, 2017

Teaching Innovations

Digitally Augmenting Curriculum Delivery

Author
Dr. Charles Weiss, Clemson University, Clemson, SC

Need: Today’s students need more than a traditional lecture. Augmented Reality provides the opportunity for educators to enhance their curriculum digitally, while still using many of the traditional methods currently used in the classroom.

Overview: Our students today are very heavy users of technology, especially when it comes to smartphones and digital apps. Augmented Reality allows an educator to take advantage of this technology use, while also allowing educators to enhance their traditional learning materials with digital content that is launched directly on a phone or tablet. This presentation will explore the basics of Augmented Reality and show participants how easy it is to incorporate this exciting technology into their current curriculum.

Major Points:
- What is Augmented Reality?
- How does Augmented Reality work?
- How can Augmented Reality be used to better reach our students?
- How can existing curriculum be updated to include enhanced digital content?

Summary: This session will investigate augmented reality and show you how easily you can incorporate this exciting technology into your existing classroom projects.
Thursday, November 2, 2017

Teaching Innovations

Electric Guitar: Concept to Product

Author
Dr. Gary Mahoney, Berea College, Berea, KY
Ms. Lisa Marks, Berea College, Berea, KY
Ms. Molly Reich, Berea College, Berea, KY

Need: Students with the ability to go from concept to finished product utilizing CAD, CAM and CNC technologies are in high demand and necessary.

Overview: This project involves designing, and virtually testing an electric guitar utilizing parametric modeling software, then going through the necessary steps of producing the instrument utilizing CAM, CNC, and other automated systems. Best practice will be discussed.

Major Points:
• Design Control
• Parametric Modeling
• Tool Selection
• Production engineering

Summary: This project involves the design and production of an electric guitar utilizing the integration of current automation technologies. Specifically, critical design components will be identified, discussed and then documented utilizing parametric modeling software. After testing, the design will be produced through the use of computer aided manufacturing, computer numerical control and other production technologies.
Emergency Preparedness Games

Author(s)
Dr. HuiRu Shih, Jackson State University, Jackson, MS
Miss Kawandrea Spann, Jackson State University, Jackson, MS

Need: Personal preparedness is a necessary component of effective national disaster readiness. Creating interactive games can offer people an opportunity to tackle disaster preparedness in a way that is memorable and fun.

Overview: The disaster simulation game is a great platform to help educate students on how to be prepared in the event of a disaster. The more people know about how to protect themselves from emergencies, the better prepared they are. Scratch is a visual programming language. When students develop games using the Scratch, they will also learn important strategies in designing projects, solving problems, and communicating ideas.

Major Points:
- Educating the public about disaster preparedness is important
- Using technology and new approaches to strengthen preparedness
- Enhancing students’ computational thinking skills

Summary: This study exposed EMT major students to interactive media, an area that is unfamiliar to them. Students with no prior programming experience created interactive games. The interactive media created in this project needs to be used to raise awareness of disasters’ significant impact and to help people prepare for emergencies. This study investigated if people can reinforce the safety and preparedness messages by repeatedly playing those games.
First-Year Mechatronic Experiences: Towards Predicting Student Motivation

Author(s)
Dr. John Haughery, Iowa State University, Ames, IA
Dr. Raj Raman, Iowa State University, Ames, IA
Dr. Steven Freeman, Iowa State University, Ames, IA

Need: A data-driven answer to whether and to what degree a mechatronic experience impacts students’ level of motivation will significantly contribute to the discussion of first-year undergraduate education.

Overview: Current literature has offered limited empirical evidence illustrating the impact that mechatronic experiences in first-year undergraduate courses have on student motivation and engagement. While there is much anecdotal evidence that these experiences are “exciting”, “fun”, or “interesting”, an evidence-based foundation that clearly delineates the impact of how students are motivated to engage has eluded publication. Therefore, a data-driven answer to whether and to what degree a mechatronic experience impacts students’ level of motivation will significantly contribute to the discussion of first-year undergraduate education.

Major Points:
• Mechatronic experiences impact the motivational orientation of students in first-year applied engineering courses
• Different student subpopulations were impacted differently by the mechatronic experience

Summary: This research examined the impacts that a half-semester mechatronics project in a first-year undergraduate course had on students’ motivational orientation.
Thursday, November 2, 2017

Teaching Innovations

From Handshakes to You're Hired: Incorporating Professionalism into the Curriculum

Author
Ms. Jennifer Warrner, Ball State University, Muncie, IN

Need: According to research conducted by York College of Pennsylvania, less than half of the human resources professionals surveyed reported that new employees exhibit professionalism during their first year at work. Professionalism is considered a key employability skill that college graduates must possess in order to be successful in their careers. In college, students learn about technical skills related to their major and about general soft skills, but not all students participate in activities to learn about and to develop professionalism skills.

Overview: This presentation discusses activities and strategies to teach students about professionalism that have been incorporated into several courses in a university’s construction management curriculum. Professionalism skills incorporated into the curriculum include communication, interviewing, networking skills, and internship and job search etiquette. Through activity based instruction, students learn the skills necessary to be successful professionals in their industries. During this interactive and hands on presentation, attendees will learn about assignments related to professionalism that can be incorporated into the curriculum at other institutions. Attendees will also have the opportunity to participate in sample professionalism activities.

Major Points:
• Reasoning for including professionalism into a program’s curriculum
• Innovative teaching strategies to teach professionalism
• Plans for modifications to the professionalism curriculum based on student and industry partner feedback

Summary: Attendees will understand the value of including professionalism into a program’s curriculum. Attendees will learn about innovative teaching strategies and course content related to professionalism that could be incorporated into curriculums at other institutions. Attendees will learn how to incorporate industry partners and students’ experiences into the professionalism activities and course content.
Integrated STEM Assessment Design: Challenges and Opportunities

Author
Dr. Paul Asunda, Purdue University, West Lafayette, IN

Need: This presentation will present a process by which educators may reflect upon as they implement and seek to assess integrated STEM learning activities in their teaching practices.

Overview: This presentation will present a process by which educators may reflect upon as they implement and seek to assess integrated STEM learning activities in their teaching practices.

Major Points:
- Assessment
- Performance Assessment
- Standards
- open-ended design challenges
- student outcomes

Summary: This presentation will present a process by which educators may reflect upon as they implement and seek to assess integrated STEM learning activities in their teaching practices.
Thursday, November 2, 2017

Teaching Innovations

IoTNet: Enhancing Cyber Security Education

Author(s)
Dr. David Hua, Ball State University, Muncie, IN
Dr. Edward Lazaros, Ball State University, Muncie, IN
Dr. Christopher Davison, Ball State University, Muncie, IN

Need: If IoT technology is to be adopted into society, concerns of consumer safety and privacy must be addressed and understood to allow for the continual growth of this field and the associated devices.

Overview: The Internet of Things has introduced an increasing number of products and services that are based on embedded systems. These items have the potential for transforming the ways in which people live and work.

Major Points:
- Introduce the concept of the Internet of Things and its component parts
- Identify the potential risks associated with using IoT technologies
- Discuss the need for cyber security education
- Discuss the IoTNet extracurricular project

Summary: The presentation will highlight the need for improving cyber security education; the design of the IoTNet project; and the impact the project has had on the student participants."
Lean Gamification between Industry and University

**Author**
Dr. Ahmed Deif, California Polytechnic State University, San Luis Obispo, CA

**Need:** The presentation will highlight the impact and challenges of applying games in order to create a “learn by doing” environment to prepare students to industry.

**Overview:** The research explores the impact of gamification as a powerful experiential pedagogical approach. Results of the conducted study over the course of 1 year highlight important aspects of gamification application and its impact on students engagement. In addition, it will discuss the challenges associated with the specific studied games in terms of importing them from industry to the undergraduate environment. The discussion will reveal some recommendations of games design in this educational level to prepare students for real practice.

**Major Points:**
- Gamification and Students engagement
- Gamification and students’ preparation for industry
- Educational Games design challenges and recommendations

**Summary:** The study attempts to understand under what circumstances different game elements can drive Lean thinking learning behavior among students.
Measurement and use of critical thinking in a fluid power course

Author(s)
Mr. Saxon Ryan, Iowa State University, Ames, IA
Dr. Gretchen Mosher, Iowa State University, Ames, IA

Need: Critical thinking has been noted as an important topic in STEM education fields. Students with critical thinking skills can analyze a situation and make a justified decision choice, both important skills for STEM graduates. Previous research has suggested that several factors play a role in a student’s critical thinking and decision-making skills. However, little research has focused on applying these findings in a fluid power course. This research focuses on how critical thinking can be measured in a fluid power classroom with authentic assessment with the intention of enhancing student assessment in this environment.

Overview: This presentation will provide an overview of the decision-making methodology and critical thinking aspects inherent to fluid power education. Options for authentic assessment will be shared, with a specific focus on decision-making applications. Implications for student learning and assessment in the fluid power classroom will conclude the presentation.

Major Points:
- Critical thinking in the fluid power laboratory
- Critical thinking measurement framework
- Authentic assessment opportunities in the fluid power laboratory using decision-making cases
- Implications for student learning and assessment

Summary: The audience will learn about decision making and critical thinking aspects that can be used to enhance student education in a fluid power classroom. Implications relating to authentic assessment opportunities and student learning will also be shared.
Thursday, November 2, 2017

Teaching Innovations

Stacking credentials with industry partnerships and support

Author(s)
Mr. Steve Williams, Utah State University, Logan, UT
Mrs. Trina Nye, Utah State University, Logan, UT
Dr. Trevor Robinson, Utah State University, Logan, UT

Need: Regionally there is a large automated manufacturing industry (i.e., food systems, air bag components, and fitness equipment). This produces a need for skilled workers in robotics, automation, and control. In recent years, industry has had to search for this skilled labor out of state, which led to higher turnover rates.

Overview: Our University has partnered with the local industry to not only provide the degree credentials they wish their employees to have but also to provide a mechanism for them to send current employees who are seeking a promotion and/or wage increase. This program utilizes a “stackable credential” method, which allows the students to step through their degrees.

Major Points:
- Degrees developed through industrial advisory committee
- Industry support through employee tuition reimbursement programs
- Industry employment obtainable after each step through the program
- Partnerships with other academic institutions
- Available via distance education
- Faculty externships available

Summary: This program utilizes a “stackable credential” method, which allows the students to step through their degrees. These partnerships with industry include: tuition reimbursement for employees wishing to go through the program, internships with industry as part of the degree, collaboration with industry for senior projects, advisory committee participation including feedback and continued development of the program, externships available for faculty to participate in the industry during summer months.
Thursday, November 2, 2017
Teaching Innovations

Successful USGBC LEED® Lab™ Implementation

Author(s)
Dr. James Jones, Ball State University, Muncie, IN
Mrs. Janet Fick, Ball State University, Muncie, IN

Need: Technology programs are known for their applied learning approaches that develop solutions for real-world problems. The LEED® Lab™ program provides an opportunity for students to learn about sustainability while certifying an existing building on campus, providing actual project experience while simultaneously benefiting the institution.

Overview: The United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) certification program recognizes energy efficiency and sustainability in the built environment. Its new LEED® Lab™ program promotes sustainability at the student level through their participation in certifying a campus building through the LEED for Existing Buildings: Operations and Maintenance (LEED-EBOM) program.

Major Points:
- USGBC LEED® Lab™ overview
- Course development process
- Institutional factors
- Lessons learned
- Challenges
- Conclusions and recommendations

Summary: This presentation examines how one program successfully implemented a program for its institution, which resulted in the third submission for certification through the LEED Lab program.
Thursday, November 2, 2017

Teaching Innovations

Teaching 101: Foundations of Successful Instruction

Author
Dr. Kimberley Gordon, University of Arkansas-Fort Smith, Ft Smith, AK

Need: Subject matter expertise of the professorial community is confirmed by the terminal degrees held by its faculty. However, many academics have little -- if any -- formal training in the art and science of education. The same is true for technical experts: a wealth of knowledge and skill yet a dearth of comprehension of teaching systems.

Overview: This session will provide foundational information about the primary learning theories, instructional design from inception in the early twentieth century to modern classrooms aided by technological advances. This session includes a case studies involving the use of instructional design in a variety of settings.

Major Points:
- Why it matters to understand and use Instructional Design (ID, ISD)
- Learning theories overview: behaviorism, cognitivism, and constructivism
- New favorite: Auten Instructional Design Model

Summary: Frequently referenced as an emerging discipline, instructional design – and instructional systems design – refers to a systematic process for developing instruction by following a prescribed model focused clearly on accomplishment of desired learning outcomes. Quite simply, instructional design provides a clear, direct map to guide educators through the creation of lessons in accordance with curriculum expectations.
Thursday, November 2, 2017

Teaching Innovations

Teaching Critical Reading and Responsiveness for the Mobile Age

Author(s)
Dr. Vigyan Chandra, Eastern Kentucky University, Richmond, KY
Dr. Ray Richardson, Eastern Kentucky University, Richmond, KY

Need: The inability to make difficult professional decisions effectively can potentially jeopardize lives, compromise sensitive personal information, or damage equipment. In industries such as aviation, network security or manufacturing there is a need for graduates to perform online research quickly, prioritizing their findings, then think through and respond appropriately. Critical thinking and response skills thus need to be taught using the technologies graduates are likely to have at hand in the workplace.

Overview: With the fundamentals of the discipline internalized, presenting different contexts within which this learning should be applied, with consideration for legal/ethical issues, and the best practices being followed by the industry will allow students the opportunity to correlate these different streams of information while choosing an appropriate course of action. The presentation will provide ideas for using a combination of conventional and mobile technologies for helping students address the needs of the industry they are entering.

Major Points:
- Industry specific requirements for critical reading and responsiveness skills
- Mobile connectivity in the classroom and learning hindrance or catapult
- Structuring case studies what-if scenarios, computer simulations, mobile technologies within the learning environment for promoting better decision making
- Listening, involving and challenging students develop their responses relying on fundamentals of the discipline

Summary: Professionals working in industries that require quick, safe, and proportional actions to events presuppose a solid foundation of their discipline and accompanying thinking skills.
The Preceptorial: Rigorous Small Group Educational Experiences Using Industry Partners

Author
Dr. Tim Obermier, University of Nebraska Kearney, Kearney, NE

Need: Many technical programs have conducted field trips for students to engage in learning experiences that are impossible to create in the classroom. These experiences allow students to witness the application of theory taught during classroom instruction.

Overview: The author of this presentation has utilized a preceptorial successfully for twenty years within an information technology program. Program graduates consistently rank the preceptorial as the one most important course in their major.

Major Points:
• What is a technical preceptorial course?
• How to use a preceptorial in technical programs to synthesize classroom concepts, develop soft skills and build industry partnerships.
• How to plan, organize, and implement an academically rigorous preceptorial course.
• What are the benefits to companies, students, instructors and the academic program?

Summary: This presentation will provide an overview of how industry-education partners can provide a rigorous technical student learning experience beyond the classroom using the preceptorial teaching/learning method. This method is particularly suited for high equipment cost programs or those programs preparing students in technological fields with complex enterprise level systems.
Trends for getting Technology Teachers in the K-12 classrooms

Author
Mr. Darnell Austin, California State University, Fresno, CA

Need: The STEM movement in the public schools has expanded offerings for industry based technology classes but it is a challenge to find qualified teachers for these classrooms. This presentation will describe a way being used in California to solve this teacher shortage.

Overview: After a discussion of the changing face of technology programs in the secondary schools, the requirements of getting qualified teachers in the classroom will be presented, including why there is a shortage of teacher in the field. A method in use in California to solve this problem will be presented.

Major Points:
• Industry is supporting commercial curriculum packages, such as PLTW, bringing industry partners into the public school classroom
• Solving the shortage of qualified technology teachers in California
• Where do the teachers come from?
  • Industry = CTE credential
  • Those already teacher other subjects = Single Subject credential
  • Combining subject matter competency test (CSET) with methodology course brings other teachers into technology subjects = second credential
• How it is working in California

Summary: So many school districts are taking advantage of a way to turn professional teachers in other disciplines into technology teachers. This requires passing a test for technology competence and methodology instruction about hand-on, project based education. Examples of how this is working are presented.
Thursday, November 2, 2017

Teaching Innovations

Universal Instructional Design and Delivery

Author(s)
Dr. James Jones, Ball State University, Muncie, IN
Mr. Gary Birk, Ball State University, Muncie, IN
Mrs. Valerie Birk, Ball State University, Muncie, IN

Need: As more students with disabilities are found in the college classroom, instructional design and delivery should be adapted to accommodate learning for all students.

Overview: Technology educators are seeing more students with disabilities in their classrooms, which poses more challenges for both professors and learners. By adopting universal instructional design principles, instruction may be delivered effectively to students of all abilities. Some of these approaches are easily implemented, such as making readings available in electronic format so that they can be viewed more readily by those with sight impairments, and some require more effort, which is rewarded by making technology education available to a more diverse student body.

Major Points:
- Need for making instruction more accessible
- Benefits for all students
- Principles of universal instructional design
- Application through delivery, facilities, and other aspects
- Tips and techniques
- Challenges and solutions
- Conclusions and recommendations

Summary: Attendees of this presentation will understand successful universal instructional design approaches for making learning accessible to all. The need for making instruction more accessible, as well as the benefits, principles, and approaches, are detailed. By adopting these methods, technology educators can make their instruction more accessible to students and the future workforce.
Thursday, November 2, 2017

Teaching Innovations

Using Escape Rooms to Teach Problem Solving in a Technology Management Classroom

Author(s)
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Need: An effective way to construct a future for tomorrow’s students is to engage them with scenarios which allow them to work together to solve a problem.

Overview: The purpose of this presentation is to provide the audience with an overview the results of using the “escape room” concept to help students work in teams to solve problems. This concept strives to mimic team problem solving in a fun and engaging environment. The team is put in a high pressure situation because of the time limit and tasked with solving a series of problems or puzzles. They have little time to become cohesive and overcome conflict. They must work together to uncover the clues.

Major Points:
• Overview of research relating to escape rooms in education
• Results of a case study involving using escape rooms to teach curricular concepts and skills
• Recommendations for adding an escape room module to existing curriculum

Summary: This presentation intends to use the escape room concept in an educational setting. The audience will be provided with an overview of using the “escape room” concept to help students work in teams to solve problems in a fun and engaging environment.
Thursday, November 2, 2017
Teaching Innovations

Using strengths-based leadership in a senior capstone course

Author
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Need: The capstone course is an important leadership experience for graduating students in technology and engineering. Several factors influence the capstone experience, but important predictors identified by previous researchers are the ability of teams to manage project details effectively and to work together as a functional team. The Strengths-Based Leadership program offers the opportunity to provide professional development for graduating students and to construct teams that are well positioned for success in a course that has been historically demanding for graduating seniors.

Overview: The presentation will provide an overview of the Gallup-based Strengths-Based Leadership and its application to the senior capstone course sequence for technology students. Implications for team construction, decision-making, and project management will be discussed. Limitations and challenges using strengths in the capstone course will conclude the presentation.

Major Points:
- Strengths-based leadership
- Why the program is well-suited for capstone students
- Connections with team construction, decision-making, and project management
- Limitations and challenges of strengths-based leadership with undergraduates in capstone

Summary: The presentation will provide an overview of the Gallup-based Strengths-Based Leadership and its application to the senior capstone course sequence for technology students. Implications for team construction, decision-making, and project management will be discussed.
Virtual Scenario for Maintenance Training

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Need: Educational and industrial specialized training has serious deficiencies. This presentation addresses this problem and proposes a technologically advanced solution with several benefits including cost reduction and an increase in safety that revolutionizes the way employees and students train.

Overview: The presentation will address the problem and explain the solution. Following the explanation, the presentation will show the steps that had to be taken to develop Virtual Training Scenarios and explain its benefits. The presentation will then show the different areas where Virtual Training can be applied and how it can be applied in industrial and educational environments. The presentation will then finish with a short demonstration of a Virtual Scenario.

Major Points:
• Justification
• Solution Approach
• Software Development Process
• Technology Advancement
• Different Uses
• Benefits
• Example

Summary: Attendees will gain an understanding of how new technology can be applied to industrial and educational specialized training. Virtual reality devices commonly used for entertainment can be applied to training scenarios to improve the way employees and students prepare themselves for real life industrial maintenance.
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A Microsoft Kinect-based Gesture System to Enhance 3D Visual Communication in Virtual Collaboration

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Abstract
Effective synchronous internet-based collaboration is essential for companies to succeed in today's globalized business environment. However, the function of existing computing tools for 3D object manipulation in collaborative product development sessions is still limited: In addition to the problem that the 3D object is presented via two-dimensional screens, the user interface to manipulate these objects is not intuitive for novices, and the presentation is usually one way instead of two-way, simultaneous interaction. To address these concerns, we present a low-cost virtual collaboration environment built upon the Microsoft Kinect system and driven by a gesture-based interface. The rationale of the system design and results from initial tests will be presented. In addition, limitations related to vision-based cameras for 3D reconstruction will be reported, and the paper will conclude by identifying several future research directions.

Introduction
With the breakthrough of internet-based computation technology in the last decade, the “follow-the-sun” business model (Carmel, Dubinsky, & Espinosa, 2009) for the extended enterprise becomes much easier to realize. Given that more product research and development are done via the collaboration of a virtual team across different time zones or locations, the practice of “collaborative product commerce” (Bardhan, 2007; Hung, Chang, Yen, Kang, & Kuo, 2011) is no longer solely practiced by major corporations in Aerospace or Automotive industries. The result is that small to medium size enterprises can also take advantages of modern communication tools to form strategic alliances and enter new markets.

For example, company X located in Minneapolis, USA, might have won the contract from an European Agriculture Machinery company to design the electrical control panel for its next generation tracker. After evaluating the digital mockup of the tracker's panel sent by its client, company X found that a switch would not fit into the pre-specified hole. With the help of modern computing tools, company X could hold a synchronous conference call with its client in Europe to discuss the possibility of moving the hole to a different location. The participants in the conference might evaluate the Engineering Change Request from company X's engineers, determine the specification of the switch, its geometry and location on the panel, and verify if the proposed change would affect the ergonomic criteria before a final decision could be made.

Issues of Existing Technology
Nevertheless, there has not been much progress made in terms of the user interface for the type of collaboration mentioned, due in part to creative approaches, and possible hardware and software limitation. The majority of technical breakthrough made so far is mostly at the backend: Broader bandwidth, higher definition of video and audio, greater speed of streaming, etc.. But the user interface for synchronous internet-based collaboration remains pretty much the same as it was twenty years ago. The presentation of information, including that of three-dimensional objects, is mainly done through flat images or video, and controlled through two-dimensional devices such as conventional mice or touch screens (Moscovich & Hughes, 2008). The spatial manipulation of three-dimensional objects, especially rotation in the 3D space, is still done by a triad (Nielsen & Olsen Jr, 1987). While this Cartesian coordinate-like triad allows the user to translate or rotate the object along the X, Y, or Z axes, it is not intuitive to untrained participants. Last but not the least, people at the listening end in a conference call most likely have no way to interact with the content until the control (the sharing of mice, whiteboard, software, or the presenter's computer desktop) is passed to them from the other end (Rekimoto, 1998; Armstrong et al., 2005). And further, the lack of spontaneous interaction could also impact real-time contributions that might be vital in collaborative exchanges.
In this paper we report an ongoing research project on a gesture-based, “natural interface” (Figure 1) designed to enhance the user experience of object manipulation in 3D space during the collaborative conference sessions. Through its ability to track human’s skeletal movement (“Developing with Kinect,” n.d.), individuals can manipulate objects with their bare hands in this proposed Microsoft Kinect-based virtual collaboration environment instead of using additional mice or touch devices. Moreover, the “hands” of participants visible in the virtual environment also can serve as the visual aid to “highlight” specific features on an object, or “direct” the audience’s attention to the focal point at the time. Illustrated in Figure 1, the participants of the synchronous collaboration sessions at different sites can use their hands to interact with the object of discussion directly, besides communicating through conventional video or audio conference tools.

System Design Consideration for 3D Object Manipulation

Researchers (Gallo, De Pietro, Coronato, & Marra, 2008; Moeslund, Störring, & Granum, 2001) have reported their work of natural interface design for spatial navigation in virtual environments. In these studies, infrared cameras were used to track the motion of a stylus or a Nintendo Wii wand, to “point” to a specific direction or an object for further manipulation. To avoid the passing of control during the collaboration session, the vision-based camera technology used in the Microsoft Kinect system was selected to eliminate the need of additional hardware.
As seen in Figure 2, both the Kinect V1 camera and V2 camera utilize one RGB camera and one IR depth camera. The spatial coordinates of joints in individuals' skeletal were then calculated by comparing images from both cameras. While some researchers utilized the movement of an individual’s body members to control digital or physical objects (Gallo, Placitelli, & Ciampi, 2011; Sanna, Lamberti, Paravati, & Manuri, 2013), others used the skeletal data to study human kinematics (Dutta, 2012; Gabel, Gilad-Bachrach, Renshaw, & Schuster, 2012). Because of the broader bandwidth of its USB 3.0 interface (5gbps vs. 60mbps of USB 2.0), the Kinect V2 camera can collect a larger amount of spatial data to describe more detailed movements. The tracking algorithm in the Kinect V2 system, along with its higher resolution cameras (1920x1080 vs. 640x480 for RGB camera, and 512x424 vs. 320x240 for depth camera), provide additional joint information to help recognize precise skeletal movement such as hands. With four joints (thumb, wrist, tip, and palm, vs. wrist and tip only in V1) identified for each hand, more sophisticated gestures such as “hand close”, “hand open”, “hand movement”, and “wrist rotation” can be designed for 3D object manipulation, e.g. grab, release, translation, and rotation respectively. The number of users could be tracked by the camera is also triple (six total vs. two in V1), which allows more participants at one site to interact simultaneously.

Figure 3. The system architecture of the proposed virtual collaboration environment

The virtual collaboration environment reported in this paper was built and tested. Figure 3 depicts the architecture of the proposed system: In addition to the Microsoft Kinect V2 camera and Kinect V2.0 SDK, a commercially available API, Unity v5.3.4 Personal, was used for rendering. The software development environment was Microsoft Visual Studio 2013, and the language used was C#. The computation platform was a Lenovo W520 mobile workstation, equipped with an Intel i7-2920XM processor, 16GB memory, and an Nvidia Quadro 2000M video card with 2GB Ram which supported both Open GL and Microsoft DX 11. The operating system was Microsoft Windows 8.1 installed on a Solid State Drive.

Further examination, to design the gesture system, could involve behavior observation of conference participants who will be able to use their hand gestures to interact with the object of discussion without holding additional hardware. Seeing how various individuals in a product design brainstorming session interact with the physical prototype could provide useful information regarding the current implementation of the proposed system around three sets of gesture, namely “object grab/release,” “object translation/rotation,” and “object pointing”.

Results of Current Implementation

In an operational scenario, once the user hands engage with the Kinect V2 camera by entering its zone of detection, the spatial coordinates of the user's hand joints were used to create a “right hand” on the screen, which the user could use to grab the object, move it in the space, turn it around, release the object, and point at specific areas. Currently the user's left hand is used for grab and release the object, while the right hand is used to control the object's spatial location and orientation. Table 1 listed the existing combination of gestures in order to manipulate the object in the virtual workspace.
There were also several things to consider to provide a better user experience. Besides the color, material, and texture rendition of the object, the rendering engine Unity provided features such as gravity and collision to simulate the physical world behavior. These features could allow users to have a more “natural” or “intuitive” experience, since the virtual object behaved similarly as in their real life experiences. However, these physically based rendering features also challenged the computing hardware used. A test of the gesture system in real time revealed some unanticipated results, namely a lot of lagging or jittering as more features were turned on. These results were possibly due to a need for more computing power, and optimized gesture detection algorithms are highly recommended to alleviate these problems.

### Limitations of Vision-based Cameras

While the proposed system appears to be promising, there were some limitations of vision-based camera such as Microsoft Kinect’s sensors. Of particular significance is that certain orientations of the hands could cause miscalculation, as illustrated in Figure 4. Whenever the index finger of the right hand turned to an orientation, the locations of four hand joints (gray squares lined with green lines) were not separated enough to determine their spatial location, the virtual hand could suddenly turn to the opposite direction. Similar situations also occurred in most of the vision-based camera systems. For example, the IR-based Leap Motion controller, while it recognized all ten figures of the human hand. Such a glitch could confuse the users and might cause unnecessary miscommunication.

**Figure 4. Problematic orientations (from left to right): Pointing forward, sideway and backward**

A similar situation could be observed with the hand open-close gesture, as shown in Figure 5. The skeletal in the left screen shot is an open left hand facing the camera, with the thumb pointing to the right, while the skeletal in the right screen shot is a closed left hand turned with the palm’s external edge facing the camera. The current system’s algorithm would consider both scenarios the same, causing the user to accidentally pick up the object or drop it unintentionally. While the issues discussed in Figures 4 and 5 could be addressed by an additional camera in a different angle, the extra computing power needed would be drastic.

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**Table 1. The object’s spatial manipulation and corresponding hand gestures**

<table>
<thead>
<tr>
<th>Rendered Object Movement</th>
<th>Object being grabbed or released</th>
<th>Object being translating or rotating in space</th>
<th>Object being pointed at the specific area</th>
</tr>
</thead>
<tbody>
<tr>
<td>User’s Right Hand</td>
<td>No need</td>
<td>Hand moving and wrist rotating in space</td>
<td>Index finger pointing at the specific area</td>
</tr>
<tr>
<td>User’s Left Hand</td>
<td>Hand closed or open</td>
<td>Hand closed</td>
<td>Hand open</td>
</tr>
</tbody>
</table>
There is yet another limitation of the vision-based camera system; when more than one user were engaged in the virtual space through the same Kinect camera, some user’s virtual hand might engage the object when it should not. This is due to how the camera captures every hand’s physical location and converts it into the virtual space. One user’s hand might be “in front of” the object, while the other’s hand was “behind” the object. In real life the hand behind would not be able to touch the object. However, the current implementation would still allow the hand to interact with the object. This would not happen in Kinect’s application in the Xbox game console, as participants were either engaging in different items, or the joints’ spatial coordinates were utilized to determine the specific gesture patterns instead.

**Conclusion and Future Research**

In conclusion, we presented in this paper the need justification, design consideration, and issues of a gestured-based system for 3D object manipulation in the virtual collaboration environment based on the Microsoft Kinect V2 system. The advanced vision-based camera enabled the user to manipulate the object in the virtual workspace without additional hardware. While the functionality of the current implementation is limited, it presented an effort toward a natural interface that echoes our experience in the physical world. As more and more companies engage in the development of vision-based sensory systems, a gesture system could drastically reduce the effort of learning and utilization, especially for the upcoming virtual reality, augmented reality, and mixed reality applications.

To better understand whether the proposed gesture-driven natural interface is able to enhance the user experience, further studies will be necessary. Firstly, an experimental study is needed to evaluate the user’s task performance between using conventional mice and through the Kinect system for object manipulation. The intuitiveness of the system can also be determined by the user’s time needed to “master” the interface and the results of a self-reported survey. Secondly, a carefully designed study is essential to understand whether the addition of visible hand gestures significantly improve the communication between users at different locations and reduce the time to complete assigned tasks. Last but not the least, while Microsoft claimed that the Kinect V2 system was able to support up to six users simultaneously, it is unknown whether the proposed system will be able to handle the amount of spatial data and provide meaningful yet simple collaboration sessions when handling the “control” of the object among more than one set of hands. Further development of the system might be necessary.
Reference


Thirsty for a Solution: Using Waste Plastic Bottles as an Additive to Enhance Asphalt Characteristics in Roadway Design

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Introduction: As we look into the future there is an unprecedented expected scarcity of fossil fuels and raw materials. In an effort to preparing young professionals, college curriculum has increased the topic of sustainability with energy efficiency, new technologies to reuse and recycle in new construction and design. Construction of new, sustainable structures has to be designed with the thought of reuse rather than simply new raw materials. This can be accomplished by considering how to repurpose materials that have already been manufactured, hence a shift in the throw away mentality (Sieffert, Huygen, & Daudon, 2014). The concept of sustainability was first described as developing ideas that meet the present needs with the least negative impact to future generations. During the last 30 years, there have been unprecedented increases in development, industrialization and population growth. These have raised concerns that the resulting damage to the earth's environment and quality of life for future generations will be irreparable. Researchers and professionals have a moral role in transforming societies and helping society by creating a more sustainable world.

This paper presents an informative interest focusing on the use of repurposed materials, more specifically, using waste plastic bottles or polyethylene terephthalate (PET) in asphalt pavement design. The rationale is described behind the re-use of materials and details the environmental concerns, economic cost concerns, how the additive is made for the asphalt, and its general design. Research studies and a case study of asphalt containing the waste plastic bottles by the Pennsylvania Department of Transportation is used as an example to help the reader gain connection of the concept with implementation.

What is PET? Nowadays, many countries are seriously encountered with problems related to waste PET, classification code 1, which is polyethylene terephthalate. In Trinidad alone it is estimated that over 500 million plastic bottles are disposed in landfills annually (Maharaj, Maharaj, & Maynard, 2015). Municipal solid waste in the U.S. on an annual basis is comprised of roughly 1.7 million tons of PET, according to the U.S. Environmental Protection Agency (Sulyman, Haponiuk, & Formela, 2016). There are two main categories of plastics used in asphalt mixtures, thermosetting polymers and thermoplastic polymers. Thermosetting polymers are cured by heating and cannot be reshaped while thermoplastic polymers can be reshaped by heating. PET is classified as a thermoplastic which exhibits dimensional stability when subjected to variable loading, good mechanical and physical properties, as well as good barrier properties to gas and chemical resistance (Sulyman, et al., 2016). PET falls into three main waste streams: bottles, foils, and cord from tires. Each waste stream has problems and issues. Bottles tend to have impurities, these could be due to gluing on the labels or additives during production. Problem area for foils is due to the additives, such as stabilizers, during production. Tire cords tend to be contaminated with metals and tire rubber (Sulyman, et al., 2016). This plastic is commonly recycled and is used for beverage bottles, medicine jars, carpet fiber, and rope. This plastic can absorb flavors and odors from the contents they hold (Ryedale.gov). The ability of plastic bottles being flexible yet strong, is due to added chemicals known as plasticizers. These chemical additives also have the ability to cause adverse health issues in humans. Not all plastic bottles have these harmful chemical additives, so how can you tell which bottles do? The recycling classification number, usually located on the bottom, provide a general guide as to the additives. Polyethylene terephthalate (PETE or PET) designated with a #1 recycling classification is the main material used for containers for individual serving size drinks (water, soda). Unlike other plastics or polymers, to produce PET requires minimal additives and antioxidants or plasticizers are not required. The formulation of the polymer or physical stress applied to the plastic creates substances, known as non-intentionally added substances that are found in PET. These substances have the potential of transfer to the...
contents of the plastic container (Bach, Dauchy, Severin, Munoz, Etienne, & Chagnon, 2014). The ingredients included are methane, ethylene and xylene combined with ethylene glycol. This type of container also have stabilizers for UV along with flame retardant chemicals. #1 and #2 type of plastics are the most recycled. Regardless of the type or designation of plastic, air pollution toxins are present during both production and incineration (Marchese, 2011). PET is a thermoplastic polymer resin of the polyester family and is used in synthetic fibers, beverage, food and other liquid containers, thermoforming applications and engineering resins often in combination with glass fiber (Maharij, et al., 2015). PET is produced by the polymerization of ethylene glycol and terephthalic acid. Ethylene glycol is a colorless liquid obtained from ethylene, and terephthalic acid is a crystalline solid obtained from xylene. When heated together under the influence of chemical catalysts, ethylene glycol and terephthalic acid produce PET in the form of a molten, viscous mass that can be spun directly to fibers or solidified for later processing as a plastic (Modarees & Hamedi, 2014).

Utilization of waste material as secondary material is being developed world wide. One of these waste materials is plastic bottles which are being produced in large amount. In food industries, plastic bottle is mostly made by Polyethylene Terephthalate (PET), and PET become very popular during the last decade because it is known as safe, durable and good material for packaging. Today, producing waste plastic becomes a main problem in many societies when it can be found almost everywhere specially in landfills. Therefore, it would be rewarding if waste plastics can be reused, for instance, in projects such as pavement construction as a useful material in order to improve service life of road pavement in one way and preventing from environmental pollution as well. On the other hand, by increasing number and frequency of passing vehicles, especially heavy vehicles such as trucks and vans which have higher gross weight than passenger cars, service live of road pavement decreases. There are different ways to improve asphalt mixture properties. First is constructing road pavement with higher thickness and second is using different types of additives as modifier in asphalt mixture. Constructing high thickness pavement will cause considerably higher construction cost. Thus, using additives might be a better solution to overcome the pavement deterioration problem. (Moghaddam, Karim, Soltani, 2013). According to the director of the Central Road Research Institute (CRRI) bitumen mixed with plastic or rubber improves the quality and life of roads (Verma, 2008).

Environmental Concerns: Plastic is used for nearly every aspect of our lives including packaging, protecting, serving, and even disposing of all kinds of consumer goods. With the evolution of the industrial revolution plastic has become cheaper and effective raw material. Today, every sector of the economy from agriculture to automobiles to building construction materials have been revolutionized by the application of plastics. Use of this non-biodegradable product continues to grow and therefore the increasing problem is what to do with the plastic-waste. Studies have linked the improper disposal of plastic to problems such as breast cancer and reproductive problems in humans and animals. So the concern is with the judicious use and re-use of plastics and plastic-waste (Verma, 2008). Statistics show that our air is being polluted at the rate of 150 million tons/year with 60% being credited to automobiles. 95 million Americans are drinking contaminated water, and solid waste outputs average 1,500 lbs./person/year with a present rate of increase of 6% annually. To purchase the New Times it costs $0.35 and it costs $0.65 to dispose of it. The situations described above are by no means a problem unique to the U.S. In 1969 it was estimated that 40 million fish died in the Rhine. The Thames where once there had been excess salmon, there have been none 200 years and the Blue Danube is unfit for bathing (bacteria count of 500 million/cc compared with 1,900/cc upstream). There are parts of Galveston Bay that are so polluted that there are warnings regarding consumption of the shellfish that could lead to infectious hepatitis. There are reports from Soviet press regarding reduced amounts of caviar due to pollution killing the sturgeon Each year Americans throw away 50 billion tin cans, 26 billion bottles, 30 million tons of paper, and 4 million tons of plastic in addition to another billion tons of agricultural waste. (Bynum, Everton, Fleisher, Ray, 1972).

A vast amount of solid waste in the world are due plastics which are used to produce or package nearly everything we purchase. These plastics are derived from petroleum or natural gas and composed of carbon, hydrogen and oxygen
Plastics exhibit a high decomposition temperature, high resistance to ultraviolet radiation and are mostly not biodegradable, resulting in the fact that they remain in the environment for years causing pollution. Plastics deteriorate by breaking into smaller fragments called macro/meso/micro-plastics. These fragments have significant negatives impact the ecosystem as well as humans and animals health. The degrading plastic releases toxic chemicals which can be transmitted up the food chain. Due to the impact on the ecosystem, prevention and minimization of plastic waste should be prevented by reuse and recycling. New policies and recycling methods should be developed before plastic waste becomes an unsolvable problem (Gürü, Metin, Kürşat, Arslan, Ali, Bilici, 2014).

Recycling has been slow to progress due to lack of education and communication. Waste is defined as “Superfluous material produced by a manufacturing process, something allowed to escape without being utilized, etc.” Part of the issue with recycling is that of responsibility. The highway engineering claims that the disposal of wasted solids is not their responsibility resulting in limited research toward improving highway performance by utilizing garbage in the pavement. City governments are responsible for waste disposal and street construction, yet they lack the resources to perform the research. In an effort to assist the federal government initiated several research efforts, however there is limited trained personnel. In furthering the recycling effort, it must be a profitable business. To do this, the processing must become a minimum (Bynum, et al., 1972). Polyethylene terephthalate (PET) bottles make up the vast majority of the waste, as single-use PET bottles have a short service life and therefore turn into residential (post-consumer) plastic waste in a short period of time. With this being the case it would be worthwhile to find new application areas for PET bottles (Gürü, et al., 2014).

Scientists and researchers are looking for ways to recycle waste materials for environmental and economic advantages with specific reuse in road construction. Reusing waste materials can make a significant contribution to the environment and economy by helping to reduce the overuse of natural resources and saves them from exhaustion, reducing the environmental pollution level as a result of the waste materials generated in urban and industrial areas, and it contributes to saving energy and money. This re-use is especially vital with respect to plastic containers. (Ahmadinia, et al., 2011). This is where the use of PET in asphalt comes into play. TRW, Inc., of Redondo Beach, California, noted that significant improvement in the ductility of asphalt concrete would be expected if these types of plastic were blended in the asphalt binder or cut in chips for replacement of some of the aggregate (Bynum, et al., 1972). The usage of PET waste as a reinforcement component for asphalt concrete pavement material, Hot Mix Asphalt (HMA), can be a research area for such an aim which is still in its infancy. In the previous studies, PET waste was generally added to the asphalt mixture with dry process (mixture modification) or used as aggregate in the asphalt mixture (aggregate replacement) in order to improve HMA performance. Researches have shown that permanent deformation resistance, Marshall Stability, stiffness and fatigue life of the asphalt mixtures were increased while moisture damage resistance was decreased when PET was used as additive in the mixture (mixture modification) The replacement of aggregate with PET was also found to increase permanent deformation resistance but decrease Marshall Stability and stiffness (Gürü, et al., 2014).

Using waste plastic as a secondary material in construction projects would help to reduce the large amount of waste plastics while improving pavement characteristics. Many studies have investigated the effects of adding plastic bottles in road pavement with respect to the Marshall Hammer test and specific gravity of asphalt mixture containing different percentages of plastic bottles. Results of these studies showed an increase in both stability, stability, and flow values of asphalt mixture due to the addition of PET. However the test results showed that adding higher amounts of plastic resulted in lower specific gravity and mix stiffness. The study concluded that the mixtures containing waste PET have lower optimum asphalt contents (OAC) values compared to conventional mixtures and this may reduce the amount of asphalt binder that can be used in road construction projects. Besides, the mixtures containing waste plastic showed significantly greater fatigue resistance than the conventional mixture (Moghaddam, et al., 2015).

Wrapping up about environmental concerns that PET bottles cause, the re-use of wastes is important from a number of...
different points of view. It helps to save and sustain the natural resources which are not replenished; it decreases the pollution of the environment and it also helps to save and recycle energy in production processes. Due to their long biodegradation period, the disposal of plastic waste has harmful effects on the environment. It seems that asphalt mixes offer a good opportunity to utilize large volumes of PET in the civil engineering field (Hassanni, et al., 2005).

Previous Research Using PET in Asphalt Pavement: Understanding some basic research regarding PET, contaminates, and potential transfer to contents Bach, et al. (2014) studied the effect of sunlight exposure on PET containers filled with water. The research monitored bottled water, exposed to sunlight, for 2, 6 and 10 days, for contents of formaldehyde, acetaldehyde, and Sb. The study tested both non-carbonated and carbonated water in both PET and glass containers. The PET container, used for carbonated water, had a PA phase which reduces the O2 and CO2 permeability. After 10 day of sunlight exposure the PET bottles containing non-carbonated water showed small levels of formaldehyde and no acetaldehyde. The PET bottles without the PA phase containing carbonated water, after 10 days of sunlight exposure, showed levels of 15 µg/l of formaldehyde and 11 µg/l of acetaldehyde. The PET bottles with the PA phase containing carbonated water, after 10 days of sunlight exposure, showed that the acetaldehyde levels were double the levels found in the bottles without the PA phase. While the tests showed migration of aldehydes and Sb into the water contained in the bottles and this migration was enhanced due to sun exposure, yet not exceeding limits specified in regulations. The formaldehyde migration produces an off-flavor in the water. In the carbonated water, the levels increased due to the carbon dioxide in the water (Bach, et al., 2014).

During the recent years, engineers have been looking for new environmental friendly techniques in construction of roads pavement and much studies have been devoted to this research field. During the service life, many external factors might deteriorate the integrity of pavement. Among these factors, traffic loading is considered as the main factor which finally leads to fatigue cracking and permanent deformations especially in upper pavement layers. There are vast majority of cases which addressed the fatigue properties of conventional or modified asphalt mixes. Effects of many parameters and additives have been studied in this regard. Different additive materials including fibers and polymers have been used to improve the fatigue resistance of asphalt mixes. Most of these materials were found to be effective with beneficial effects on the fatigue behavior of asphalt mixes. The main reason of incorporating polymer modifiers in bitumen is to extend the range of service temperature or reduce the temperature sensitivity of them. These binders are visco-elastic materials. The degree to which their behavior is viscous or elastic is a function of temperature, loading period and loading duration. At high temperatures or long loading times, they behave like viscous liquids whereas at low temperatures or short loading times they behave as elastic (brittle) solids. Under intermediate conditions of the service period, they exhibit viscoelastic behavior in which the material’s response will be dependent upon temperature or loading velocity. For a polymer to be effective in road applications, it should be blend with bitumen and improve its efficiency at service temperatures without making it too viscous at mixing temperatures or too brittle at low temperatures (Modarres & Hamedi, 2014).

There are two common processes for mixing asphalt. One process is to mix the asphalt with the additives prior to mixing with the aggregate, this is referred to the wet process. The other process, referred to as the dry process, the additives are mixed after the aggregate has been mixed with the asphalt. The use of PET as an additive in an asphalt mixture can be accomplished by either using the PET as a replacement for the aggregate or by adding PET particles. One study incorporated PET to replace the course aggregate. The mixture used PET replacing 20% by volume of the asphalt mix with a result of this plastiphalt mixture meeting the majority of the required specifications for actual use. While proving to be more resistant to permanent deformation, plastiphalt was less stiff than traditional asphalt mixtures (Moghaddam, et al., 2014).

Moghaddam, et al. (2014), using the dry process to add PET to an asphalt mixture showed positive impacts when tested. The experimental plastiphalt mixtures added different amounts of PET, the best results were from mixtures that included 4%-6% PET by weight of asphalt content. The improvements included an increase in fatigue life and fatigue cracking in dynamic load testing, there was a decrease in permanent strain, and improvement in the mixtures resistant to rutting. For the tests 80/100
(penetration grade) asphalt was used with crushed PET passing 2.36mm sieve. The samples were prepared following ASTM D1559 procedures. Tests for bulk specific gravity were conducted according to ASTM D2726, Marshall Stability and flow tests according to ASTM D1559, indirect tensile stiffness modulus tests according to AASHTO TP31, and indirect tensile strength according to ASTM D6931. Results of the Marshall Stability tests for the plastiphalt mixture showed that PET mixtures are less rigid than standard asphalt mixtures. Stiffness abilities of the plastiphalt mixtures increase at low percentages of PET and decrease at the percentage of PET is increased. The plastiphalt mixtures showed lower tensile strength under static loading than standard mixes. The concluding results comparing mixtures of plastiphalt and standard asphalt were that the plastiphalt was lower in stiffness but showed higher resistance to permanent deformation due to dynamic loading (Moghaddam, et al., 2014).

Based on previous studies PET has a great potential to be reused as modifier in asphalt mixture. Results indicated that adding PET to asphalt raised the mix resistance against permanent deformation and rutting. During a laboratory study, Mahrez and Karim (2104) examined the effect of different PET contents on the properties of modified bitumen. They found that addition of PET to bitumen will increase the viscosity and reduce the temperature susceptibility of modified bitumen. Also, the PET modified bitumen showed preferable elastic properties than the original one (Modarres & Hamedi, 2014). In this study, waste plastic bottle (PET) was used as modifier additive in hot mix asphalt. To this end, PET bottles were cut into small pieces and crushed by a special crusher. Finally crushed particles were sieved to obtain the needed gradation. As indicated by previous researches, desired results were obtained by single size PET particles between the range of 0.425–1.18 mm. Hence, in this research, PET chips were crushed and sieved to obtain the above-mentioned dimensions (Modarres & Hamedi, 2014).

One property that is vital for asphalt is shear modulus 'G'. The shear modulus property denotes a material’s ability to resist deformation. In tests adding PET to a stone mastic asphalt (SMA) resulted in lower stiffness of the mixture but increased the mixtures resistance to fatigue and flexibility. The study used indirect tensile and fatigue testing. The tests included the heating of the plastic to 320o F and concentration levels of the plastic from 0% to 10%, by weight, incrementally by twos. During the addition of the plastic the mixture was kept at a constant temperature between 320o to 329o F. Overall the conclusions from the research showed that the addition of PET improved the asphalt’s ability to resist rutting and permanent deformation (Maharij, et al., 2015). One of the well-known asphalt mixtures that has already gained international popularity is stone mastic asphalt (SMA), which was first developed in Germany in the mid-1960s. SMA has been utilized in other European countries for over two decades because of its capabilities to provide higher resistance against rutting as well as studded tire wear. As a result of the considerable success achieved by SMA in Europe, in 1991, the United States of America also launched the construction of SMA pavements in some states in collaboration with the Federal Highway Administration. Currently, more than 28 states in the USA use SMA, which, as reliable reports confirm, has resulted in a significant increase in pavement durability by up to 20-30% compared to the conventional mixtures. Ever since, the increase of SMA utilization in pavement construction has been significant in the USA. Japan has also initiated the use of SMA in paving mixes, which, to date, has also gained considerable success (Ahmadinia, Zargar, Rehan, Abdelaziz, & Shafigh, 2011). Research results from a study by Maharij, et al. (2015) showed that, using the dry mix method where the PET additive was mixed with the binder after it was heated and tested using the DSR (Dynamic Shear Rheometer) testing following AASHTO specifications. The results of the tests showed higher levels of PET resulted in lower shear moduli, while the addition of larger sized PET particles resulted in increased shear moduli. Peak values of shear moduli occurred with larger particle sizes and lower concentrations of PET. Concentration level of 2% provided the best resistance to fatigue cracking and particle size of 0.024” to 0.035” preformed the best with respect to rutting resistant Maharij, et al., 2015).

Modifying the asphalt mixture with polymers appears to have the greatest potential for successful application in the design of flexible pavements to increase the service life length of the pavement or to reduce the pavement layer or its base thickness. Asphalt mixtures modified by polymers currently have a wide range of usages. When polymers are added to mixes,
they typically result in a higher degree of stiffness in the bitumen as well as improvement in its temperature susceptibility, which, in turn, increases the mixture resistance against rutting, which is a common occurrence in hot climates. Permanent deformation or rutting is characterized by a surface cross section that is no longer in its designed position. This is due to its represents an accommodation of small amounts of unrecoverable deformation that occur each time a load is applied. Rutting typically happens during at high temperature. There are two principal causes i.e. rutting from weak subgrade and rutting from weak mixture (Rahman & Wahab, 2013). Rutting from weak subgrade occurs as too much repeated stress being applied for the subgrade (or sub-base or base) to withstand. It is considered a structural problem and happens in the underlying layer. The thickness of pavement layers not enough strength to reduce the applied stress to a tolerable level as well as it is weakened by the intrusion of moisture. Meanwhile, the familiar rutting occurs is deformation in asphalt layers. This situation happens due to asphalt mixture without enough shear strength to resist repeated heavy loads and defect appears in asphalt surface course. The week asphalt mixture will accumulate small area (but permanent defect) and foaming a rut characterized by a downward and lateral movement of the pavement (Rahman & Wahab, 2013). In such cases, the applied polymers allow the application of softer base bitumen that can provide superior low temperature performance. One of the significant properties of polymer modified binders is their improved adhesion and degree of cohesion. Another application of polymers is in the creation of an aggregate coating material, which is expected to increase the roughness of the aggregate surfaces and produces superior asphalt mixtures (Ahmadinia, et al., 2011).

The construction industry is one of the major consumers of polymers and a significant potential customer for recycled plastics products, therefore it is imperative that the construction industry become actively involved in post-consumer polymer recycling efforts (Kibert & Waller, 1992). Construction material applications have a high potential for consumption of the vast quantity of post-consumer or waste stream thermoplastics which has become an environmental issue due to a shortage of landfill disposal space. This post-consumer polymer waste stream has created a new industry which collects, sorts, and processes the post-consumer thermoplastics and has evolved into a supplier of recycled polymers to various industries. Some of these waste plastics, such as high density polyethylene and polyethylene terephthalate, already have well established processes for creating acceptable end products (Kibert & Waller, 1992).

Plastic is a very versatile material and due to the industrial revolution, and its large scale production, plastic seems to be a cheaper and effective raw material. Today, every sector of the economy from agriculture to packaging, automobile, electronics, electrical, building construction, and communication sectors have been revolutionized by the use of plastics. Plastic is a non-biodegradable material and researchers are found that the material can remain on earth for years without degradation (Gawande, Zamare, Renge, Tayde, Bharsakale, 2012). With severe municipal solid waste (MSW) problems associated with disposing post-consumer plastics there is an opportunity for the construction industry to become a part of the solution. The process of developing new applications and advanced technologies for improved products will result from the participation of the construction industry in studying its roles, both in contributing to MSW as well as in fostering recycling efforts (Kibert & Waller, 1992; Arabani & Pedram, 2016).

**How the PET Additive is Made?** The quantum of plastic waste in municipal solid waste (MSW) is increasing due to increase in population, urbanization, development activities and changes in life style which leading widespread littering on the landscape. Disposal of waste plastic is not only a menace but is becoming a serious problem globally due to the non-biodegradability which leads to ground and water pollution. The majority of bottles are made from Polyethylene Terephthalate (PET) estimated that the ratio is 55-60% (Hassani, Ganuidoust, & Maghanaki, 2005). This waste plastic has been studied as a partial replacement in conventional paving asphalt mixes as a way to improve desired mechanical characteristics of the mixes. These studies have developed techniques to use PET for construction purpose of roads and flexible pavements. In conventional road making process bitumen is used as binder, the bitumen can be modified with waste plastic pieces to produce a bitumen mix which can be used as a top layer coat of flexible pavement. Aged plastic has also triggered abundant
research interests, which can be used in hot mix asphalt (HMA) in two ways: serving as an agent to modify the asphalt binder and replacing portion of aggregates (Yu, Jiao, Ni, Yang, 2014). The PET modified bitumen mix exhibited improved binding property, stability, density, and was more resistant to water. Studies reported the use of re-cycled plastic, mainly polyethylene, in the manufacture of blended asphalt mixes indicated reduced permanent deformation in the form of rutting and reduced low – temperature cracking of the pavement surfacing. The field tests withstood the stress and proved that plastic wastes used after proper processing as an additive would enhance the life of the roads and also solve environmental problems (Gawande, et al., 2012). In order to withstand tire and weather, pavement surface layers contain the strongest and most expensive materials in road structures. Characteristics they exhibit like friction, strength, noise and ability to drain off surface water are essential to vehicles' safety and riding quality. Apart from the nature of component binder and aggregates, asphalt performance strongly depends on the mixture type. Selection of components for surface layers must consider factors such as traffic, climate, condition of existing surface, and economics. No single mixture type can provide all the desired properties, often some are improved at the expense of others, making the selection difficult and contentious (Gawande, et al., 2012).

It is interesting how the waste plastic is used and interacts with the bitumen. Waste plastic is ground into small pellets or powder; 3 to 4 % plastic is mixed with the bitumen. Due to the fact that the plastic has a higher melting point it increases the melting point of the bitumen. This higher melting results in pavements that retain flexibility during winters resulting in long useful life. Use of shredded PET serves as a strong “binding agent” which results in the asphalt lasting long. The melted PET is mixed with bitumen in a specific ratio, this blending takes place at a temperature of 114°F once mixed the PET remains stable even at higher temperatures. Another advantage of the PET bituminous mixes are that they can withstand adverse soaking conditions under water for longer duration (Verma, 2008). Viscosity is a fundamental characteristic of asphalt and defines the flow resistance of the material at a certain temperature. The use of PET in asphalt pavement mixes would result in a 2.8% reduction in unit weight of the mix, increase the Marshall Quotient (MQ), a significant reduction in the need for aggregate, while recycling waste PET (Hassani, et al., 2005).

Asphalt pavements produced with shredded PET exhibit increased durability over conventional asphalt pavement mixes. The binding property of plastic results in longer lasting pavements while providing increased strength to withstand heavier loads. While a normal ‘highway quality’ road lasts four to five years the belief is that plastic-bitumen roads can last up to ten years. PET asphalt technology also results in fewer road repairs (Verma, 2008).

The purpose of the study by Rahman and Wahab (2013) was to determine the optimum quantity of PET as a replacement of fine aggregate for the best permanent deformation and stiffness of an asphalt mixture. This study incorporated PET granules (3 mm) as the fine aggregate in an asphalt mix. The mix used 60/70 penetration grade bitumen. The aggregate and bitumen were mixed between 284o F and 356o F. Compaction was accomplished with Marshall Hammer, 50 blows per side. With 20% total weight of fine aggregate and 5% of the total mixture weight being PET showed the best results in gaining the highest Marshall Quotient, lowest flow, and highest stability. The overall test results showed that the additional of PET to the asphalt mixture did not improve the stiffness properties, however test results for the PET asphalt mixture were better with respect to permanent deformation (Rahman, Wahab, 2013).

Rutting and cracking of pavement are not just due to traffic loads but also depend on the asphalt properties to withstand temperature changes and exhibits strong bonding with the aggregate. In low temperature situations, the addition of PET creates a ‘softer’ mix that reduces cracking conversely in high temperature environments ‘stiffer’ mixes provide resistant to rutting. Increased stability and strength of a mix can be accomplished by a thicker or reduced viscosity mix. The use of PET as aggregate in asphalt mixtures provide increase cohesive and adhesive properties in the mix and provide reduced life cycle costs of the mix, while assisting in the reduction of municipal solid waste (Sulyman, et al., 2016).

In conclusion, the use of the plastic additive is intended to reutilize the hard plastic waste particles as bitumen modifier for flexible pavements. The use of recycled waste plastic in pavement asphalt represents a valuable outlet for such materials.
The use of modified bitumen with the addition of processed waste plastic of about 5-10% by weight of bitumen helps in substantially improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous concrete mix, resulting which improves the longevity and pavement performance with marginal saving in bitumen usage. The process is environment friendly. The use of waste plastics in the manufacture of roads and laminated roofing also help to consume large quantity of waste plastics. Thus, these processes are socially highly relevant, giving better infrastructure (Gawande, et al., 2012).

**Cost Concerns**: To produce polymer modified asphalt mixture is relatively costly. Using waste polymers, or PET, is a way of reducing the cost of such constructions while reducing waste. From an environmental and economic stand point, the use of recycled materials could advantages such as easing demand for more landfills, reduction of environmental pollution, and reducing demands of extraction from natural quarries. Waste glass, rubbers, plastics and mineral productions were some popular materials used to modify the properties of bitumen and asphalt mixes. Most researches have focused on using waste additives to improve the deformation and fatigue characteristics of asphalt mixes (Modarres & Hamedi, 2014).

In term of economic value, it has been shown that recycled PET could reduce cost of road construction because this recycled material is cheaper than bitumen and easy to obtain this material. Therefore PET modified asphalt can resist the previously mentioned road failures. Also, it improves the level of performance and the service life of the road. It can be concluded that the application of recycled PET modified asphalt gives more advantages compared to the conventional asphalt mixture especially in term of permanent deformation. Having considered the environmental and economic aspects, PET modified asphalt is found suitable to be used for road pavements (Rahman & Wahab, 2013). According to the deputy director of the CRRI, polymers mixed with bitumen increased the construction cost up to six per cent, but resulted in increased longevity of roads in various ways. However, in the long run this would result in a net savings (Verma, 2008).

**Where is Plasphalt being Used?** Two studies will be compared in this paper to provide connections between shared and differing results. The first study was done in 2012 by Moghaddam et. al. and the second done by the Pennsylvania Department of Transportation. Moghaddam et al. suggests that the use of waste plastic bottles as a secondary material in construction projects would be a solution to overcome the crisis of producing large amounts of waste plastics in one instance and improving the structure or materials characteristics in the other hand. PENNDOT actually performed a project using Plasphalt.

In a 2012 study, Moghaddam et al. used crushed plastic bottle to replace different percentage of aggregates and found that the mixtures containing suitable amount of waste plastic bottles have lower optimum asphalt content and greater fatigue resistance versus the conventional mixture. Hassani et al. (2005) and Yu, et al. (2014) performed similar studies and concluded that waste plastic bottle mixtures have the same Marshall Stability (MS) and Marshall Quotient compared to the control samples (Hassani, et al., 2005; Yu, et al., 2014). In the by Moghaddam et al. (2013) study, Marshal Stability (MS) value increases by adding waste plastic bottles into asphalt mixes up to 0.6 % plastic; however, at higher plastic contents MS decreases. It is also noted that MS value decreases at higher asphalt amount. These results indicate that better adhesion is provided between asphalt binder and aggregate particles by adding waste plastic to the asphalt mix. Bulk Specific Gravity (BSG) of compacted mixtures initiated with an increasing trend of adding plastic bottles, tend to decreased at higher plastic contents. Further, mixtures manufactured at higher asphalt contents showed to have higher BSG. Test results showed the highest BSG is for a mixture containing 0.4% PET and 7% asphalt content. For stone mastic asphalt mixtures optimum asphalt content (OAC) was calculated to achieve 4% air voids in mix. The research study showed that the OAC value decreased by adding PET into asphalt mixes (up to 0.6%), however, the OAC increased when higher percentages of plastic were added. Based on these findings less asphalt binder is needed to achieve the proper air voids in the mix when lower amounts of PET are added. Mixes including PET showed higher stiffness at lower percentages of PET; however, in contrast, increasing the percentage of PET resulted in mixes that were not as stiff. These results infer that mixes containing higher amount of plastic exhibit
recoverable displacement under cyclic loads compared to conventional mixture. Adding PET to asphalt mixes also increases the fatigue life. Mixes with 1% plastic showed the highest fatigue life which were more than doubled at lower stress levels. Mixtures containing PET had higher stability values compared to conventional mixture and the stability increased by adding lower percentages of PET and decreased at higher amount of plastic. These results indicate that the flexibility of mixes are improved by the addition of PET, and by improving the flexibility crack creation and propagation into asphalt mixes would be postponed (Moghaddam, et al., 2013).

Penn DOT, under their Strategic Recycling Program, provides assistance to the state entities in the selection and performance evaluation of projects that incorporate recycled materials. The report by Vukov (2008) provides an overview on the five year performance evaluation of the Jefferson Street Plasphalt Project, which is located in the Borough of Wilson, Pennsylvania. Two project contracts were awarded to Lehigh Valley Site Contractors Inc. to perform the Plasphalt paving of three residential streets within the Borough. Hot mix asphalt concrete containing Treated Recycled Plastic Aggregate (TRPA) is referred to by the trade name PlasphaltTM (plasphalt). TRPA material, which was supplied for the projects by Telecan Internaitonal, Inc., is composed of ground recycled thermoplastic that is treated to improve the bond between the plastic and asphalt binder. While there is still limited available research on the performance-related properties of plasphalt, some initial studies suggest that plasphalt, used as a pavement surface has the potential to eliminate or reduce the severity of rutting. Plasphalt specifications call for the use of hot mix asphalt (HMA) with some conventional aggregate substituted TRPA to a maximum of 1.5% substitution. The research guidelines suggested that a minimum of 600 tons or 7040 square yards (approximately one lane mile at 12 feet wide land at 1 ½" depth) of Plasphalt HMA pavement course to be used to compare against a standard Superpave 9.5 mm pavement wearing course (control section). The projects tested approximately 200 tons of wearing course placed on Jefferson Street, with control sections using conventional asphalt comprising 97 tons, and plasphalt paving contributing the remaining 97 tons (Vukov, 2008). The results of this project were evaluated as follows for five consecutive years (there was no report given for the third year in the study):

**FIRST YEAR PERFORMANCE:** Overall, both the plasphalt and conventional paving sections show good aging. There was no rutting or surface impairment observed. As is normal the asphalt binder was worn off both the plasphalt and conventional wearing surfaces. The visible colors of TRPA are red, blue and yellow and there were no visible TRPA pieces dislodged along the road side.

**SECOND YEAR PERFORMANCE:** The plasphalt paving sections continued to show good aging. No rutting or cracking was observed on plasphalt wearing sections. In contract there was one location on the control section that exhibited signs of rutting which measured at a 3/16" maximum deflection on conventional wearing course. There was no visible difference to plasphalt paving surface in terms of exposed TRPA material in comparison to the previous (first-year evaluation). There were some TRPA pieces from the plasphalt course visible at the edge of the pavement, accumulated near down gradient storm water inlet.

**FOURTH YEAR PERFORMANCE:** Conventional pavement shows normal wear. The plasphalt showed cracking forming on Jefferson Street approximately 4 feet from curb. The longest crack was 10 feet in length with a maximum width of approximately ½ inch wide and ½ inch deep. No rutting was observed throughout Jefferson Street or intersections. There was a visible distinct color difference between conventional and plasphalt wearing courses.

**FIFTH YEAR PERFORMANCE:** The conventional pavement continued to show normal wear. The cracking, in the plasphalt, did not increase in length however the width of the crack had increased to approximately 1½ inches wide, but remained at ½ inch deep. There was still no signs of rutting and there continued to be a visible distinct color difference between conventional and plasphalt wearing courses. Plasphalt wearing surface shows very slight continued loss of fines in comparison to the previous year inspection. No visible loss of TRPA pieces along plasphalt roadside were observed.
In summary, the plasphalt showed comparative aging to standard conventional asphalt mixes. No rutting of the plasphalt sections were observed during the five-year performance evaluation period. There were some limitations as to the results of this project performance evaluation due to the fact that the paving mixes were not produced at the same facility. Testing of the plasphalt core samples taken from the project indicate that plasphalt pavement did not meet the minimum 92% theoretical density requirement (Vukov, 2008).

Conclusions: This paper highlights the re-utilization or recycling of waste plastic bottle as a bitumen modifier for flexible pavements. The use of recycled PET in pavement asphalt represents a valuable outlet for such materials. Asphalt mixes that incorporated PET of about 5-10% by weight of bitumen helped in improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous mix. Thus resulting in improved longevity and pavement performance. The use of innovative technology not only strengthens road construction, increases the life of the roadways, and improves the environment. The process is environmentally friendly and the use of waste plastics in the manufacture of roads helps to consume large quantity of waste plastics. Resulting in processes that are socially highly relevant, provide better infrastructure, and create safer, more structurally, environmentally, and cost efficient roadways.

References:
Factors Affect Students’ Adoption of Digital Technology in Learning Process

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Abstract: The purpose of this research was to study the factors that affect students’ adoption of digital technology in their academic learning process. The literature review outlines key individual factors related to people’s adoption of digital technology. Based on the research findings and theoretical models in existing literature, this study investigated the contribution of two specific individual factors on the students’ adoption of digital technology in their academic learning. The study made theoretical and practical contributions to the literature on integration of digital technology in academic learning process.

Introduction: Increasing numbers of higher education institutions are integrating innovative digital technologies as instructional tools to enhance effective implementation of learning objectives (Abrantes & Gouveia, 2010, Dron & Anderson, 2014). Students are using innovative digital technology extensively in their everyday lives primarily for socializing and entertainment. They are the generation with extensive experience in using digital technology as they are spending much of their time using interactive multimedia, social media, Web 2.0, etc. (Rodriguez & Lozano, 2012, Dron & Anderson, 2014). But, students’ use of digital technology in their academic learning process is still relatively low (Padilla-Meléndez, Aguila-Obra, & Garrido-Moreno, 2013). Students can be benefitted from using digital technology in their academic learning only if they actively and effectively integrate this technology in their learning process (Shroff, Deneen, & Ng, 2011). Therefore it is important to study the factors that affect students’ adoption of digital technology in their academic learning process.

Literature Review: The fast changing digital technology is highly influencing the higher education environment by enhancing effective learning and providing students unprecedented immediate access to up-to-date course content (Abuzir, 2015). The advancement in digital technology, along with lowering costs, has increased the adoption of such technology for learning in higher academic institutions. Today, without incorporating digital technology no higher educational institution can expect to excel in their students’ learning experience (Omar, Kalulu, & Alijani, 2011; Agbatogun, 2012). Adoption of digital technology in learning process can lead to digital literacy, which may resulted in situated learning. Lankshear and Knobel (2008) argued that students’ participation in digital literacy practices such as digital animating, gaming, blogging, etc. can provide them opportunities for gaining situated learning rather than merely verbal (or literal) meanings for concepts, processes and functions.

According to Fuller, Vician, and Brown (2006), researchers have been examining the role of digital technology in higher academic learning environment for over several decades. However, the understanding of how digital technology is used for academic learning process from the students’ perspective is relatively limited (Lai, Qiu, & Lei, 2012). What is also missing in current literature on students’ adoption of digital technology for academic learning process is a conceptualization of individual factors. Most literature on digital technology in higher education has a specific focus on the characteristics of the technology itself (Musawi, 2011), but to gain a full understanding of why a particular technology is or is not used, careful attention need to be paid on individual factors. A number of individual factors have been identified as significant in acceptance and subsequent use of digital technology (Fuller et al.).

Individual factors are the psychological characteristics of the person making the decision about adoption of technology (Mathieson & Chin, 2001). Many theoretical models focused on the contribution of individual factors on people’s decision to adopt digital technology (Venkatesh, Thong, & Xu, 2012). Especially, the Technology Acceptance Model (TAM) that has supported by extensive empirical research (Padilla-Meléndez, Aguila-Obra, & Garrido-Moreno, 2013). In this context, this research intended better understanding of the issue by focusing on two individual factors, Computer Self-Efficacy and
Attitude toward digital technology, which may have effect on students’ adoption of digital technology in their academic learning process.

**Computer Self-Efficacy:** Compeau and Higgins (1995) introduced Computer Self-Efficacy (CSE) as an important construct to explain people’s adoption of computer technology. The CSE derived from self-efficacy construct, which is the key element of Social Cognitive Theory developed by Bandura, refers to people’s beliefs in their ability to use computer (He & Freeman, 2010, Hauser, Paul, & Bradley, 2012). Self-efficacy is not about the assessments of the actual skills that a person may possess, but it is instead about the level of confidence the person has in his or her ability to perform the task successfully. Compeau and Higgins (1995) stated that CSE is a specific type of self-efficacy, which is people’s believe in their capability to use computer technology. They argued that people’s adoption of computer largely influenced by their CSE (Compeau & Higgins, 1995).

Literature shows that CSE has a significant positive effect on people’s adoption of digital learning technology and performance (Hauser, Paul, & Bradley, 2012). The research findings also suggest that CSE is a strong predictor of a variety of computing attitudes, beliefs, behaviors, and performance. People with higher CSE are less anxious about computer, use computers more, and perform better in different computer tasks (Downey & Kher, 2015).

**Attitude toward Digital Technology:** Attitude is defined by Ajzen (2005) as “a disposition to respond favorably or unfavorably to an object, person, institution, or event” (p. 3). According to Allport (1935), “An attitude is a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual’s response to all objects and situations with which it is related” (p. 810). Research findings revealed that students’ attitudes toward digital technology are influential in determining their digital technology-based learning experiences. In this context, it is important to consider students attitude regarding their adoption of digital technology in academic learning process (Larbi-Apau & Moseley, 2012, Wong & Fong, 2014).

**Digital Technology as Instructional Tool:** Digital technology, as an effective critical tool in learning experience, is changing the instructional process (Musawi, 2011). With advanced digital technology, the opportunities for more flexible technology-supported learning environment emerges for students. The integration of digital technology play important role in moving learning process from instructor-centered to student-centered (Male, 2011, Efe, 2011). The role of digital technology in delivering learning objectives continues to grow with achievement of effective learning outcomes (Wong & Fong, 2014). Those innovative digital technology also has been increasingly support instructors by providing tools that help them to transform their instructional method efficiently. As a result, in recent years, more and more instructors are interested in integrating digital technology in their classes. They are using digital technology as a cost-effective instructional tool to improve their students’ learning outcomes (Shroff, Deneen, & Ng, 2011, Ngafeeson & Sun, 2015).

According to Süleyman and Özlem (2014), the world is becoming a mobigital virtual space where learning and teaching digitally is possible anywhere and anytime. Today, when timely access to information is vital, mobile devices such as laptop, tablet, smart phone, iPod, digital camera, netbook, e-Readers etc. have become common devices used by younger people, especially college students. Social media and other digital tools that promote collaboration and information sharing, can be used in academic settings to enhance student engagement and facilitate better learning process. Digital communication in social media such as Facebook, Twitter, Instagram, YouTube, etc. can strengthen students’ learning skills. Therefore, social media can be used to create high level of students’ engagement, promote collaborative learning environments with positive effects on the teaching and learning process (Dron & Anderson, 2014, Gonzalez & Young, 2015). Academic professionals see a significant effective potential in integrating social media technology in higher education. Research shows that the use of social media in learning can impact students’ academic achievement in significant level. Social media that includes a variety of web-based tools and services such as blogs, wikis, multimedia (audio, photo, video, text, etc.), sharing tools, and other platforms i.e., Facebook, Twitter, Instagram, YouTube etc. can be used as learning tools to increase students engagement for
active learning (Tarantino, McDonough, & Hua, 2013).

**Purpose of the Study:** The purpose of this study was to assess how individual factors affect students' adoption of digital technology in their academic learning process in higher education. The literature review outlined the key individual factors related to people's adoption of digital technology. Based on the research findings and theoretical models in existing literature, this study investigated the contribution of two specific individual factors on the students' adoption of digital technology in their academic learning process. Consequently, the study specifically addressed the following issues in higher education perspective:

1) The effect students' computer self-efficacy on their intention to adopt digital technology in academic learning process.
2) The effect students' attitude on their intention to adopt digital technology in academic learning process.

**Methodology:** In this research, an electronic survey instrument was used as a multi-item, Likert-type scale for collecting data. The e-survey was sent to students via e-mail. The sample for this study was full-time and part-time students enrolled in different online or on-campus classes in Business, Law, and Technology department at a regional campus of a large public university. Total 94 students participated in the survey with response rate of about 35%. Students' participation was completely voluntary and anonymous.

**Research Findings and Discussion:** The study assessed the effect of undergraduate students' individual factors such as computer self-efficacy, and attitude on their intention to adopt digital technology in academic learning process. The statistical analysis of collected data from the survey addressed the research goals. The statistical analysis Multiple Linear Regression (MLR) was used to analyze the collected data from the survey. The results indicated that both aforementioned individual factors have significant effect on students' intention to adopt digital technology in their academic learning process. The MLR analysis showed that both predictive variables computer self-efficacy, and attitude in combination have significant effect on dependent variable undergraduate students' intention to adopt digital technology in their academic learning process. The MLR analysis indicated that the aforementioned independent variables account for 85% of the variation of dependent variable.

The MLR model analysis also showed that weight-wise, the impact of the predictive variable computer self-efficacy was greater on dependent variable students' intention to adopt digital technology than that of the predictive variable attitude.

![Figure 1. The weight-wise effect of predictive variables on dependent variable.](image)

As shown in Figure 1, weight-wise the impact of computer self-efficacy on dependent variable intention to adopt digital technology in academic learning process was greater ($\beta = .609$, $p < .001$), than the impact of their attitude toward digital technology ($\beta = .345$, $p < .001$).

**Conclusions:** This research intended to enhance the understanding of students' adoption of digital technology in their
academic learning process by focusing on the effect of their individual factors. The purpose of this study was to assess the specific individual factors such as computer self-efficacy, and attitude on students’ intention to use digital technology in their academic learning. The research specifically focused on students' digital literacy practices using technology, for example, the use of Web 2.0 applications in and around the curriculum (Lea & Jones, 2011). The study finding shows that aforementioned individual factors significantly affect students’ intention to adopt digital technology in their academic learning process. Consequently, these individual factors should be considered essential in the process of implementation of digital technology in learning environment. Hence, the results from this study will provide educators and administrators in higher academic institutions a better understanding about integration of innovative digital technology in learning process. The study made theoretical and practical contributions to the literature on adoption of digital technology by undergraduate students in their academic learning process. Therefore, the study findings will specifically:

• Provide faculty and instructional designers in higher academic institutions an in-depth understanding of individual factors that contribute to undergraduate students' adoption of digital technology in their academic learning process,

• Provide instructors with strategies to incorporate digital technology in their course content delivery ensuring effective learning for their students in classroom.

References:
Using Explain Everything App for Creating Instructional Support Videos for Statics and Strengths of Materials Courses

Author
Dr. Denise Gravitt Ph.D., Western Illinois University

Introduction
Construction programs may have increasing number of students with insufficient skills in solving mathematical problems being taught in the curriculum. This lack of mathematical skill, even after students have passed General Education Math courses, may result in students leaving the Construction program, dissatisfaction with the program and instructors, and students struggling in many courses that require the use of math. Additionally, it may result in low student satisfaction ratings for the instructor and specific course since students feel their learning is not being supported by having the course materials taught at their own pace and level of understanding or skill. Additional coverage of mathematical principles in the classroom may not be feasible due to the limited class time and required course materials needing to be covered for accreditation or per industry groups.

Some student learning styles are not suited to just lectures or written examples in text books typically available to students outside of class time, and they need visual examples with spoken instructions to support their learning style or the need for extra or slower explanations of materials that they may not feel comfortable asking for in a classroom setting. Additionally, instructors may have limited time to repeat instruction for students that may be struggling with concepts or are lacking confidence in their skills (poor self-efficacy). To address this problem, and student feedback related to their frustrations, the author attended a Professional Development workshop on the Explain Everything App to investigate the potential for this technology to address the issues.

After attending the workshop the author felt that just providing short 5 minute mini-lessons on a class platform available to students 24 hours a day may help those students with poor note taking skills, provide lessons for students that may have been absent, or repetition of lesson topics for those wanting slower or repeated explanations especially for the math steps and logic. Some students are not capable of listening in class and taking notes at the same time and miss valuable explanation of each step in problem solving; the ability to pause lesson tutorials while working on similar homework problems seemed to be a valuable benefit from using the App to create video tutorials.

This paper summarizes an approach of using a technology application for instructional support in explaining mathematical principals and skills. Results indicate that some students do find benefit from the videos, and the time taken to prepare them is reasonable for instructors while not requiring special skills.

Literature Review
The National Science Foundation has noted U.S. students' mathematical problem solving skills are dropping in comparison to other nations as evidenced in STEM programs since the early 2000's (Seymour, 2002). Using a mathematics basic skills pretest for a Statics and Strengths of Materials course in the spring of 2017 the instructor found that only 20% of the students could solve basic volume, fractions, percentages, areas, Trigonometry, and unit conversion problems found on a Florida Contractors license exam. These are basic skills that instructors in Construction programs expect students to possess.

Flipping classrooms, lecture, and problem-based learning methods have all been used to see which method(s) improve mathematical skills the most. Lee, Lee, & Kovel (2016) found that the top students improved no matter the pedagogical
method, but problem-based learning had the highest increase in skills for moderate ability students. However, learning in classroom settings using problem-based assignments may not be sustainable when students attempt homework alone where they may experience frustration resulting in nonproductive time on task, and doubt their abilities. Bandura (1982) says that learners who think they can succeed or have self-confidence in their skills are more likely to do so than those that doubt their abilities in that topic. He concluded that self-efficacy is vital to sustained perseverance and effort in learning when challenged with a cognitive task. Nowikowski (2016) concluded that if learners have high self-efficacy for a mental task or challenge that they are more likely to invest mental effort and time into that preferred task because it is perceived as “easy.”

**Purpose:** The purpose of this study was twofold: 1) to investigate if providing supplemental instruction of problem solving via short videos of the more common topics in Statics and Strengths of Materials courses that students struggle with would support higher retention rates among students in the course, and 2) to see if the video lessons would result in improved student feedback for the instructor and course.

**Methodology:** Surveying, Statics, Strengths of Materials, and Estimating courses may all share challenges relating to students not being adequately prepared for the mathematics used in the courses and have students that do not feel comfortable in their abilities to learn new materials requiring the use of math. The Explain Everything App is inexpensive (under $10) and can be used with an iPad or iPhone by an instructor to create short lesson videos with both picture, video, sound tracks and embedded links. Written instructions can be added on top of pictures or inserted into videos as well as drawn by hand on the iPad. Narration can be added to slides by the instructor after all the visuals are in place.

These saved lesson videos can be created anywhere, be exported to a Google Drive, OneDrive, YouTube, or an email account among other options. These files can then uploaded onto any web platform such as Blackboard, Desire to Learn, or YouTube where students can access them when ever needed as long as they have internet access. It was theorized that short lessons, between 5 to 10 minutes to match students’ attention span and short loading times onto student devices may support student learning and possibly improve course and instructor feedback scores from students taking challenging courses.

The initial course chosen by the author to try this application to see if it improved students’ learning and mathematical skills, and hopefully reduce student complaints by providing mathematics review topics as well as slow detailed explanations of basic math problem solving skills, was the 200 level Statics and Strengths of Materials course. Students in past semesters had complained of the instructor not teaching them math or not reducing course content in order to slow the lessons down to their abilities. Reduction of course content was not a viable option due to program competencies established, but something had to be done to address student concerns. Using the Explain Everything App, the instructor created seven lessons on basic topics such as recognizing special triangles, basic Trigonometric functions, Algebraic solutions for two equations and two unknowns, moments, distributed loads, reactions, and solving for forces in trusses. These topics were also covered briefly in a mathematical review the first week of the course in the classroom sessions.

The topics were identified as the basic learning blocks for Statics that would be used in most homework problems and needed for students’ success on exams. The review of Trigonometry, Geometry and Algebra was needed since many students did not have those skills, as identified on the pre-test and class time for mathematical review and explanations of basic mathematical problem solving including exponents, sign changing, fractions and scientific notation was limited. The lessons were saved to the instructor's Google Drive then uploaded into the Desire-To-Learn class platform for the course. Students were emailed notifications of new lessons and it was announced at the beginning of lectures as well multiple times during the first weeks of the semester. Each video was created after the lecture on the material was delivered in the class session and took approximately 30 to 50 minutes to create, edit and post to the classroom platform.

At the end of the semester a survey was given to the 15 students present that had completed the course to gather feedback and their impression of the lessons.
**Results:** In terms of retention, by the end of the second semester of offering the Statics course after it was added to the curriculum:

- 1/3 (10) of the students dropped the course within the first two weeks, and
- 95% of the remaining students that finished the course passed with an average class grade of 73% (C).

This was before the creation of the videos for learning support and the only help available for students was for them to come to instructor’s office hours. The majority of students did not take advantage of office hours. The instructor received comments that students felt stupid after getting help and that made them not want to get help afterwards. Students also noted that while the instructor clearly knew the material they could not effectively communicate difficult concepts in some student’s opinions. No details as to what the instructor specifically did or said in the explanations of the work were given as to why the student ended up feeling stupid after getting help, or what they could have done to be more effective in the students view, but the negative emotions definitely resulted in fewer students asking for help in spite of some student’s low success rate in the course.

The third time the course was offered, spring 2017 semester, the Explain Everything App videos were created and shared made available to the students. They were notified of the videos existence and location via mass email messages to the entire class and in class announcements at least three times. The end results were:

- only 3 students dropped the course in the first weeks of the course; and
- 100% of the remaining students that finished the course passed with an average class grade of 78% (C+).

The informal class written survey (select questions shown in Table 1) indicated that even though only 20% of the class passed the basic mathematics skills pretest with a 60% or above score, only 33.3% of the class thought their math skills hindered their success in the course. This could indicate the students have a false perception of the importance of math skills in being successful in a course, or felt they had adequate skills since they passed the course no matter what grade they received. In regards to the Explain Everything App videos, even though everyone was told of their availability:

- 33% of the class didn’t use them at all,
- 33% of the class felt they were beneficial, and
- 33% either didn’t answer the question or felt they weren’t that helpful.

Student comments are included in Table 1 right.

Table 1. Student survey responses, April 2017.
A comparison of two semester’s anonymous student feedback of the same course (Table 2), the second semester the course was offered without video support and the third time the course was offered with Explain Everything App video support showed a significant decrease in complaints about the pace and teaching, but there were still two complaints about not enough examples or explanations. However, since the student feedback is anonymous those comments could have been from the 2/3 of the students in the course that reported they either didn’t view the videos at all (or claimed they didn’t know they were available) or used them very little. On a positive note, there were two student comments that listing an instructor “strength” concerning teaching math and explanations compared to none from the previous course semester feedback.

Table 2. Select examples of Anonymous Student Feedback, spring 2016 and 2017.

<table>
<thead>
<tr>
<th>Instructor Strengths</th>
<th>Instructor Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>knows what she is doing</td>
<td>teaches materials too fast/moves very quickly through material/not enough time on some material (4)</td>
</tr>
<tr>
<td>struggles teaching, doesn’t know how to teach us to understand clearly, doesn’t teach well</td>
<td>most of class is left confused after class</td>
</tr>
<tr>
<td>instructor is almost too smart to connect with students</td>
<td>difficult topics unclearly taught</td>
</tr>
<tr>
<td>patience to teach the basic steps of math</td>
<td>moves a little fast on topics (1)</td>
</tr>
<tr>
<td>when does go over examples explains it well</td>
<td>doesn’t go over enough example problems</td>
</tr>
<tr>
<td>knows the materials</td>
<td>not the best at explaining, information unclear at times and doesn’t get explained enough/ doesn’t explain information that she thinks you should have known</td>
</tr>
</tbody>
</table>

**Summary:** The time to create and save the very basic instructional videos varied from 30 to 50 minutes depending on the complexity of the information being presented and the number of slides needed to cover the explanation steps and the time needed to load the videos to the course platform. However, the time was well spent since it saved repeating the same explanations and instructions multiple times in class and to students during office hours by the instructor.

The feedback from the informal (instructor given anonymous survey) and the formal anonymous course feedback from students at the end of the semester indicated there is no amount of effort for lesson preparation or supplemental instruction provided by the instructor that will satisfy all students, but those students that are motivated and want to learn can be helped by the addition of the videos.

The number of students dropping the course also declined after the creation of the videos; however, this may not be a direct result of the videos since students have also begun to accept the course as a required and necessary component to the Construction program of study. When the Statics and Strengths of Materials course was first offered it was not a requirement for students in the older version of the Construction program, but any new students enrolling in the program after fall 2014 effective date had to take the course. This resulted in some resentment and resistance from students in the current version of the program.
Individually created lessons by their own professors or instructors may be more beneficial for students in courses where extra instruction at a slower pace may be what students need for success, compared to the many videos and tutorials on the Internet and YouTube. Additionally, once the videos are created they can be used for subsequent semesters with no additional time investment from the instructors. Student feedback did improve, and student complaints about the lack of mathematical explanations were reduced overall. Some students felt their learning was better supported by the videos, but not all. Thus, both objectives were achieved to some degree with the creation of the supplemental instructional videos.

References:


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Abstract: Researching curricular components along pathways that lead to the success of degree completers and their transition into STEM careers, we can better understand the preferred or ideal curricula for postsecondary education into the workforce. The resulting progression of educational activities collected from successful placements into manufacturing careers serve as the authentic assessments and pathways for individuals entering into the post-secondary education pipeline. This research allows us to look closely at successful programs and better understand how they are leading students to positive outcomes in employment. Linking programmatic coursework of graduates to industry specified employment expectations; researchers develop an understanding of the curricular elements essential for employment in the manufacturing sector of our nations STEM workforce. Results identified clusters of coursework that align to employment expectations, a framework that links relevant industry experience to continued education, and stackable credentials or continued education that can provide for accelerated promotion within industry. Recommendations include the need for industry-supported assessments to validate skills verification of proposed modules, a process for institutions of higher learning to offer credit for work experience, and the expansion of matriculation agreements to include more traditional AAS degrees. This research challenges the conventional wisdom or the perceived pathway to successful careers in manufacturing.

Background: The US is on the edge of a precipice with regard to its manufacturing sector. Today there is a shortage of talent at the technical level. This shortage could be realized with over 2 million technical level jobs being unfilled by 2020 (Giffi, 2015). This crisis is not just limited to the US, there is a lack of manufacturing technical personnel across the globe (Gordon, 2014).

Due to the high-tech nature of manufacturing in the US, technical employees require higher literacy and career skills to attain employment in industry (Gordon, 2014). This is combined with the large amount of baby boomers who are leaving the workforce in what has been described as “The Silver Tsunami” (Schumpeter, 2010) leaves a gap between the demand for highly skilled technical people and the supply of those people from the K-20 education system. This requires the upcoming K-20 population to become more receptive to careers in manufacturing, which are high skill/high-paying jobs (Elkins, S. A., Bell, R. R., Hartgrove, L., & Pardue, 2016)(Meyer, H. D., & Benavot, 2013)(Augustine, 2005)(Symonds, W. C., R. B. Schwartz, 2011).

To undertake this we need to investigate where the gaps between education and employment ready skills occurs, (Bhadury, Joyendu, 2014), to allow the demand v supply gap to be narrowed, which in turn will allow for economic growth.

Currently, our K-12 school system is deeply immersed in the era of standardized assessment (Atkin & Black, 2003), and efforts recently have been made to change the curricula and expected outcomes to align more closely with college and career readiness standards. However, once students complete a degree program, they are still faced with some difficult decisions. Graduates of four-year degrees typically earn more than those with only some college, but the range in earning potential for bachelor's degrees is so wide that graduates entering the workforce could be beginning a sustainable career or a life of struggle, poverty, and debt (National Forum on Education Statistics, 2015). Unfortunately, when graduates are unable to secure employment they often endure prolonged unemployment or accept a position for which they are overqualified.
Furthermore, with national student debt exceeding 1 trillion dollars, graduates carry the financial burden of their decision for years to come. For these reasons many students seek alternatives to the traditional postsecondary education pipeline, and find alternatives such as a more competency-based approach to be more beneficial for gaining employment in STEM fields. This research defines curricula to include a combination of learning and experience within a field or program of study. Within each curriculum there is a scaffolding of learning that moves learners step by step to a predetermined outcome (e.g., both skill set, and knowledge base). At the micro level, curricula make up a single lesson or a unit. For this project, researchers primarily focus on the macro level, which involves the components of a program of study that are aligned to the desired career outcomes. Curricular research traditionally has three parts: the planned (material deemed important to the degree or career), the delivered (the experiences an individual needs in order to acquire that information), and the received (which is measured with respect to the usefulness and relevance of the material to the individual, or what the individual can do as a result of these experiences). This project focused specifically on understanding how the planned curricula aligns to employer expectations in the manufacturing sector of a STEM based economy. Our current education system assesses the value of the planned curricula and the impact of the delivered curricula with standardized assessments that are not aligned to the expectations of employers for the received curricula. This flaw in the applied education theory fails to take in to account the specific skills required for entering into the STEM workforce.

The Understand By Design (UBD) philosophy for curriculum development targets three specific stages of development: identify the desired results, determine acceptable evidence, and develop a learning plan. Proposed by Wiggins and McTighe (2005), this methodology begins with the end in mind, meaning curriculum development begins with the ideal received curricula or employment expectations. The first stage requires the identification of acceptable evidence that ensures students are on target to meet desired outcomes. In a conventional classroom, the evidence collected would be regular classroom activities. Whether these pieces of evidence are collected as formative or summative assessments, it is essential that they be aligned to the target outcomes. The final stage of UBD requires the development of a learning plan. Closely aligned to both the evidence required and the intended outcomes, the learning plan provides a curriculum map that will lead the student down a particular pathway (Wiggins and McTighe, 2005). This backwards approach to mapping a curriculum from the end to the beginning aligns with the intent of this research because our goal is to determine what pathways lead to more successful outcomes for manufacturing careers.

**Research Questions:** This project will employ the Statewide Longitudinal Data System (SLDS) and curriculum mapping to address the following research questions:

1. What current employment options are available in Advanced Manufacturing? And who is being hired?
2. To what extent does the Industrial Technology degree align to these positions?
3. Who is being hired for job title Mechanical Engineering? What are the educational and experience expectations of employers? What is the educational and experience of the positive referrals? How important is experience?

**Methodology:**

Using Archived data from the Mississippi State Longitudinal Data System (SLDS) researchers implemented a methodology of reverse curricular mapping of industry preferred qualifications to educational pathways. This process employs qualitative research methodology to review archived job postings, along with the corresponding academic transcripts and work experience of the individual hired into the position. Collectively these data are referred to as a positive referral. In 2016 this included 35,622 individuals successfully hired into 40,876 unique job postings. Data mining techniques, such as keyword analysis, will be used to identify specific expectations of employers. All data are de-identified and matched within the multiple data sets using an approved methodology supported by the SLDS. The established expectations for each occupation will be
aligned to the micro level curricular elements for Advanced Manufacturing pathways. This process has allowed researchers to not only validate the appropriateness of an education pathway to a specific career but also develop understanding of any gaps between training objectives and industry expectations.

**Results & Discussion:** Results in this section will be presented with respect to each individual research question. This will include specific methodology related to each item, followed by a summary of results and relevant discussion.

**Item 1: What current employment options are available in Advanced Manufacturing? And who is being hired?**

Researchers retrieved data from the Mississippi Works Job Matching tool for Advanced Manufacturing Job Postings from 2011-2016. Table 1 presents the Number of job openings by O*NET Standard Occupational Classification (OSOC). Mississippi has a total of 125,423 openings in 14 unique occupations (averaging 20,904 job openings per year). These positions represent the top 75% of occupations across the sector. A secondary analysis reduced the list to 11 occupations that offered a sufficient number of positive referrals for curricular mapping. Table 2 presents the number of positive referrals and the range of salaries from the Bureau of Labor. It is important to note that the salaries are based off the entire industry, not solely Advanced Manufacturing. Yearly salaries for the 11 OSOCs range from $16,740 to $137,970. The observed range in earning potential within each occupation can be associated with the level of education or relevant experience required for the position. For instance, a entry level Team Assembler position could be offered to an individual with no training or experience at a starting salary of $19,760. On the other end of the spectrum you may have individual with extensive experience and a two year technical degree earning $48,780.

Positive referrals from 2007 to 2017 Mississippi Job Resumes were then reviewed for educational backgrounds under each OSOC. Educational levels were ranked from highest to lowest as the following: PhD, Master's, Bachelor's, Associate's, certification, some college, high school/GED, some high school, and then any type of education. The first and second highest educational level requirements were high school/GED or any type of education. However, within the “Engineers, All Other” and “Mechanical Engineers” titles a Bachelor's degree was the highest required by the employer. Only the highest degree earned by each referral was used in the analysis. Based off the referrals highest degree, the percent of who met or succeeded the educational requirement of the employer was found. Majority of the employees at most had a high school diploma or GED fulfilling this requirement. But for the engineering positions, over 70% of employees had at least a bachelor's degree. A limitation of this analysis can be identified in the failure to link degree type to the related occupation. For instance an employee may hold a bachelors degree in art but is employed under an unrelated occupation thus exceeding the employer specified education requirement.
Table 1: Top Occupations in Mississippi's Advanced Manufacturing Sector

<table>
<thead>
<tr>
<th>OSOC Code</th>
<th>OSOC Title</th>
<th>Year Posted</th>
<th>Total</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>173029</td>
<td>Engineering technicians, except drafters, all</td>
<td>8  33  123  53  83  55  355  59</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>172199</td>
<td>Engineers, All Other</td>
<td>63 31 87 181 238 219 819 137</td>
<td></td>
<td></td>
</tr>
<tr>
<td>531021</td>
<td>First-Line Supervisors</td>
<td>30 40 1,112 108 259 201 1,750 292</td>
<td></td>
<td></td>
</tr>
<tr>
<td>111021</td>
<td>General and Operations Managers</td>
<td>128 132 286 662 629 872 2,709 452</td>
<td></td>
<td></td>
</tr>
<tr>
<td>519198</td>
<td>Production Workers</td>
<td>2694 6319 2631 3440 2508 2074 19666 3278</td>
<td></td>
<td></td>
</tr>
<tr>
<td>537062</td>
<td>Laborers and Freight, Stock, and Material</td>
<td>1812 3294 3820 3143 4431 4662 21162 3527</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Movers, Hand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>514041</td>
<td>Machinists</td>
<td>290 231 394 439 658 461 2,473 412</td>
<td></td>
<td></td>
</tr>
<tr>
<td>173027</td>
<td>Mechanical engineering technicians</td>
<td>35 13 28 24 44 30 174 29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>172141</td>
<td>Mechanical Engineers</td>
<td>27 58 114 196 218 233 846 141</td>
<td></td>
<td></td>
</tr>
<tr>
<td>537064</td>
<td>Packers and Packers, Hand</td>
<td>1160 932 1667 2060 1822 3043 10684 1781</td>
<td></td>
<td></td>
</tr>
<tr>
<td>519199</td>
<td>Production Workers, All Other</td>
<td>6090 8423 6010 6524 8542 7100 42,689 7115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>512092</td>
<td>Team assemblers</td>
<td>279 480 514 1811 729 1664 5,477 913</td>
<td></td>
<td></td>
</tr>
<tr>
<td>113071</td>
<td>Transportation, Storage, and Distribution</td>
<td>108 258 128 294 215 184 1,187 198</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Managers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>514121</td>
<td>Welders, Cutters, Solderers, and Brazers</td>
<td>1,377 4,304 3,471 2,966 1,966 1,318 15,432 2,572</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Job Openings: 14,101 24,548 20,385 21,931 22,342 22,116 125,423
Table 2: Occupational Openings and Salary Ranges

<table>
<thead>
<tr>
<th>OSOC Code</th>
<th>OSOC Title</th>
<th>MS Yearly Salary Range</th>
<th>Job Openings</th>
<th>Positive Referrals</th>
</tr>
</thead>
<tbody>
<tr>
<td>172199</td>
<td>Engineers, All Other</td>
<td>$29,320 - $137,970</td>
<td>355</td>
<td>21</td>
</tr>
<tr>
<td>172141</td>
<td>Mechanical Engineers</td>
<td>$55,090 - $124,650</td>
<td>819</td>
<td>65</td>
</tr>
<tr>
<td>113071</td>
<td>Transportation, Storage, and Distribution Managers</td>
<td>$38,700 - $128,850</td>
<td>1,750</td>
<td>229</td>
</tr>
<tr>
<td>111021</td>
<td>General and Operations Managers</td>
<td>$31,740 - $163,850</td>
<td>2,709</td>
<td>10</td>
</tr>
<tr>
<td>514121</td>
<td>Welders, Cutters, Solderers, and Brazers</td>
<td>$27,270 - $61,390</td>
<td>19,666</td>
<td>315</td>
</tr>
<tr>
<td>514041</td>
<td>Machinists</td>
<td>$24,990 - $59,630</td>
<td>21,162</td>
<td>335</td>
</tr>
<tr>
<td>512092</td>
<td>Team Assemblers</td>
<td>$19,760 - $48,780</td>
<td>2,473</td>
<td>1821</td>
</tr>
<tr>
<td>519198</td>
<td>Production Workers</td>
<td>$17,640 - $43,950</td>
<td>174</td>
<td>7549</td>
</tr>
<tr>
<td>519199</td>
<td>Production Workers, All Other</td>
<td>$17,440 - $44,480</td>
<td>846</td>
<td>15425</td>
</tr>
<tr>
<td>537062</td>
<td>Laborers and Freight, Stock, and Material Movers, Hand</td>
<td>$17,050 - $36,070</td>
<td>10,684</td>
<td>1704</td>
</tr>
<tr>
<td>537064</td>
<td>Packers and Packagers, Hand</td>
<td>$16,740 - $30,830</td>
<td>42,689</td>
<td>2809</td>
</tr>
</tbody>
</table>

Item 2: To what extent does the Industrial Technology degree align to these positions? For this research question, a UBD reverse mapping methodology was implemented to link employer expectations to degree pathways. Of the 14 Advanced Manufacturing occupations, people with an Industrial Technology degree from Mississippi State University (n=195) held a position in 12 of the occupations. There were two professions that were unmatched, Laborers and Freight & Transportation Distribution Managers. In a follow-up analysis, researchers identified 52 positive referrals with Industrial Technology degrees within the Mississippi Works Database. This analysis confirmed the previously identified areas of employment but also included the Laborers and Freight occupation.

An analysis of the curricular components of the Industrial Technology degree at Mississippi State University indicate that this is a subject area of specialization within a degree program. And could potentially be filled by a graduate, thus this degree program is perfectly aligned to the needs of the Advanced Manufacturing sector, and offers potential to close the employment gap within the industry.

The Bachelor of Science in Industrial Technology at Mississippi State prepares students for supervisory and management positions in the production, automation, maintenance or logistics areas of industry. Students receive a background in science, mathematics, design and human relations. This is coupled with the practical use of both manual and automated machinery and associated tools, as well as knowledge of industrial manufacturing processes, materials and logistics. Students have the opportunity to specialize in specific areas by selecting from three concentrations: Industrial Automation, Industrial Distribution, & Manufacturing and Maintenance Management.
Item 3: Who is being hired for the job title Mechanical Engineering? What are the educational and experience expectations of employers? What is the educational and experience of the positive referrals? How important is experience?

In an analysis of mechanical engineering positive referrals (n=45), over half of the employers listed a Bachelor’s degree in Mechanical Engineering as a requirement. However, 40% of positive referrals did not meet this educational requirement. Experience requirement ranged from 2 to 5 years, but 80% of the referrals did not meet this requirement. Of those that did not have the desired level of experience, over 45% did not have a Bachelor’s degree in Mechanical Engineering. In this analysis researchers did take into account degree type revealing that specificity of a mechanical engineering degree excluded other times of engineers and bachelors degrees for qualified individuals. In other words employers are asking for a mechanical engineering degrees but they are hiring outside of this criteria.

Researchers analyzed Mechanical Engineering job postings (n=219) to identify employer specified requirements for education, experience, knowledge, skills, and abilities. Specific occupations were reduced to 17 unique job titles. Within each title the data was coded to broad categories of expectations. These data were used to identify title specific expectations and general themes across the OSOC. Results validate information derived from positive referrals, in that 67% required a bachelor’s degree with 3 to 8 years of experience. However, 20% of these postings would substitute a Bachelor’s degree with a high school diploma if the employee had 4 to 8 years of relevant experience. Finally, over 12% would substitute a Bachelor’s degree with an Associates’ degree if they at least 4 to 6 years of relevant experience.

To better understand how the identified knowledge, skills, and abilities align to mechanical engineering degree programs researchers compared employer expectations to ABET accreditation standards. Results revealed a gap, indicating the employers were looking for specific skills not found within the ABET standards. Deficient areas include business, leadership, technical, and organizational skills. Researchers acknowledge that the standards are designed to guide curriculum development within mechanical engineering programs, and that individual programs may supplement programs of study to include these elements. But it is also possible for accredited programs to be producing graduates that do not have the knowledge, skills and abilities expected by employers. This gap is doing a disservice to graduates from engineering programs, in that they lack specific skill sets that do not align to ABET accredited programs but are expected in employment. Furthermore, students exiting these programs often lack the opportunity to develop industry specific experience in regular classroom activities. Putting them at a disadvantage for meeting the experiential component of employer expectations. Tables 3 and 4 show the gap and breakdown of skills.

To validate findings of research question two, researchers aligned the curricular objectives of MSU’s Industrial Technology program to the same ABET standards. Coursework and laboratory experiences met all expectations identified by employers. Researchers identified 52 incidences of curricular objectives meeting established employment expectations. This includes curricular elements not identified within the ABET standards. To communicate the ability of training pathways to meet employer expectations for mechanical engineering positions, researchers piloted visual data techniques to illustrate the investment of students in relation of the expectations of the employers for each identified pathway. This includes two criteria, student investment of time and resources and the expected investment in on the job training required to close the training gap. Figure 1 provides a representation of return on investment for each pathway.
Table 3: Breakdown of the priority of skills that employers expect from applicants to advanced manufacturing positions

<p>| Employer Expectations for Job Postings (n=219) |</p>
<table>
<thead>
<tr>
<th>% of Jobs</th>
<th>Skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>89.95%</td>
<td>Computer Literacy</td>
</tr>
<tr>
<td>69.41%</td>
<td>Organizational Skills</td>
</tr>
<tr>
<td>43.84%</td>
<td>Creativity</td>
</tr>
<tr>
<td>25.57%</td>
<td>Leadership Skills</td>
</tr>
<tr>
<td>22.37%</td>
<td>Technical Expertise</td>
</tr>
<tr>
<td>11.87%</td>
<td>Economical Management Skills</td>
</tr>
<tr>
<td>11.87%</td>
<td>System Operations Skills</td>
</tr>
<tr>
<td>7.76%</td>
<td>Mechanical Design Construction</td>
</tr>
<tr>
<td>3.65%</td>
<td>Ability to Multiask</td>
</tr>
<tr>
<td>2.28%</td>
<td>Electrical Distribution</td>
</tr>
</tbody>
</table>

Table 4: Descriptions of the skills that employers expect from applicants to advanced manufacturing positions

<table>
<thead>
<tr>
<th>Skill</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to Multiask</td>
<td>The Ability To Work Multiple Things At The Same Time.</td>
</tr>
<tr>
<td>Computer Literacy</td>
<td>3-D CAD Systems</td>
</tr>
<tr>
<td></td>
<td>Allen Bradley</td>
</tr>
<tr>
<td></td>
<td>AutoCAD</td>
</tr>
<tr>
<td></td>
<td>MathCAD</td>
</tr>
<tr>
<td></td>
<td>Microsoft Office Suite</td>
</tr>
<tr>
<td></td>
<td>Microsoft Project</td>
</tr>
<tr>
<td></td>
<td>PLC</td>
</tr>
<tr>
<td>Creativity</td>
<td>Latitude</td>
</tr>
<tr>
<td>Economical Management Skills</td>
<td>Familiarity with Market Based Management &amp; Its Principles</td>
</tr>
<tr>
<td>Leadership Skills</td>
<td>Demonstrate Progressive, Responsible Experience</td>
</tr>
<tr>
<td>Mechanical Design Construction</td>
<td>Ability To Design And Analyze A Range Of Mechanical Technical Systems.</td>
</tr>
<tr>
<td></td>
<td>Experience And Knowledge In Design And Construction Of Mechanical Systems</td>
</tr>
<tr>
<td>Organizational Skills</td>
<td>Ability To Prioritize &amp; Multitask</td>
</tr>
<tr>
<td>System Operations Skills</td>
<td>Familiarity With Lock Out/Tag Out System</td>
</tr>
<tr>
<td></td>
<td>PLC'S Systems</td>
</tr>
<tr>
<td></td>
<td>Material Flow, Quality Control (Statistical Process Control), And/or Inventory Systems</td>
</tr>
<tr>
<td>Technical Expertise</td>
<td>Read &amp; Interpret Work Orders, Drawings, Blueprints, &amp; Manuals Ex. Quality Control Assessment</td>
</tr>
</tbody>
</table>
Conclusion: From this study it appears that if a four-year degree is required in an advanced manufacturing position, then a technical degree has more employment opportunities than engineering degree. This is combined with a better return on investment in both time and financial resources to the student, as well as, to the employer as there are fewer skill gaps that require on-the-job training.

However, many students wish to become engineers without the knowledge that there are many engineering related careers that technical degree will be better suited for, as it aligns more readily to employees requirements/expectations. This leads to the question of how we steer potentially great technical people at the K-12 level into career pathways that could give them great career potential. Some of these students would be aspiring engineers who learn better through a tactile experience rather than those of a more traditional lecture format. Other potential candidates could be those that do not have the extensive math and science background/skills to become an engineer, but have good reasoning and problem-solving skills that can be encouraged and built upon. This student needs to have guidance into technical career paths to fulfill their potential.

The guidance of these two types of students, as well as others, these to begin at the K-12 level, the earlier the better. This requires a student to be educated in different careers and the educational requirements and pathways. To this extent it will also require that school counselors be retrained in those career/educational pathways. This retraining must come with the support from state departments of education.

Finally, as well as educating students and counselors, the parents of the students need to be educated in the career opportunities that are available to their children this has to be in holistic approach would not just higher education in industry leading the way but all stakeholders being invested in this process.

In order to better understand how institutions of higher learning our meeting STEM employment and advanced manufacturing careers, we propose a model that would allow K-12 students to gain technical credits, from community colleges, that will transfer into technical programs. Allowing students to gain hands-on experience, even in a lab, could possibly stimulate them to either enter directly into the workforce, or continue their education develop a specialization and then into the workforce.
Figure 1: Representation of return on investment for each pathway, in both terms of the students time and financial investment and the investment of the employer to bridge the skills gap of a new employee.

References:


Learning Requirements for Manufacturing Organizations

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Introduction: The current competitive manufacturing environment requires engagement with firms globally to improve quality and delivery while lowering costs. A manufacturing organization can only compete by learning at a faster rate than its competitors (Kapp, 2017). The drive for transforming a manufacturing organization into a learning organization is the resulting improvement in the bottom line results (Moret, 2017). The implementation of learning through training and education programs yields an outcome of increased productivity by 17 percent (Kapp, 2017). The action of assessing and identifying training needs is important in helping executives develop a plan to address the gaps between the existing learning methods and the learning methods necessary to move the company forward (Pajaron, 2017).

In manufacturing firms, the encompassing term for learning is training. Specifically, the term “highly trained workforce” is often used (Moret, 2017). Many areas within a manufacturing organization drive the learning requirements (Garvin, 1993). Drivers that require training, education and learning development existed in many parts of the organization and presented in Table 1. These areas needing learning development are determined both from the author’s experience and referenced sources for this paper (Garvin, 1993; Kapp, 2017; Moret, 2017; Slater & Narver, 1995). The International Organization for Standardization for Standardization (2017) relates that ISO 9000 is an international standard that ensures a company meets a minimal quality assurance and management program. ISO 9000 defines the manufacturing organization requirements for a manufacturing company. The term driver used in this paper indicates that the learning need is a result of the listed topic or topics with the ISO 9001 checklist. Replicated in Table 1 are many of the requirements outlined in the ISO 9001 checklist (2017). The development of these drivers occurred through benchmarking and mapping against the state of the art manufacturing methods and world-class actions at competitors and other similar organizations. Performing the benchmarking activity will enable contact between companies which have similar strengths and weaknesses (Bessant & Caffyn, 1997).

Table 1
Drivers of Learning in Electronics Manufacturing

<table>
<thead>
<tr>
<th>Category</th>
<th>Driver of the training requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Employee Training</td>
<td>ISO 9000, ESL, Total Quality Management</td>
</tr>
<tr>
<td>Higher Education</td>
<td>Bachelor, Master Degrees</td>
</tr>
<tr>
<td>General Education</td>
<td>Business Lunch and Learn, Customer Lunch and Learn, Customer Education</td>
</tr>
<tr>
<td>Management Team</td>
<td>Leadership Principles, Strategic Planning, Business Operating Systems</td>
</tr>
<tr>
<td>Team Training</td>
<td>Problem Solving, Teamwork, Teamwork tools</td>
</tr>
<tr>
<td>Specialists</td>
<td>Customer satisfaction, Policy setting, Compensation, Environmental Policy, Advanced Quality Planning, internal auditor, FMEA, Waste</td>
</tr>
</tbody>
</table>
Literature Review: The peer-reviewed literature availability within ERIC database for the topic of educational learning systems within manufacturing organizations is sparse. Supporting literature does exist within the training and education for commercial industry magazines. An online presence exists containing extensive information that exists written by consultants to these manufacturing organizations. Addressed in these articles are assessment methods for assuring that employees are meeting learning objectives set by their organization’s leadership.

The literature selected for this review consists of articles that are peer reviewed within the last ten years. There are supporting articles used for groundwork in this investigation that represent the source of the referenced quotes in recent articles. Online references contained in this review provide a current and expanded view of learning requirements within manufacturing industries.

The survey of literature performed for this informational review consisted of an analysis of the articles available. The articles were selected based on the abstract information or reading of the entire article. The selection of articles to include in this review was determined by appropriateness, merit, and quality of each reference through comparison of the individual articles. Finally, during the reading of the articles, highlighted key points and notations were reviewed and categorized.

The quality of the sampled literature ranges from formal publication in the Harvard Business Review to an in-depth review of the education requirements of a manufacturing organization published in the Journal of Marketing. White papers issued by the Society of Manufacturing Engineers and the Manufacturing Institute are very detailed and are considered leading resources by industry. Supporting websites are used to round out the information and help to provide a current comprehensive review of learning within the manufacturing environment. Industrial training publications and websites publish relevant articles which are part of this literature review.

A significant white paper found during this study was supplied by the Society of Manufacturing Engineers (SME), (2012). In this article, there is an assessment of the learning requirements that are needed by a manufacturing organization. The paper summarizes a necessity of a standard core of manufacturing knowledge. The report indicates that there is a shortage of trained faculty to develop and implement this requirement because of the lack of focus on manufacturing in the United States of America (USA) in recent years. Faculty need to be developed and trained to be able to offer certification, degrees and credentialing within the manufacturing learning space (Clark & Clark, 2017).

Currently not documented and incorporated into course curriculum for engineers and technicians are advanced methods of manufacturing. The lack of learning and educational studies includes topics such as robotics, automation, and control systems. Information that has been available to support learning requirements are areas within the four pillars of manufacturing. These four pillars are:

- Materials, manufacturing processes, and product;
- Product, tooling and assembly engineering;
- Manufacturing, operations, and systems; and
- Manufacturing competitiveness.

The SME (2012) reports that these pillars represent the areas in which a manufacturing company must excel to be competitive.

The SME recommends the documenting of production and learning methods thoroughly to ensure that manufacturing organizations can be competitive. The next requirement is to keep this information current to the processes used to compete at world-class levels by manufacturing operations. Finally, the SME recommends that standardized learning materials be dispersed centrally by the national center of manufacturing.
Slater and Narver (1995) wrote a comprehensive article which addresses the learning requirements of an organization. The process of organizational learning is the acquisition of information, information dissemination and resulting in shared interpretation amongst the staff or the manufacturing organization. During information acquisition, collecting information from the experiences of others, direct experience, and organizational memory is possible. Information dissemination occurs through formal and informal within the organization and persons employed by the company. Collecting organizational learning by transferring information results in an organized, shared, organizational, learning environment. The last stage of organizational learning is the shared understanding and interpretation of the information. To initiate this needed learning, the manufacturing organization must have a consensus as to the meaning of the information.

The breakdown of learning in the article indicates that there are three methods of learning. These are lecture-based, skills-based, and inquiry-based. The culture and climate in the manufacturing organization determine which of the learning methods will work best for learning to occur in an organization (Slater, & Narver, 1995). Hayes (1988) relates that in a learning organization individuals review the process, look for process performance improvements, and recommend improvements. Problem-solving is an exercise that is paramount to building the foundation of a learning environment. Resolving problems can help to understand and improve the manufacturing process.

This review of the literature indicates that there are five key areas of learning that need to be addressed by the manufacturing organization’s leadership. Garvin (1993) reports that the organization needs to have learners who can experiment, solve problems, learn from others, learn from past experiences and transfer that information. These skills need to be developed by the manufacturing organizations. Soft skills is a term that includes these five skills. A flexible workforce requires these soft skills (Stone, Kaminski, & Gloeckner, 2009).

There is a need for the members of the manufacturing organization to learn to solve problems. A formalized company new employee mentoring ensures that the problem-solving methods transfer to the new employee (The Manufacturing Institute, 2006). The mentoring process creates an effective learning environment that develops confidence and skills to contribute to the high-quality output. In an organization focused on learning, the reaction to when it is determined that a product is not in compliance with a specification that the product is not just scrapped and thrown away without initiating corrective action. A continuous improvement process is an ongoing approach to improving processes, products or services. This advancement often occurs through improvements achieved over time but can happen by having a breakthrough development. The continuous improvement environment will have employees working to find solutions so that problems are not recurring (Kapp, 2017). Well-trained workers have continuous learning experiences throughout their lives. Evolving companies and advancing technologies process require an agile and highly trained workforce (Moret, 2017).

The ability to experiment and adapt to change is important. Capacity to learn how to manage change is critical to a manufacturing organization’s success (Bose & Sinba, 2012). In organizations in which the labor is unionized, there may be the importance of critical understanding as to why there has been a change in labor relations resulting in union organization (Brown & Yasukawa, 2010).

Learning from organizational experiences and understanding lessons learned will allow an organization to advance without repeating mistakes (Center for Business and Industry, 2017; Stone, Kaminski, & Gloeckner, 2009). Unions are prevalent in manufacturing firms. There is a need for these unions to learn from the past negative experiences of union activities to ensure that the businesses the union supports can succeed in international competition (Brown & Yasukawa, 2010).

The ability to learn from other organizations and their leaders is crucial to the success of the firm. This learning develops through three competencies: foundational, functional and technical (Despina, 2013). Solutions exist to address the skills gap among manufacturers. The Manufacturing Institute (2011) suggests using older employees to train younger employees can help avoid brain drain. Older workers at the organization can gradually scale back their hours as they move into retirement while tutoring their younger colleagues.
A literature review of a manufacturing organization must address total quality management and the role of innovation (Kocoglu, Imamoglu, & Ince, 2011). Organizational learning has similar characteristics to individual learning. Group learning occurs when expanded individual learning results in the collective learning which promulgates amongst the people in the manufacturing organization. Burke (2014) cautions that a consistent effort to improve organizational learning can achieve continuous improvement results. However, the core leadership team may not fundamentally change the team methods. A shock to the organization may have to be administered to keep the focus on improving learning and continuous improvement. Choo’s (2006) analysis found that an organization learns by testing, constructing and reconstructing the approach to the manufacturing process. Continuous improvement happens as learning occurs and the employees begin to correct errors through modification of the previously developed production methods.

**Discussion:** Manufacturing organizations can improve the generation of cash and profits by assessing the organization’s educational needs and placing focus on developing learning. This profit generation is the reason the business exists (Kapp, 2017; Moret, 2017). The business does not transform into a learning organization because of goodwill or kindness; the transformation happens so that the organization can gain an advantage and remain ahead of their competitors. Unfortunately, very few manufacturers emphasize learning, innovation or knowledge (Kapp, 2017).

With the advent of online education (E-class), costs for employee education could lower as employees could work independently to obtain training. Should the manufacturing line have to stop, employees could move to a learning situation quickly. The trainer or education department does not have to scramble to develop a class and provide an instructor. The E-class would be available so that students could move to a learning environment (Batalla-Busquets, & Pacheco-Bernal, 2013).

Any manufacturing organization is attempting to develop and train their workforce to assess and identify training needs (Pajaron, 2017). Training and education programs provide students with skills and knowledge. Employers are often not sure if the employees as students have understood the content and can perform functions that the individual learned in the classroom. To assess learning in a manufacturing organization:

1. **Assess talent.** Possibly using consultants or higher education faculty. Individual assessment reviews each person to discover the possible level of performance.

2. **Review of current workers skills and abilities.** Will scrutinize the learning skills of particular employees to assess their level of knowledge and performance. This review compiles the individual’s existing qualifications and competencies and determines the individual’s capacity for learning. The results of this survey will identify the strengths of employees and the specific areas that need capability improvement (Pajaron, 2017).

3. **Audit training resources and skill building.** A review of programs within the business and community needs to be performed to determine what education processes are available to support the organization’s educational needs. Auditing the education process in a manufacturing organization allows the management team to use this feedback to find when the learning development needs may require improvement or the learning needs may have changed. A training survey could be performed once a year to ask employees what in-house and external training is necessary to meet their learning needs.

4. **Check with organizations outside the company (outside of the state also) to identify what training needs they are developing, or what training should develop internally.** A manufacturing firm that makes high-tech products may require the organization to research and gain an understanding of how the organization’s customer will use the part. When assessing the learning needs, the organization must differentiate what must be understood by the manufacturing organization and differentiate this requirement for desired learning and knowledge from what would be considered helpful to know (Pajaron, 2017).
5. Assess job functions and tasks. An analysis of the main tasks, skills, and competencies that are needed to perform a job. The task assessment focuses on the enterprise's effectiveness. This analysis of key competencies, skills, and tasks to do the job effectively and efficiently. This review establishes the detailed job descriptions, skills inventory questionnaires and competencies are required to carry out the job. The goal is to identify the gap between the existing techniques and those skills needed to support continuous improvement (Pajaron, 2017).

Reviewing and inventorying of each type of training is to be performed before making a plan of action for the manufacturing organization. This assessment will address the different areas within the firm and create training programs to address critical holes in learning. The result will improve the competitive performance of the organization.

Summary: This paper discusses the need for organizational assessment of learning and the importance of developing a strong learning culture. The necessity of assessment will give the management the ability to identify and support educational needs. The internal review will determine the motivation for learning, change, and development of a new learning culture. Resources can then be allocated to support these training needs. These resources are utilized for learning and development of the organizational culture to help improve the effectiveness and productivity of the staff.

Conclusion: Change is coming to the manufacturing sector. Manufacturing organizations, especially those who produce electronics and need to gain back market share from outsourced world manufacturing locations will benefit in having a chief learning officer. The hope is that more job descriptions within manufacturing organizations will use words such as learning, learner, and mentor to describe the responsibilities of their staff at all levels of the organization. Future hiring decisions, promotion decisions, bonuses, and incentives need to have a recognition of the importance of learning.

Improvements in technology and changes in the organization's approach to organizational learning and training will overcome the barriers and challenges that restrict the manufacturing organizations from being globally competitive. Innovative methods of educating, training and assessing the manufacturing workforce will allow continuous improvement within the organization. This continuous improvement will lead to increased earnings and profits.

References


Society of Manufacturing Engineers (2012). Workforce imperative: A manufacturing education strategy. Dearborn, MI.


In-situ Integration of MEMS Switches to Realize Reconfigurable Multifunctional Antennas

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Abstract: This paper reports the in situ realization of MEMS switches and their monolithic integration with other RF components to achieve reconfigurable structures that can deliver multiple functions. The control of thin-film stress is the key to realizing free-standing membranes for MEMS switches. The results indicate that the thin-film stress and stress gradient can be purposely tailored to achieve curving or non-curving membranes by using different layers that are made by different methods or different processing parameters. The stress-control technique is utilized to produce MEMS switches of various geometries on Si, quartz and printed circuit boards (PCBs). PCBs are the most common substrates used in RF applications and it is very significant to realize MEMS switches on them. Low-temperature dielectric films are crucial for realizing MEMS switches on PCBs. The actuation of the switches in the reconfigurable structures is accomplished through high-resistance DC biasing lines, which cause negligible impacts on RF performance. Low-temperature SiNx films and high-resistance DC biasing lines are developed in this research. Finally, MEMS switches have been integrated in situ with RF components to realize various reconfigurable structures. As example, two multifunctional reconfigurable antennas, a double-band annular slot antenna and a penta-band planar inverted-F antenna, are demonstrated.

Introduction: RF MEMS switches and their applications have been one of the most attractive and prevalent topics of research in RF and millimeter wave communication systems. The RF MEMS switches exhibit superior advantages over conventional PIN and FET switches, which include very high isolation, very low insertion loss, very high linearity and near-zero power consumption. Being essentially broadband devices, RF MEMS switches are far less affected by frequency and are more suitable for high-frequency applications. The contemporary need for increasing functionality within a confined volume has promoted the utilization of RF MEMS switches in today’s RF and millimeter wave systems. RF MEMS switches are now being used to realize reconfigurable or tunable phase shifters [1-5], varactors [6, 7], filters [8], impedance matching networks [9, 10], and antennas [11-16] and RF subsystems [17, 18] that can deliver multiple functions. The reconfigurability and multi-functionality are realized by placing RF MEMS switches at various locations to either change the physical dimensions, or route RF signals into proper paths, or connect/disconnect with other passive or active RF components.

Despite their remarkable advances and expanding applications, RF MEMS switches still fall far short of fulfilling their early promise. The reliability and packaging of RF MEMS switches are believed to be the two principal issues that have limited their high-volume applications. With success in packaging, the reliability of RF MEMS switches has then become the main and urgent problem to be solved. Reliability data of RF MEMS switches are very scarce but significant successes have been made. Their lifetime reported spans over a broad range from several million to tens of billions cycles under different laboratory environments [17-30]. The lifetime in practical applications is not clear and the reported numbers are often vague. The leading supplier of RF MEMS switches in U.S, Analog Devices, recently reported that the actuation lifetime (not the lifetime in terms of RF performance) of its switches is over 1 billion [27, 28]. Another leading supplier, Radant MEMS, reported on its website that its switch reliability is over 1.5 trillion cycles, but the datasheets of its new products indicate that the lifetime depends on the loading condition and it quickly reduces from 1011 cycles at DC (cold-switched) to 109 cycles at the power level of -10 dBm and 103 cycles at the power level of 20 dBm (hot-switched) [29, 30]. For commercial markets, the lifetime needs to reach tens of billions of cycles; and for the aerospace and national security applications, the lifetime needs to reach hundreds of billions of cycles [18]. Obviously, there exists a large gap between the present developments and the practical needs. The researcher of this paper is also engaged in improving the reliability of RF MEMS switches by mechanical and material approaches.
As RF MEMS switches make inroads gradually into commercial uses, an urgent issue that remains to be addressed is their in-situ integration capability. This capability is essential in creating high-performance RF systems because monolithic integration will eliminate all the wire bonds and most of impedance mismatching. In-situ integration requires housing both MEMS switches and other circuit elements on a common substrate. MEMS switches need to be activated by using DC voltages. Meanwhile, in order to provide a maximum number of reconfigurable operational modes in an RF system, more RF MEMS switches need to be used and each of them requires to be controlled individually, thereby resulting in a great number of biasing lines. For MEMS integrated RF systems with a large number of switches, the space is very limited to accommodate numerous biasing lines, and the biasing lines are often closely packed together with active RF elements. As a result, a variety of electromagnetic couplings and interferences between biasing lines and RF elements occur that degrade RF performance. High-resistance DC biasing lines become critical for realizing the in-situ integration.

RF MEMS switches represent an enabling technology that can dramatically revolutionize the modern communication systems. The full potential of RF MEMS switches can only be realized through monolithically integrating them with other active and passive RF components. Currently, the practical uses of RF MEMS switches often involve wire-bonding discrete MEMS switches. This is not an effective way of using RF MEMS switches to achieve high functionality. This paper reports a work on the in situ realization of various MEMS switches and their monolithic integration with other RF components to achieve reconfigurable structures on common substrates.

**Results:** In the following, RF MEMS switches are first presented. Then, the low-temperature SiNx film, which is crucial for realizing RF MEMS switches on printed circuit boards (PCBs), is given. Following that, high-resistance DC biasing lines, which are essential for monolithic integration of MEMS switches with active RF elements, are introduced. Finally, two of the researcher's on-site integration efforts are demonstrated.

RF MEMS switches: Controlling thin film stress is critical for realizing free-standing membranes. Stress in thin membrane often causes unwanted deformation and distortion. Residual stresses are different in different metals, such as Au, Al, Cu, Ti and Ni, and in the thin films of the same metal by different processing methods, such as e-beam, sputtering and electroplating. As a result, stress and stress gradient can be purposely tailored to repeatedly and reliably achieve curving or non-curving metallic membranes by using different metal layers that are made by different methods or different processing parameters. In this research, the membranes can be a couple of millimeters long. There is no limitation on membrane width. For RF applications, it is greatly beneficial for avoiding impedance discontinuity due to the presence of different widths along signal paths. The membranes obtained are robust because they are totally metallic, differing from the sandwich structure developed by other researchers [31]. This approach has potential to simplify fabrication and benefit monolithic integration. Figure 1 shows the curvature of membrane under different stressed conditions. Their curvature is independent of membrane length, and it is solely decided by the stress gradient along the membrane's length.

![Fig.1: Curvature of metallic membranes under different stressed conditions: (a) very low stress; (b) low stress; and (c) high stress, different width membranes with the same curvature.](image-url)
This stress control technique has been used to develop various switches. More than seventy-five switches with different types (bridge or cantilever, ohmic contact or capacitance coupling, and slot or hole) and different dimensions have been made and tested. Figure 2 shows three samples of RF MEMS switches. Membrane thickness is 8-12kÅ and the sacrificial layer is 3.5 μm thick for these devices. The sacrificial layer defines the gaps between the membranes and substrates as well as the switches’ actuation voltage. The actuation voltage is measured to be 30~40 V for the capacitive-coupling switches and 50~60 V for the cantilever ohmic contact switches. If needed, the actuation voltage can be significantly decreased by using a thinner sacrificial layer, for example, 1μm.

Dielectric films: Dielectric layers are integral parts for electrostatically-actuated switches. Because PCBs cannot stand temperatures more than 250°C~300°C (depending on the types of PCBs), low-temperature dielectric films have to be developed for realizing RF MEMS switches on PCBs. SiNx films are deposited at 170°C by inductively coupled high-density CVD. The main challenges of using the low-temperature SiNx are how to make quality films with significantly high breakdown voltages and how to reduce interface charge trap density and fixed charge density because these defects will affect switches’ operation and reliability. Fixed charges have caught great attention in the field of RF MEMS switches, but charged interface traps are largely ignored. Actually, both affect switch performance, such as actuation voltage, stiction, self-actuation and latching. In this regard, the SiNx deposition parameters have been optimized and the post-process treatments have been developed [32].

Figure 3(a) shows the I-V measurements at four different points of the annealed SiNx film. Under the low electric field (<1.5 MV/cm), carriers pass as a form of leaking current, which obeys ohmic’s law. In this regime, dielectric charging by an external electrical field does not happen. As the electric field increases, ohmic’s law fails. After the electrical field is larger than 2.5 MV/cm, carriers pass through the films by Schottky or Frenkel-Poole emissions, in which the relationship of \(V \) vs. \(E\) is close to a straight line [33]. In this regime, the dielectric films can be charged by charge injection. As the electrical field further increases, ionization becomes active and an avalanche breakdown occurs.
Figure 3(b) shows the C-V behavior of the SiNx film at as-deposited and annealed conditions. The charged traps lead to the stretch-out of a C-V curve and also add Qinterface(ψs=0)/CSiN to a shift of flatband voltage (Q is charge density). Fixed charges originate from freely-dangling chemical bonds and cause a parallel shift of a C-V curve by –Qfixed/CSiN along the voltage axis with respect to the ideal curve. The significant stretch-out of the C-V curve indicates a large interface trap density existing in the as-deposited film. The asymmetry of the hysteresis is attributed to the difference in capture and release kinetics during the forward and reversal bias sweeps. The large flatband voltage reveals that the as-deposited film contains a high density of fixed charges. After annealing, the hysteresis becomes narrower and more vertical, and the flatband voltage decreases significantly, indicating that both the densities of the interface charge traps and fixed charges have been reduced as result of annealing.

In conclusion, the low-temperature SiNx films exhibit significantly high breakdown voltages, both interface charge traps and fixed charges exist in dielectric films, and an annealing treatment can significantly decrease their densities. Charge injection is a phenomenon at high electrical strengths. Reducing electrical strengths is the essential way to prevent its occurrence.

High-resistance DC bias line: When MEMS switches are integrated with RF elements, an effective DC biasing strategy needs to be used to achieve both switch actuation and RF decoupling. There are different ways to realize that but the high-resistance approach is preferred. When the high-resistance approach is used, the sheet resistance should be high enough to achieve an effective RF blocking. It must be far larger than the characteristic impedance of the RF transmission lines or elements. Meanwhile, the total absolute resistance of a bias circuit also needs to be controlled. The delay time for charging and discharging capacitance depends on the time-delay constant (RC). If the total resistance is too large, it leads to a very slow actuation. The resistivity of SnO2 and TaN is closely related to their stoichiometry, which is determined by the processing parameters during sputtering, especially, the ratios of O2/Ar and N2/Ar. In this research, reactive sputtering and stabilizing annealing are used to make high-resistance bias lines. The sheet resistance can be precisely adjusted between 100 and 20,000 Ω/□ with the film thickness to be controlled around 2–3 kÅ.

Penta-band PIFA: One of the on-situ integration efforts in using RF MEMS switches to realize reconfigurability and multifunctionality is to develop a reconfigurable planar inverted-F antenna (PIFA) for five commercial bands of GSM900, GPS1575, GSM1800, PCS1900 and UMTS2100 in order to achieve global roaming with a single handset. The design principle is to deliberately manipulate the PIFA patch structure to create three resonant current paths on the antenna surface to deliver triband radiation behavior. Furthermore, the electrical length of each resonant current path is altered through MEMS switches to shift the location of the highest frequency band, thereby realizing penta-band behavior.
A quartz substrate is used to realize the top part of the PIFA. The fabrication procedure is as follows. First, RF MEMS switches and antenna patches are made simultaneously by microfabrication on a quartz substrate. Then, the fabricated chip is mounted on a PCB with the needed separation to generate the PIFA. The DC biasing and RF signals are fed into the antenna through the ports on the sides. Ohmic contact switches in Figure 2(b) are used in this implementation. Several designs are developed for realizing the antenna's reconfigurability. Figure 3(a) shows the geometry of one of the designs. Figure 3(b) is a fabricated PIFA with high-resistance lines on a quartz substrate mounted with a quartz spacer on PCB. Figure 3(c) is the simulated result. The device is being tested.

Annular slot antenna: Another on-situ integration effort is to develop a reconfigurable annular slot that is designed to realize frequency band selectivity (for popular 2.4 GHz and 5.2 GHz WLAN applications) while maintaining radiation pattern. The PCBs, TMM10i (ɛr=9.8, tgδ=0.002), are used in this work. Because the surfaces of the PCBs are not smooth, the work is intentionally used to test the robustness of the microfabrication process that has been developed on discrete RF MEMS switches. The antenna consists of an annular slot front side and a feed stripe back side. The reconfigurability of the antenna is realized by using RF MEMS switches to change the resonating gap size of the slot and the feeding length of the signal stripe.

The fabrication procedure is as follows. The front side plate and the back side plate are fabricated separately and they are then bonded together. The annular slot and stripe are made by patterning the existing copper layers of the PCBs. Then, RF MEMS switches and DC biasing lines are made on the designed locations by using the microfabrication process developed. Figure 4 shows the front and back sides of the annular slot antenna constructed on a PCB. Two switches are placed cross the outer slot to connect/disconnect the main ground and the inner metal stripe. The dual band behavior is achieved by selectively activating the two concentric radiating slots. One RF MEMS switch is placed along the feeding microstrip line and it allows the selectivity to feed either slot. The sheet resistance of the DC biasing lines is ~1 kΩ/μm and the total absolute resistance is ~20 kΩ. When no switch is activated, the outer slot is fed to radiate at 2.4 GHz; when all the three switches are activated, the inner one is fed to radiate at 5.3 GHz. The antenna has been tested. The testing result indicates that the influence of the high-resistance biasing lines is very minimal.

![Fig.4: Photographs of annular slot antenna fabricated on microwave laminate: (a) microstrip side and (b) slot side.](image-url)
Conclusions:

1. The thin-film stress and stress gradient can be purposely tailored to achieve curving or non-curving membranes by using different layers that are made by different methods or different processing parameters. The stress-control technique is utilized to produce MEMS switches of various geometries on Si, quartz and printed circuit boards (PCBs).

2. Low-temperature dielectric films are crucial for realizing MEMS switches on PCBs. The low-temperature SiNx films developed exhibit significantly high breakdown voltages. Both interface charge traps and fixed charges exist in SiNx dielectric films, and an annealing treatment can significantly decrease their densities.

3. High-resistance biasing lines are used to achieve both switch actuation and RF decoupling. The resistivity of SnO2 and TaN is closely related to their stoichiometry, which is determined by the processing parameters during sputtering, especially, the ratios of O2/Ar and N2/Ar.

4. MEMS switches have been integrated in situ with RF components to realize two multifunctional reconfigurable antennas, a double-band annular slot antenna and a penta-band planar inverted-F antenna.

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References


Design and Implementation of a Virtual Reality Laboratory for Mechanical Maintenance

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Abstract: Every manufacturing facility requires preventive and corrective maintenance to their industrial equipment to maintain the performance indicators at the desired level. One of the limitations related to maintenance is the training of new and existing personnel. New personnel are unaware of the necessary steps and skills to perform maintenance on equipment. The lack of available training equipment often requires either shutting down operations which cost the industry money and/or putting trainees and other employees in potentially dangerous situations if mistakes are made during live operations without previous training. At the educational level students lack the proper industrial level training due to the lack of training equipment and high budget constraints. Universities often train students with obsolete equipment and/or lower level training stations compared to the once use at an industrial level. For this reason, Virtual Scenarios for Maintenance are proposed. The potential of these laboratories relies on their ability to carry out industrial personnel training in a safer and more efficient way without the constraints of equipment availability and budget constraints. Virtual Scenarios lower the cost of maintenance, increase safety, reduce replacement costs for obsolete equipment and open options for online training. Virtual Scenarios for Maintenance open new possibilities since components possess the physical, electrical, and mechanical characteristics of the industry necessary to simulate real behavior without the limitations of having to acquire and maintain a physical laboratory or industrial space reserved for training.

Introduction: Industrial maintenance can be defined as the repair and upkeep of equipment and machines used in an industrial setting. Some general knowledge that is required to perform industrial maintenance is safety, an understanding of tools and following procedures. Using the correct tools and comprehending how the tools must be used is a crucial skill for performing maintenance on industrial machines. A second crucial skill that the person performing maintenance should focus on is safety, this includes his or her own safety as well as those using the machinery. Industrial maintenance cannot be overlooked, it plays a very important role in the effectiveness of manufacturing success and lean manufacturing. Industrial maintenance is required to effectively reduce waste as well as to run efficient, continuous, and safe operations. Maintenance training is critical to any given manufacturing success because the maintenance ensures all of the equipment, new or old, is functioning efficiently and effectively. [7]

Industrial maintenance training takes time, employees must have proper general knowledge prior to performing any maintenance on specific machines and then the employee must also have proper maintenance and safety training on the specific machine the maintenance is being performed on. Companies as well as academic institutions face training limitations when teaching maintenance to students or employees. Limitations in industry are largely related to high costs of employee training, since training often requires shutting down operations and/or putting employees and trainees in potentially dangerous situations. Industrial facilities also face limitations with equipment availability, companies need to have equipment
sitting just for maintenance training, or wait until a machine is damaged to teach how to perform maintenance. Academic limitations include the lack of infrastructure that allows students to conduct trials in an industrial level environment. Often time academic institutions face budget restraints, limiting the amount and variety of machinery available for student use. Industrial facilities and academic institutions strive on safety, keeping employees and students safe is a priority. Maintenance training if not done correctly with the proper prior knowledge, the right tools and right procedures can be extremely unsafe, since high temperatures, heavy machinery and electric current can be involved. [1]

Due to these reasons, Virtual Reality Scenarios are proposed for maintenance training applications. These scenarios will benefit manufacturing companies, industrial facilities, [3] as well as academic institutions ranging from technical high schools to Universities. Virtual Reality scenarios for maintenance focus the training to a close to reality approach where the scenario and machines possess the physical characteristics found on the real world as well as the implementation of tools and a grading system. [2] VR scenarios solve the problem of availability, costs, maintenance, constant upgrades, and safety. [1] The virtual reality scenarios use a Game Engine platform in this case Unity, CAD modeling and C# programming to implement everything needed into a VR reality headset where the trainee is fully capable of interact with its surrounding by grabbing, touching, holding, dropping, throwing and more through existing virtual reality controllers. The VR scenarios allow for the trainee to master the procedures, by using muscle memory and repetition. [4] As a procedure is practiced over and over again the activity becomes easier and easier ultimately forcing the skill into a subconscious level where the trainee can recall it for habitual use when needed. Trainees and employees have a fully immerse experience with no equipment availability constraints that allows them to do the procedure several times. Virtual Reality Scenarios possess no safety concerns for trainees or people that operate the machines since the equipment is not physically available and its strictly virtualized into a computer software. [5] Students and trainees can perform maintenance on machines that without the use of virtual training the safety hazards could cause severe injuries if the training is not perform adequately. The virtual scenarios propose will provide real time feedback when mistakes are made, if the procedure is not followed correctly or a safety rule is broken, this feedback will allow the trainer to understand that when the maintenance is performed in live operations outside of the VR environment those mistakes can cause injuries or damage the machine.

**Definition:** Virtual environments or virtual scenarios are custom created 3D virtual worlds created out of 3D models, which allow trainees to interact and immerse themselves in “worlds” that are distant, expensive, hazardous, or inaccessible. Virtual scenarios can be called different names such as, “artificial reality”, “virtual worlds” and “synthetic environments”. Some Virtual Reality scenarios like the ones described in this paper offer full immersion into the virtual world, through virtual reality headsets from existing companies leading the VR headset industry. [5]

**Development of a Virtual Scenario.** The development of the virtual scenarios for maintenance training applications, has several different steps. Each step plays a vital part on the final implementation of the environment for training, the steps have to be completed in the right order for the process to work effectively and on a timely manner. (Figure 1)
The first step of the development process starts with the design specifications. The environment recreates a real-life application in the desired field, this paper focuses on mechanical maintenance. The mechanical process or machine that the virtual process is going to recreate has to be analyzed and comprehended as well as practiced. Once the designer has a good understanding of the process and specifications on whichever part of the process and tutorial will be created for and the tools, machines and physical parts needed are established the first step is completed. The scenario discussed in this paper focuses on the disassemble, bearing maintenance, and re-assemble of an AC motor. The design specifications determined the type of motor that will be needed as well as which components of the motor will be required for the tutorial. (Figure 2) The second part of the design specifications step focuses on the selection of the tools needed for the specific process and the steps required for the tutorial, such as order in which the parts have to be assembled.

The second part of the process starts once the parts necessary for the development of the scenarios are listed. The parts can either be provided through existing 3D cad models or can be created through 3D modeling software's such as Solid Works, Solid Edge, NX9, etc... (Figure 3)
Once the 3D model of the desired part is obtained or created the process of mesh simplification begins, by using a different software than that of 3D modeling, in this case 3D StudioMax. 3D Studio Max is a software by Autodesk for modeling, animation and rendering. A mesh is a collection of vertices, edges, and faces that describe the shape of a 3D object: A vertex is a single point. The more complicated the mesh the better the object will look in the final Virtual Reality Scenario, but the more complicated the mesh the heavier the file. This will create complications when importing several files into the Game Engine creator(Unity), which is the software where the environment is created and the real physics are applied to the objects. The “sweet spot” between mesh size and file size has to be found, where the object will be detail enough to look good in the virtual environment but, light enough for Unit to manage it. The complications when in the game engine creator occur because Unity has to render every single object that the person wearing the Virtual Reality is looking at, as well as calculate the physical behavior of this objects in real time. The objects meshes have to be divided depending on the parts of the object that have to move or have different colors and textures. If a part of the 3D model will not be necessary for the desired tutorial application this object can either be eliminated or simplified. Once the objects is exported from 3D StudioMax into Unity the meshes cannot be altered. Meaning that the process between the Game Engine and 3D StudioMax has to be done several times until the optimal condition is found. The Game Engine has a specific file type that accepts, so 3D Studio Max software also allows to change the file type from a 3D modeling with endings such as .SLDPRT or .SLDASM into an .FBX which Unity supports.

The next step is the design of the environment, this step creates a realistic environment where the person using the virtual reality actually feels like they are immersed on a building, classroom or lab. For this step the same steps as the previous step are taken where using 3D models and 3D modeling software we are able to build a realistic environment, with objects such as tables, walls, lights, etc.. A lot of the objects used for creating a realistic environment can be downloaded from CAD model sharing websites. Once the models are inside the Unity textures colors and physical behavior is applied, to create a realistic experience. The realistic experience created by virtual reality environments is not only created by real-looking objects, but by more in depth realism that includes the use of shades and shadows, lighting, and sounds. The use of all of these characteristics together in one same environment create an experience that fully immerse the person wearing the virtual reality headset.
Now that the environment is created and looks and feels realistic the physical behavior of the machines or parts that the tutorial wants to train on must be programmed. Just as objects in real life Unity allows to implement real characteristics to objects such as mass, gravity, weight, drag, force, buoyancy and more. (Figure 6)

These characteristics are used by applying something called colliders to objects. Colliders are a region that surrounds the object which delimitates the space of contact with other objects. Colliders play a big roll on the creating of virtual reality laboratories since without them every object would have no physical interaction with the trainee or other objects. There are different types of colliders available in Unity: Box collider, Sphere collider, Capsule collider, and mesh collider. The next figures provide an example of a collider on an object, the collider used is a box collider. (Figure 7-8) This collider will allow for the door in this furnace to have physical boundaries which allow for the VR trainee to touch the door, grab the door as well as for other objects using colliders to not go through the door.

The majority of the physical behaviors of the objects such as interaction with the trainee as well as movements have to be programmed using scripting. Unity allows for two programming languages C# and Java. C# was the programming language used for creating the physical behavior of the Virtual Reality Laboratory for Mechanical Maintenance. Programmers can choose between C# or Java depending on experience or preference since both have the same functionality. Some of the functions that were programmed using C# in Unity for the Mechanical Maintenance scenario include, the reproduction of a assemble and disassemble of a motor which serves as a tutorial, the interaction between the trainee which allows to grab parts in the environment such as parts of the motor or tools, the interaction between tools and parts for example a bearing puller and the bearings. The next figures shows and example of an script used for grabbing objects. (Figure 9)
The last step in the creation of the virtual reality environment for mechanical maintenance is turning the game into a tutorial. This is done by scripting as well as by implementing voice commands. The scripting allows for the trainee to realize when mistakes are done, by implementing different colors to parts when the wrong parts is grabbed or by not allowing to assemble a part when this part is not being assemble in the right order. The voice commands guide the trainee through the different steps of the mechanical maintenance process, each voice commands is activated when the prior step is completed correctly.

**Conclusion:** The idea of implementing virtual reality scenarios for training in mechanical maintenance is presented and the different steps to being able to create one of this scenarios was discussed, if the scenario is implemented correctly, the physical characteristics of the parts or machines are applied, the behavior through scripting is employed and the virtual environment is realistic, students or trainees could benefit from Virtual Reality learning and practice how to perform maintenance on mechanical parts in Virtual Reality prior to real life applications.

**References**


4) Bruner, Robert F., Repetition is the First Principle of All Learning (August 17, 2001). Available at SSRN: https://ssrn.com/abstract=224340


Integrated STEM Assessment Design: Challenges and Opportunities

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Abstract
National reports (e.g. National Governors Association, 2007; President’s Council of Advisors on Science and Technology, 2016; Next Generation Science Standards [2013]), perpetuate the need for transdisciplinary careers, and merging traditional disciplines to better meet the needs of citizens in the 21st century. Numerous studies (e.g. Satchwell & Loepp, 2002; Klegeris & Hurren, 2011; Felix & Harris, 2010; Fortus, et al., 2005; Kolodner, et al. 2003) have documented the many strengths of integrated STEM curricula through problem-oriented learning. However, there is lack of clarity about the integration of STEM disciplines and assessment practices. This study, examined engineering and technology education K-12 teachers understandings of integrated STEM in an attempt to understand how best we can develop assessment practices to support learning in integrated STEM environment. Survey design was utilized to collect data through Qualtrics Survey Software. Descriptive statistics i.e. percentages was employed to provide teachers perspectives with regard to questions guiding this study. Findings revealed that teachers offered mixed reactions even though they acknowledged the power of integrating STEM disciplines through design challenges in a PBL fashion.

Keywords: engineering and technology education, STEM, Assessment, integrated STEM, PBL

Introduction
National reports (National Governors Association, 2007; President’s Council of Advisors on Science and Technology, 2016), The New Framework for K-12 Science Education (National Research Council [NRC], 2011), and Next Generation Science Standards (NGSS; NGSS Lead States, 2013), perpetuate the need for transdisciplinary careers, and merging traditional disciplines to better meet the needs of citizens in the 21st century.

Numerous studies (e.g. Satchwell & Loepp, 2002; Klegeris & Hurren, 2011; Felix & Harris, 2010; Fortus, et al., 2005; Kolodner, et al. 2003) both at the university level and K-12 have documented the many strengths of integrated STEM curricula through problem-based learning (PBL) to include increased retention of information, the development of lifelong learning skills, early exposure to real-life experiences, increased student-teacher interaction, and an increase in motivation and interest levels in science, technology, engineering, and mathematics (STEM). The National Academy of Engineering and NRC (2014), Vasquez, Sneider and Comer (2013), and Wang, Moore, Roehrig, & Park (2011) stated that the basis of STEM education involves integration of science, technology, engineering, and mathematics by breaking down the “silos” of discipline independent teaching such that students begin to see how the concepts and skills from different disciplines can work together to help answer intriguing questions and solve meaningful problems. An integrated STEM curriculum therefore shifts the teachers focus from how to teach the concepts and skills within each discipline to how to help students learn to apply STEM concepts and skills and relate what they are learning throughout their school day (BSCS, 2000; Tsups, Kohler & Hallinen, 2009). However, educators and the schools they work for often approach integrated STEM in different ways due to unique populations, challenges, and needs. Therefore, no single school strategy has risen to the top (Means, Confrey, House, & Bhanot, 2008; Honey, Pearson, & Schweingruber, 2014).

In order to build the knowledge base for students to be successful in STEM related disciplines, the Next Generation Science Standards (NGSS) includes a set of performance expectations regarding 5 different core concepts for all grades through the creation of 4 grade bands (K-2, 3-5, 6-8, and 9-12) (NGSS, 2013). In fact, one of the major recommendations emerging out of the NAE and NRC’s synthesis of K12 STEM education was a call for increased focus on and clarity about the integration of STEM disciplines and assessment practices (National Academy of Engineering & National Research Council, 2014). Therefore, it
is imperative to exam lessons from educators that are integrating STEM practices such that we can begin to tell a story about how coherence within STEM disciplines can be supported by identifying challenges and opportunities to design expected outcomes.

In this study, integrated STEM (i-STEM) has been defined as an approach to teaching and learning in a manner such that the curriculum and content of the four individual STEM disciplines seamlessly merge into real-world experiences contextually consistent with authentic problems and applications in STEM careers. Such integration may refer to making meaningful connections between core disciplinary practices of each STEM domain being integrated, with the goal of using this integrated knowledge to solve real-world problems (Mobley, 2015; STEM Taskforce Report, 2014). As such, this study was guided by the following research question, how best can we develop assessment practices to support learning in integrated STEM environments? It is anticipated the outcomes of this study will reveal strategies that educators may incorporate in their teaching and assessment of integrated STEM learning experiences.

**Integrated STEM Curricula in K-12 Classrooms**

According to Drake and Burns (2004) integrated curricula is about making connections, across three approaches, interdisciplinary, multidisciplinary, and transdisciplinary. These approaches offer a starting point for understanding different approaches to integration. Drake and Burns further stated that the difference between these three approaches is the perceived degree of separation that exists between the subject areas. However, they also noted that in a standards-based school system these perceived boundaries are blurred; thus, an interdisciplinary approach is an excellent way by which educators can utilize a backward design process to teach. Nevertheless, debate on whether pre-college curricula should be integrated or subject-based is still controversial because it involves distinct differences in beliefs about the type of knowledge that should be taught (Association for Middle Level Education, 2010). For example, Satchwell and Loepp (2002) and Cantrell, Pekcan, and Itani (2006) reported teachers’ concerns with integrated curriculum at the K-12 level, specifically middle school, to include complex level of development, scheduling of teacher planning time and resources, and teacher’s pedagogical ability to facilitate instruction and classroom management. Bybee (2013) stated that STEM teachers continue to face several challenges, namely (a) integrating technology and engineering in STEM education related practices, (b) the contexts for STEM integration, and (c) moving STEM from a slogan to an educational definition. Further, Bybee noted that since its inception, STEM has been viewed as a conglomerate and not as an integrative expression.

Ejiwale (2013) identified ten barriers to successful implementation of STEM education. Those that have not been previously mentioned include a lack of research collaboration across STEM fields, poor preparation of students, teacher’s lack of connection with learners, a lack of support at the administration level, poor content preparation, delivery and method of assessment, poor laboratory facilities and instructional media, and a lack of hands-on training for students. He recommended addressing these barriers throughout K-12 education in order for i-STEM to achieve its goals and objectives. This study included perceptions about the foci of STEM integration, perceptions regarding the processes of how to teach a STEM integration unit, and beliefs about how STEM integration can improve students’ learning, leading to different emphases in their STEM lesson units. However, Czerniak (2007) stated as researchers and educators search for ways to provide and implement an integrated curricular approach in STEM education, issues such as varying existing understandings of integration and described characteristics of STEM integration, should be considered. To this end, Honey, Pearson, and Schweingruber (2014) suggested that integrated STEM education initiatives need to be explicit about the goals they aim to achieve and design the integrated STEM experience purposefully to achieve these goals. They also need to better articulate their hypotheses about why and how a particular integrated STEM experience will lead to particular outcomes and how those outcomes should be measured.

**Procedures**
We used a survey research design (Fowler, 1993) to investigate perceptions of engineering and technology teachers about their comprehension of integrated STEM with regards to teaching and assessment practices. The survey had 19 items. The first 4 items of the survey examined teacher demographics, e.g. gender, race, years of teaching experience, etc. The next 5 items examined the teacher’s professional development activities with regard to STEM and i-STEM, i.e., courses they are certified to teach, what other courses out of their specialty they can teach, what subjects do they currently teach etc. The last 10 survey items used Likert scale: “cannot do at all,” “would have difficulty doing this,” “mostly confident I can do this,” and “very confident that I can do this.”

We obtained engineering and technology teacher emails from the Indiana Department of Education. The list was comprised of 342 emails. Upon careful examination, we reduced the list to 286 emails due to duplicates. We then sent a pilot email survey to check for inactive email accounts, of which we further reduced the list to 236 active emails. An e-mail invitation through Qualtrics Survey Software was sent to the 236 emails in the spring of 2017. The invitation described the purpose of the study and included the link to the online questionnaire. The questionnaire was available for 8 weeks. At weeks 3 and 5, reminder e-mails were sent requesting completion of the survey. Eight weeks after initial contact was made, data collection was closed. Despite two reminder e-mails, the response rate was extremely low: 53 teachers (22.45%) completed the survey. Low response rates are not uncommon in online surveys (Newton & Rudestam, 1999).

Participants’ Profiles

Of the 53 respondents, 41 (77.36%) were male and 12 were (22.64%) female. The majority of the teachers were Caucasian (49), and 3 were of African and 2 were of Hispanic origins. With regard to classes, the teachers taught multiple grades, for example, grades 9-10 received 49 responses, while grades 11-12 received 45 responses. Grade 6 received 3 responses and grades 7-8 received 11 responses. With regard to teaching experience, 5 teachers indicated they had 1-2 teachers of experiences, 4 teachers indicated 3-5 years, 10 teachers indicated 6-10 years, 8 teachers indicated 11-15 years, 8 teachers indicated 16-20 years, 7 teachers indicated 21-29 years, and 12 indicated 30 plus years. Forty (74.07%) of the teachers indicated that they teach STEM courses where integrated STEM focuses on using engineering design.

Data Analysis and Findings

As suggested by Gall, Gall, and Borg (2007), data was analyzed using Microsoft Excel to calculate descriptive statistics i.e. percentages to get a perspective of the challenges and opportunities that engineering and technology teachers face when implementing integrated STEM design challenges. To investigate the research question how best can we develop assessment practices to support learning in integrated STEM environments? The survey for this study examined the following 24 sub-questions-

a. Does the school/organization include STEM education as one of its mission statements or school-wide priorities? In response to this question, 22 (40.74%) teachers answered “yes” and 32 (59.26%) responded “no.”

b. Does the school/organization include integrated STEM education as one of its mission statements of school-wide priorities? In response to this question, 15 (27.78%) teachers answered “yes” and 39 (72.22%) responded “no.”

c. With regard to teacher confidence relative to integrated stem teaching and learning: 29 (20%) indicated that they were very confident and understood what integrated STEM teaching means through engineering design, while 7 (17%) indicated that they would have difficulty with i-STEM, and 16 (21.05%) shared that they were mostly confident.

d. With regard to “Use current knowledge and skills to teach problem and project based content from within an integrated STEM framework through engineering design.” 30 (20.69%) indicated that they very confident they could use their current knowledge and skills to problem bases content in an integrated STEM environment through engineering design, while 7 (17%) indicated that they would have difficulty, and 15 (19.74%) shared that they were mostly confident.
e. Develop knowledge and skills necessary to teach problem and project based content from within an integrated STEM framework through engineering design: 27 (18.62%) indicated that they very confident, while 7 (17.07%) indicated that they would have difficulty, and 19 (25%) shared that they were mostly confident.

f. On this survey item, “Teacher’s use of their understanding of engineering design practices in a way that allows me to teach problem and project based content from within an integrated STEM effectively:” 30 (20.69%) indicated that they very confident, while 10 (24.39%) indicated that they would have difficulty, and 12 (15.79%) shared that they were mostly confident.

g. On this survey item, “Teacher’s use of their teaching experience to teach problem and project based content effectively from within an integrated STEM framework through engineering design practices:” 29 (20.00%) indicated that they very confident, while 10 (24.39%) indicated that they would have difficulty, and 14 (18.42%) shared that they were mostly confident.

h. Connect science concepts to those of engineering, mathematics, and technology: 20 (15.87%) indicated that they very confident, while 7 (12.21%) indicated that they would have difficulty, and 26 (19.12%) shared that they were mostly confident.

i. Teacher’s use of their understanding of cross-cutting concepts to better teach problem and project based content from within an integrated STEM framework through engineering design practices: 19 (18.63%) indicated that they very confident, while 15 (40.54%) indicated that they would have difficulty, and 18 (25%) shared that they were mostly confident.

j. Overcome challenges of teaching multiple disciplines at once: 28 (27.45%) indicated that they very confident, while 6 (16.22%) indicated that they would have difficulty, and 19 (26.39%) shared that they were mostly confident.

k. Access and learn new technologies that will enable me to teach problem and project based content from within an integrated STEM framework through engineering design practice: 28 (27.45%) indicated that they very confident, while 10 (27.45%) indicated that they would have difficulty, and 18 (25%) shared that they were mostly confident.

l. Teachers adoption to new teaching situations such as those necessary to teach problem and project based content from within an integrated STEM framework through engineering design practices: 27 (26.47%) indicated that they very confident, while 6 (16.22%) indicated that they would have difficulty, and 20 (27.78%) shared that they were mostly confident.

m. Obtain the materials/resources necessary to teach STEM in an integrated way: 20 (17.24%) indicated that they very confident, while 12 (32.43%) indicated that they would have difficulty, and 22 (20.87%) shared that they were mostly confident.

n. Get students to learn standards-based content while participating in integrated STEM activities: 22 (18.97%) indicated that they very confident, while 8 (21.62%) indicated that they would have difficulty, and 24 (20.87%) shared that they were mostly confident.

o. Get students to become interested in STEM careers through participation in integrated STEM learning: 22 (18.97%) indicated that they very confident, while 6 (16.22%) indicated that they would have difficulty, and 26 (22.61%) shared that they were mostly confident.

p. Collaborate effectively with other teachers in planning integrated STEM activities: 23 (19.83%) indicated that they very confident, while 3 (8.11%) indicated that they would have difficulty, and 26 (22.61%) shared that they were mostly confident.

q. Foster student enthusiasm for STEM disciplines while teaching in an integrated STEM framework through engineering
design practices: 21 (18.92%) indicated that they very confident, while 6 (11.76%) indicated that they would have difficulty, and 25 (26.04%) shared that they were mostly confident.

r. Provide my students with technology resources to engage in problem and project-based content learning within an integrated STEM framework through engineering design practices 24 (21.62%) indicated that they very confident, while 10 (19.61%) indicated that they would have difficulty, and 19 (19.79%) shared that they were mostly confident.

s. Meet evaluation requirements while teaching integrated STEM through engineering design practices: 23 (20.72%) indicated that they very confident, while 10 (19.61%) indicated that they would have difficulty, and 19 (19.79%) shared that they were mostly confident.

t. Find professional development programs to acquire knowledge and skills for teaching problem and project-based content learning within an integrated STEM through engineering design practices: 21 (18.92%) indicated that they very confident, while 13 (25.49%) indicated that they would have difficulty, and 17 (17.71%) shared that they were mostly confident.

u. Formatively assess student learning of discipline-specific content while teaching integrated STEM through engineering design practices: 20 (15.87%) indicated that they very confident, while 10 (18.87%) indicated that they would have difficulty, and 23 (16.91%) shared that they were mostly confident.

v. Develop summative assessments to measure students' integrated knowledge of STEM at the end of an instructional unit: 19 (15.08%) indicated that they very confident, while 10 (18.87%) indicated that they would have difficulty, and 22 (16.81%) shared that they were mostly confident.

w. Earn acceptable teacher-evaluation/performance scores despite teaching science in an integrated manner: 24 (19.05%) indicated that they very confident, while 11 (20.75%) indicated that they would have difficulty, and 18 (13.24%) shared that they were mostly confident.

Some Verbatim excerpts of teacher statements from the survey:

• “The biggest challenge with integrated STEM is teaching teachers what integrated STEM actually is. One teacher can have a great vision of how to do it, but it can be very difficult to get other teachers on board. If no other teachers are trying to teach the same way, then integrated STEM gets limited to the engineering class, excluding many students in the school.”

• “It is my thought that many teachers already include many STEM principles in their instruction. Whenever we relate a topic to the "real world" we are teaching how that particular principle applies to the world of work or life that incorporate Science, Technology, Engineering or Mathematical principles. We need to recognize this so that teachers will begin to see the connection.”

• “Teacher preparation is the biggest challenge. I have a degree in engineering, mathematics teaching and over 20 years of workplace experience. From what I have seen in achieving my teaching degree and experiencing two PLTWA courses, teaching preparation programs do not adequately prepare teachers to teach STEM courses. This is especially true in integrating the four areas and giving the teacher an understanding of how the four areas are connected.”

• “Collaborating with other teachers would likely be the most difficult part of creating integrated STEM teaching environments. Teachers need time to line up their schedules and work out the kinks of the collaborative projects. Even a one day difference has thrown off some of the collaborative projects I have done over the years.”

• “My hesitation with project-based learning is that it does not lend itself to the repetition of concepts that 80% of my students need to learn a concept. In group projects, there is almost always an unequal division of labor, with some taking the more
intellectual tasks, and others doing aesthetic or rote tasks. Project-based learned also is susceptible to ad hoc problem solving where the formal concepts are not always crystalized, reinforced, and remembered. For my most advanced students, I would love to have them doing more projects.”

“Standardized testing…”

Discussion

So how do teachers then design assessment project/problem based integrated STEM design challenges based on findings? Assessment has to move from ‘assessment of learning’ to ‘assessment for learning’, whereby assessment procedures and practices are developed to support learning and underpin rather than undermine student confidence, achievement, and progress (Black & Wiliam, 1998; Shepard, 2000). For example, a review of design rubrics found on sites from the World Wide Web, like www.teachengineering.org, www.tryengineering.com, www.linkengineering.org, etc., offer examples of i-STEM design challenges that teachers may model to develop assessment practices that might be used for assessing the design and testing of an Air Blaster Car. The focus of the design of this car revolves around four main areas:

• principles of aerodynamics involved with air blaster car construction,
• design of the vehicle
• construction of the vehicle
• and racing of the vehicle

The engineering and technology teacher will be required to collaborate with a physics teacher. The teacher will need to discuss with students scientific concepts that explain the principles of aerodynamics along with the mathematic principles behind racing the car. Both of which are integrated with engineering technology principles behind design and construction of the vehicle. The next step in developing the assessment guide would be to develop the objectives, learning activities and materials, and evaluation criteria for each of the four main areas. The teacher might need to align the standards, levels of objectives, and utilize the Revised Blooms Taxonomy (RBT), where the fact, concepts, procedures, and metacognitive process (Anderson & Krathwohl, 2001) is used to identify the level of knowledge dimension the instruction targets. Refer to Table 1 for an example and Table 2 for a suggested evaluation guide.

Conclusion

This study shared engineering and technology education teachers concerns with regards to the challenges they face with the design and assessment of i-STEM learning experiences in the classroom. Findings revealed that teachers offered mixed reactions even though they acknowledged the power of integrating STEM disciplines through design challenges in a PBL fashion. For example, they noted the differing visions and understanding each teacher may have of i-STEM, and the inherent challenge of planning and teaching such lessons, as such a difficult endeavor to assess students i-STEM artifacts. In conclusion, this study offered a sample rubric that may start conversations regarding how teachers may design i-STEM assessments using the RBT process. As such teachers may then align standards and learning experiences they deem appropriate for students to learn in an i-STEM environment.
<table>
<thead>
<tr>
<th>STL/NGSS Standards</th>
<th>Objectives</th>
<th>Levels in RBT</th>
<th>Knowledge dimension in RBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>STL8-10-MS NGSS-MS-PS3-1</td>
<td>Research pertinent information on underlying principles of aerodynamics with air blaster car construction</td>
<td>Remember, and Understand</td>
<td>Factual</td>
</tr>
<tr>
<td>STL9, 16-MS, MS-PS3-3, MS-PS3-4</td>
<td>Recognize principles of Newton’s Third Law of Motion and how it relates to air blaster car competition</td>
<td>Understand and Apply</td>
<td>Conceptual</td>
</tr>
<tr>
<td>STL9, 16-MS MS-PS3-2</td>
<td>Explain how mass, friction, and design of air blast car relate to its movement</td>
<td>Understand and Apply</td>
<td>Procedural</td>
</tr>
<tr>
<td>STL9-11-MS MS-PS3-4, MS-PS3-5</td>
<td>Utilize the process of engineering design to design and develop a drawing design which shows understanding of air blast concepts and construct a prototype car, present the model to peers</td>
<td>Apply, analyze, create and evaluate</td>
<td>Meta-cognitive</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STL/NGSS Standards</th>
<th>RBT Dimension</th>
<th>Activity corresponding to Original bloom cognitive processes</th>
<th>Suggested Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>STL8-10-MS NGSS-MS-PS3-1</td>
<td>Factual</td>
<td>Students submit portfolio of sketches that document initial research of challenge, criteria and constraints used to design air blaster car, Car Design Sketches.</td>
<td>Complete submitted portfolios with at least 2 sketches detailing the challenge, criteria and constraints in the context of performance improvement.</td>
</tr>
<tr>
<td>STL9, 16-MS, MS-PS3-3, MS-PS3-4</td>
<td>Conceptual</td>
<td>Speed and weight of car: students to record weight of their cars in grams, race car three times on a race track and calculate the speeds of their cars by utilizing the formula Speed = Distance / Time. Compare the data from their findings to those of their peers, and be able to explain how the weight (mass) of their car impacted the rate of the speed it travelled.</td>
<td>Application of the Formula speed = distance/time upon students recording of weight of the car and tie to race on a specified length track. Students provide an explanation of how the mass of their car impacted the speed compared to at least 2 peers. application of the process of engineering design and STEM concepts to design and manufacture air blaster car</td>
</tr>
<tr>
<td>STL9-11-MS MS-PS3-2</td>
<td>Procedural</td>
<td>Manufacture (car, shape, sand, paint, and detail) car as per chosen design utilizing provided materials and tools. Weigh car and race car on track 3 times and record the speed</td>
<td></td>
</tr>
<tr>
<td>STL9-11-MS MS-PS3-4, MS-PS3-5</td>
<td>Meta-Cognitive</td>
<td>Project reflection, students to write about their overall experience with project. For example, how their compared to peers, and what would they change about their car to make it better, faster. More aerodynamic? Smaller wheels? Shorter race track?</td>
<td>Justification of their selection of given design, and how these design modeled the design process and STEM concepts compared to the design of 2 peers. A description of how they can improve their design or their peers utilizing the engineering design process.</td>
</tr>
</tbody>
</table>
References


Association for Middle Level Education. (2010). This we believe: Keys to educating young adolescents. Retrieved from. http://www.amle.org/AboutAMLE/ThisWeBelieve/tabid/1273/Default.aspx


Czerniak, C. M. (2007). Interdisciplinary science teaching. In S. Abell, N. Lederman, & N. Lederman (Eds.), Handbook of research on science education (pp. 537-559). Mahwah, NJ: Lawrence Erlbaum


Objective Evaluation of Mobile Robot Trajectories using Multiple View Geometry

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Abstract
The objective estimation of mobile robot trajectory is critical in evaluating navigation performance. In the context of developing new mobile robot platforms and algorithms, it is important to measure the navigation performance in a quantitative and objective manner. The conventional methods of performance evaluation for mobile robot navigation typically rely on the human evaluator’s manual usage of a chronometer to measure the time spent for the completion of a given task and the accuracy of calculating the score (pass/fail) on the task. This paper proposes a multi-camera vision system that can automatically estimate the movement of mobile robots in terms of physics-based profiles: position, velocity, and acceleration in navigating patterns with respect to a user-defined world-coordinate system. The proposed vision system runs two synchronized cameras to simultaneously capture the movements of the robot at 30 frames per second. A simple procedure for camera calibration is performed using a calibration board based on multiple-view geometry. The system then runs a homography-based projection algorithm that converts the view-dependent appearance of the robot in the camera images to a view-independent orthographic projection map on the registered world coordinate system. This enables the human evaluator to view the robot navigation from a virtual top-down view regardless of the actual cameras’ viewing positions. The proposed multi-camera vision system can estimate the mobile robot’s navigation in quantitative manner and provide objective performance evaluation based on the physics-based profile.

Introduction
Mobile robot development and competition have become very popular in STEM (Science, Technology, Engineering and Mathematics; National Science Board, 2010) education. Mobile robots are an effective platform for stimulating student motivation at K-12 institutions as well as a good tool for rigorous engineering practices in colleges, universities, and graduate schools. In robot design and development at all levels of institutions, it is import to objectively measure and estimate the performance of the mobile robot navigation. However, the usual practice in performance evaluation of mobile robot navigation is typically based on the human evaluator’s manual intervention, using a chronometer to measure the time of completion of a given task or the percentages of pass versus fail on the task. This manual intervention is error-prone and also can be biased. We need a tool that reliably and objectively evaluates the performance of the mobile robot in an automated manner. It is also desirable to develop an unobtrusive method that does not require the attachment of any sensors, transponders, or beacons to the mobile robot, since such attachments will alter the weight of the robot, not to mention the complicity of the installation and management of such attachments. A computer vision-based object detection and tracking approach is a promising solution in this regard.

This paper explains an effort to develop a vision-based evaluation testbed for mobile robot navigation by using multiple cameras that automatically record the movement of the robots and objectively estimate their navigation performance. Unlike the methods for robot’s self-localization using heterogeneous sensors and robot models (Suliman et al. 2009; Beinhofer & Burgard, 2014), the proposed system provides a purely vision-based testbed that evaluates the navigation performance in terms of the physics-based profiles: position, velocity, and acceleration of robot over time with respect to a given world-coordinate system.
Performance Evaluation Approaches

The performance evaluation of mobile trajectory has been a major issue in developing autonomous mobile robots. Most of the approaches are motivated by the method of how to make a robot control its movement as commanded or planned. SLAM (simultaneous localization and mapping) (Durrant-White & Bailey, 2006) is an example of such efforts. The goal of SLAM is to make a robot autonomously and incrementally build a map of an unforeseen environment and determine its location within this map.

Robot competitions are another motivator to develop and test mobile robot platforms for specific applications. Various kinds of competition formats were exercised (Verner & Ahlgren, 2004; Afonso et al. 2006; Behnke, 2006; Grimes & Seng, 2008; Anderson et al. 2011). Some competitions emphasize student engagement, while others foster advancement of new algorithms.

The focus of this paper is somewhat distinct; we propose a new approach to evaluating mobile robot trajectory from an observer’s point of view. Regardless of the internal control algorithms of a robot utilized to maneuver itself, we want to objectively evaluate the robot’s trajectory pattern: how far it moves, how fast it moves, how consistently it maneuvers itself, etc. For this purpose, we use a computer vision method to detect, track, and estimate the trajectory of the robot.

Methodology

Our methodology starts by modeling the process of image formation when a scene is viewed through a camera. We adopt a pinhole camera model shown in Figure 1. The pinhole camera model (Forsyth & Ponce, 2003) assumes that exactly one ray from each point in the scene passes through the pinhole lens and hits the image plane opposite to the scene, forming the inverted image. For convenience, we use the virtual image in front of the pinhole, forming the new image plane in Figure 2. The mathematical description of the imaging process in Figure 2 denotes the world scene coordinates with uppercase roman letters (X, Y, Z) and image coordinates with lowercase roman letters (x, y, z). Note that the vectors pointing from the camera center C to the world coordinate point and the corresponding image coordinate point are denoted by boldface symbols, such as \( \mathbf{X} \) and \( \mathbf{x} \), respectively. The process of the camera's imaging is mapping the point (X,Y,Z) in the 3D space to the point (x,y) on the 2D image plane, and is modeled as follows, where the superscript t means column vector notation.
As shown in Figure 3, we use two cameras, each of which forms image plane I1 and I2 with the corresponding camera origins O1 and O2, respectively (Ma et al., 2001). We define the relative configuration of the two cameras in terms of the relative rotation R and translation T. Note that the same point p in the world scene π appears very different in the two image planes as vectors x1 and x2, respectively, which is due to the perspective distortion effect. Overall, the camera imaging process is mathematically modeled as the mapping from the 3D-world scene coordinate (X,Y,Z) to the 2D image plane coordinate (x,y) of a viewed object, which results in inevitable loss of information during the downgrading transformation from the higher to lower dimension.

Our real goal with the computer vision system is to recover the inverse mapping from the 2D image coordinate (x,y) R^2 of the viewed object on the image planes I1 and I2 to the world scene coordinate (X,Y,Z) R^3 in the world scene π in order to achieve the accurate estimation of the world scene given only the 2D image data. We need at least two camera views to resolve the ambiguity caused by the information loss during the downgrade transformation. To do this, we first conduct the camera calibration that establishes the camera configuration (R,T) in Figure 3 as:

\[ x_2 = Rx_1 + T \]

A perspective projection (Hartley & Zisserman, 2003) is created to perform the inverse mapping from the image- to world-coordinate system. The two versions of the inverse mapping from each camera are joined to a common ground by the planar homography (Hartley & Zisserman, 2003), which generates a virtual top-down plan-view display of the world scene π. Using the homography matrix H, we can write the transformation of points in 3D from camera 1 to camera 2 as:

\[ X_2 = HX_1, \quad X_1, X_2 \in \mathbb{R}^3 \]

By using the 4-point algorithm in (Ma et al. 2001), the homography matrix H can correct the projective distortion of image planes I1 and I2 in Figure 3 and map the virtual top-down view displayed on the monitor that represents the world scene plane π. This virtual top-down view of the world scene is camera-independent and orthographic, and provides the objective measure of the actual scene dimensions without view-depending distortion. The orthographic virtual top-down view display enables the generation of the navigation trajectory profile of moving objects in terms of position, velocity, and acceleration on the world scene coordinate system.

The overall system diagram is depicted in Figure 4. The system starts from the camera calibration after deploying the cameras to specific locations. The calibrated and synchronized cameras (camera-1 and camera-2) keep capturing the synchronized image frames. The computer vision algorithm conducts the perspective projection and planar homography mapping, as explained earlier. The color-based object tracking algorithm (Allen et al. 2004) follows the processing. The navigation-trajectory profiling will be explained in the next section.
Experiments

We developed a testbed composed of two cameras, a desktop computer, and a flat area as shown in Figure 5. The current testbed uses two synchronized cameras, and they can be mounted in a versatile manner: a top-down view or arbitrary oblique views, depending on user need. In Figure 5, the upper view on the right is from camera-A, while the lower view is from camera-B. O, U, V, and D indicate the locations of the marker objects placed on the testbed for the user-defined world coordinate system.

The appearance of the same scene looks very different on the camera-A vs. camera-B images due to the different perspectives. We define the world coordinate system on the flat area in terms of the origin O and U-/V-axis extended from the origin. The camera calibration is achieved by using a standard checkerboard pattern, shown in Figure 5. Multiple snapshots of the calibration board at different positions are used in the procedure.

Figure 6 shows a remote control car used in the experiment and the two camera views of the car on the testbed. We used a remote control car with a known maximum speed (i.e., 8-12 miles per hour or 3.5 – 4.3 meters per second) in the experiment. The right-most picture of Figure 6 shows the planar-homography mapping of the two camera views to achieve a virtual top-down view on the user-defined world coordinate system. The world coordinate system is defined by the horizontal axis
between the two points O and U (denoted by the horizontal line) and the vertical axis between O and V (denoted by the horizontal line). The individual trajectory points of the robots are time-stamped, and the calculation of the position, velocity, and acceleration provides the full description of the robot's movements. It is straightforward to convert between image coordinate system (U,V) vs. mathematical coordinate system (X,Y) (Ma et al., 2001.)

Figure 7 shows two instances of tracking: linear navigation (shown in the top row) and circular navigation (shown in the bottom row). Each homography-mapped frame contains the information of the frame number, position, velocity, and acceleration of the tracked mobile car in image coordinate units (i.e., pixels.)

The testbed has an intuitive user interface with which students can run the system easily and visualize the trajectories intuitively.

Figure 8 shows an example profile of a cumulative navigation trajectory that involves 1830 frames (including those in Figure 7). The tracking algorithm of the control software successfully tracks the moving robot and assigns the enclosing ellipse with a track ID, as shown in Figures 6 & 7. The center position (xi, yi) of the ellipse at the i-th frame is regarded as the position of the robot at the given time. The instantaneous velocity is defined as vector v_i=(v_x,v_y) in terms of the differential location in the x- and y-axis between the current i-th frame and the previous (i-1)-th frame. The velocity components v_x and v_y are defined as:
The speed of velocity is defined by the amplitude of the vector as:

\[ |v| = \sqrt{v_x^2 + v_y^2} \]

Figure 9 shows the speed profile for the navigation trajectory of Figure 8. The horizontal axis is the frame number, while the vertical axis is the speed in [mm/sec]. It shows multiple sharp spike noise points, which are due to imaging noise and tracking errors. But a human interpreter can easily separate those noise points from the speed profile. The typical value of the measured speed on the smooth bumps/plateaus of the Figure-9 profile is approximately 2 [meters/sec], which is reasonable in the current experimental setting.
The control software for the video capture, object tracking, and profile generation was written in C++ language. We tested the proposed system with a general-purpose desktop PC installed with a Microsoft Windows 7 operating system and 3.4 GHz Intel Core i7 CPU. The current system was set up in a small lab space, but the system is scalable to deploy to larger environments such as a larger lab floor for moderate-size robots or a spacious gym floor for larger robots. Different deployment options do not require software code modification; only the camera calibration needs updating for new camera positions.

Our system provides reasonably accurate trajectory profiles of robot navigation in terms of the position, velocity, and acceleration of every frame. Some inaccuracy is evident in some files; most of the inaccuracy is from imaging noise and tracking errors; it is an open research issue in computer vision to achieve a robust method for perfect detection and tracking.

Conclusions

We have presented a vision-based evaluation testbed for mobile robot navigation. The testbed can be used to estimate mobile robot navigation in a quantitative manner and provide students and developers with insights about objective performance evaluation based on the physics-based profile. The proposed system is a general-purpose system that can be deployed to estimate the navigation of various moving objects including, but not limited to, mobile robots. The developed system is versatile in that the cameras involved can be installed in various configurations such as top-down viewing direction or arbitrary oblique viewing directions, as long as the two views are not parallel. The system is non-obtrusive, since it is purely vision-based and does not require the attachment of any sensors, transponders, or beacons to the tested object. Our future research plan includes the improvement of imaging and tracking algorithms and testing the system in various environments such as moving-object tracking on a wide area.

Acknowledgement

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References


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Development of an Interdisciplinary Cybersecurity Laboratory for Information Technology and Automation & Controls Engineering Technology Programs

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It is now accepted that the national and economic security of the United States depends on the reliable functioning of critical infrastructure. Critical infrastructure is defined in Presidential Executive Order 13636 as “systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters.” (Obama, 2013)

In plain language the critical infrastructure is comprised of the microprocessor based control systems which perform the everyday tasks associated with modern life. This includes utility operations such as the national power grid, municipal drinking water systems, communications systems, and transportation systems. Also included in this definition is critical manufacturing operations necessary for the economic well-being of the nation. Examples of this would be petrochemical refineries, food processing, transport, pharmaceuticals, and defense manufacturing. (Homeland Security, 2016)

The networked digital electronic controllers and their peripheral equipment systems which perform these tasks are referred to in industry as Operational Technology (OT) to distinguish it from networked electronic data handling systems known as Information Technology (IT). Traditionally, industrial control systems were virtually immune from cyberattack as there physically isolated from networks. As the sophistication of digital computer based equipment designed specifically to operate manufacturing and process control grew in the late 1990’s, industry rapidly began incorporated this new capability to increase production capability. This resulted in groups of control systems that required network quality communications between them so that they could coordinate operations. This created Distributed Control Systems (DCS) and became the standard for large OT installations. The new systems were not only able to control industrial equipment but were able to gather real-time data from the process that could be used in production planning, inventory control, and sales. This process became known as Supervisory Control and Data Acquisition (SCADA). To effectively use the information collected by SCADA meant that the controllers running the equipment had to be networked back to the data servers which stored and processed the data collected by SCADA. Thus the vulnerable OT system was networked back to the IT system and lost its protection by isolation. (TechTarget, 2016)

This created the potential for OT systems to be hacked in the same manner as IT systems were. However, the implications were far greater with the ability to not only to commit cybercrimes such as data theft and industrial espionage, but to actively engage in a new range of illegal activity ranging from denial of service blackmail attacks to destructive sabotage. (N-Dimension Solutions Inc., 2017) In 2011 a new computer virus named Stuxnet was discovered which was specifically designed to enter OT systems, gather data, map the system, and commit sabotage leading to system failure. The source code for Stuxnet has since been released onto the Internet and can be modified to attack specifically targeted OT systems. (Kroft, 2012)

It has become as essential for a nation to protect its OT systems from attack by cybercriminals and terrorist agents as its IT systems. As OT systems differ in many respects to IT systems this requires a different skill set of knowledge and training abilities to prepare a professional workforce to secure the critical infrastructure.

The focus of this paper is the development of a cybersecurity laboratory facility for the College of Technology at Indiana State University (ISU) as part of it BS and MS programs in the Information Technology and Automation and Controls Engineering
Technology programs. The laboratory will be used to allow students to design secure networked systems applicable to infrastructure and manufacturing controls, or an IT enterprise system. The purpose of the cybersecurity lab is to serve as an experiential learning center to develop a cybersecurity workforce for both business and manufacturing applications.

Need for a Cybersecurity Workforce

Cybersecurity has been defined as the practice of protecting electronic systems from unlawful or unauthorized use, access, modification, or destruction. As networked data systems increasingly become a necessary part of everyday life in the modern world the need for cybersecurity professionals in all aspects of the field is increasing. In 2015, Michael Brown, CEO of Symantec, one of the world’s largest software vendors, projected that by 2019 the global demand for a cybersecurity workforce would be 6 million, and that there would be a shortfall of 1.5 million trained professionals to take the positions. This was supported by the Cisco Systems 2014 Annual Security Report which estimated the shortage of cybersecurity workforce was at 1 million openings, with cyberattacks and data breaches increasing every year. (Morgan, 2015)

Hardware Systems for Lab Infrastructure and Instruction

To provide a networking infrastructure to support lab activities for cybersecurity required an isolated system within the department. For that reason the ISU Office of Information Technology (OIT) worked with faculty to develop an independent network from the University. A Lenovo ThinkServer was used as the system’s host server, with an uninterruptable power supply to ensure operation. In the laboratory a Cisco 3650 24 port switch was installed to interconnect all the equipment. Physical layer connectivity was made using Category 5e twisted pair cabling between switches and all devices. Student interaction is accomplished using twelve desktop computers, with a separate instructor station desktop, all interconnected via the 24 port switch.

Development of the OT hardware and software capabilities of the Laboratory

There are a number of original equipment manufacturers (OEM’s) available for control system equipment and software products. In choosing a supplier for an educational setting the task is to find a vendor whose products are standards used by industry, and who are experienced in supporting educational institutions after the completion of the sale. The best choice after examining the options was determined by faculty to be Rockwell Automation and their Allen-Bradley and Rockwell Software subsidiaries.

The industrial networking and cybersecurity training system is built around a simulated DCS using a two Allen-Bradley ControlLogix Programmable Automation Controller (PAC) units with Logix5571 processors and Ethernet/IP communications modules. System I/O interaction is accomplished using DC modules and Analog modules to allow for a range of application simulations using discrete and variable inputs. Discrete I/O is created using a variety of switches and indicator lights, while analog I/O is created using simple potentiometer voltage divider circuits and voltmeters.

All of the laboratory workstations are connected via the switch to the PACs, and allow students to independently develop solutions to control systems design and protection assignments, then download, run, and monitor the operation. Each workstation contains emulator software that allows each student group to concurrently develop programs without the necessity to run on the actual controllers for the purposes of development and debugging. The Operator Interface (OI) unit consisted of an Allen-Bradley PanelView Plus 1000 models with a 12” touchscreen. A second unit is available for addition to the lab unit to accommodate future student project work. Figure 1 shows the network basic design of the lab module.
The laboratory is expandable to add additional processor units currently in use with other laboratory systems, including two units used in process control operations, a Radio Frequency Identification (RFID) unit, and a manufacturing assembly line. In addition, the ControlLogix unit is equipped with a bridge module to allow DeviceNet networks to be constructed and interact with the EtherNet/IP network. EtherNet/IP communications modules allow any control device which communicates by RS-232 to be connected to the system.

**Software Selection for Laboratory Use**

The selection of software was determined by the choice of hardware. For control program design Rockwell Software Studio5000 (Ver 28) was selected. To develop SCADA programs incorporating cybersecurity programming Rockwell's FactoryTalkView Machine Edition was selected. Communications between the programs to the network was accomplished using Rockwell's RSLinx software. To allow students to work on laboratory exercises using only the PC to develop software and SCADA programs the Rockwell Software Logix5000 Emulator software was loaded at each station. By use of the emulator each workstation could develop control and SCADA programs then run them in a simulated environment using the PC as a test bed for debugging the program. Once vetted, students could download programs to controllers and have the network operate as controllers and peripheral devices exchanged information.

**OT System Training and Cybersecurity Curriculum Development Materials**

To effectively use the training platform the technology educator must be thoroughly familiar with the software and hardware used. This can be obtained through two methods, access to OEM developed literature and through instructor training. A major consideration in selecting Rockwell Automation as a supplier of software and hardware was its extensive free online library of literature available at: http://www.rockwellautomation.com/global/literature-library/overview.page. The on-line library is searchable and is regularly updated to provide current information to both instructor and students.

In the area of instructor training, Rockwell provides an extensive program of training courses which covers all of its major hardware and software products. The courses are available in classroom or distance format. Some network communications and systems management courses are developed in cooperation with Cisco systems, and can be used in preparation for taking the Cisco Industrial Networking Specialist (CINS), Cisco Certified Network Associate Industrial (CCNA Industrial), and Cisco Certified Network Associate Security (CCNA Security) certifications.

Cybersecurity training for educators is also available free of charge through the Department of Homeland Security Industrial Control System Cyber Emergency Response Team division (ICS-CERT). Their web page at: https://ics-cert.us-cert.gov/Training-Available-Through-ICS-CERT gives details of specialized cybersecurity training for OT systems personnel, and a list of dates and locations for training workshops. ICS-CERT also offers conference opportunities and email updates of recent developments to allow educators to remain current in the field.
Curriculum development is aided by use of a curriculum outline developed specifically for infrastructure and industrial cybersecurity which is freely available online to educators from the US Department of Homeland Security (US Department of Homeland Security: National Cybersecurity Division, 2008). Additional educational support materials are available from ICS-CERT. Besides instructional literature, ICS-CERT has software available that can be used free of charge by educators. The Cyber Security Evaluation Tool (CSET) is a system self-assessment tool that can be used by students to perform network design architecture reviews, network traffic analysis, and determine system weaknesses. The information returned from assessments can provide students with the understanding and context necessary to build more effective defense designs for enhancing cybersecurity in a safe environment (National Cybersecurity and Communications Integration Center, 2017).

**IT System Training and Cybersecurity Curriculum Development Materials**

Resources for IT cybersecurity instructor training and curriculum development are more readily available through traditional commercial sources than for OT cybersecurity. The principal reason is that the need for cybersecurity of IT systems has been more firmly established over a longer period than for control systems. One software tool that is freely available to educators which has application to students in a cybersecurity classroom for either IT or OT learning experiences is Cyberceige. Cyberceige was developed by the US Navy Office of Naval Research and the National Science Foundation and provides a simulated computer game style of environment where students can construct a computer defense against intrusion using a limited set of provided resources. The simulation will then attempt to circumvent the prepared defenses using a variety of attacks used by malware. The attack can be viewed by the students as it unfolds. The results of the attacks can be examined by students to help them learn for mistakes and develop more effective defense strategies. Longer scenarios can be constructed where attacks are escalated to give experience in long term protection of assets.

The software program includes the ability to setup configurable firewalls, VPNs, link encryptors and access control mechanisms, as well as system management tools such as identity management components such as biometric scanners and authentication servers. In the simulation run a variety of attack methods are used including trap doors, Trojan horses, viruses, denial of service, and dishonest employees (Thompson & Irvine, 2015).

**Conclusion**

The cybersecurity training platform developed at ISU will allow engineering technology students entering the commercial or workforce in management or systems positions to have a base knowledge of how to develop and maintain secure information or operational technology systems against cyberattack. The laboratory will provide theoretical and experiential learning activities in effective and secure system design, operation, and response to attack to aid in the development of a more effective cybersecurity workforce in commerce and industry.

**References**


ADVANCES IN SENSOR TECHNOLOGY

Abstract
Through advances in sensor technology, there are various types of ranging sensors that are currently available in the market with different ranges and features. Each sensor has its own advantages and limitations. Time-of-Flight (ToF) ranging sensor that measures distance by converting the time taken by laser light to reach back after colliding with an object has become popular in robotic range finder applications. This sensor has several advantages compared to other ranging sensors such as its compact size and low noise. However, the sensor accuracy may depend on the environment where the sensor operates. Thus, this study investigates the effectiveness of the ToF ranging sensor (VL53L0X) utilized in various scenarios. In the study, multiple types of materials are used to simulate different objects that the light will collide. The actual distance to the objects and measurements recorded from the sensor are then compared and analyzed. Similar experiments are repeated through the capable ranges of the sensor. The results from this study will help students and hobbyists to implement this sensor in their projects, also help researchers and manufacturers to decide whether the sensor can meet their requirements.
Keywords: Time-of-Flight, Ranging Sensor, Robotic Sensor, VL53L0X

Introduction
In the robotic field, identifying the distance between a robot and surrounding objects in the environment is a challenging task. Many types of sensors can be used to perform this task including ultrasonic sensor, infrared (IR) sensor, and a traditional laser sensor. Recently, Time-of-Flight (ToF) ranging technology sensor which measures the distance based on the time that is taken by the light to travel has become popular in robotic range finder applications. This study evaluates the performance of VL53L0X (Figure 1 and 2), one of the ToF range finder sensors in the market.

Figure 1: Pololu VL53L0X sensor with breakout board and its size comparison (Pololu)

Figure 2: STMicroelectronics VL53L0X Sensor (Mouser Electronics)
The effectiveness of this ranging sensor in different scenarios should be tested as the accuracy of this sensor may vary when the light collides with different material surfaces. The purpose of this study is to analyze the sensor’s effectiveness in different environments in which the sensor may be operated. Different materials are used to simulate various types of objects in the study. Indoor and outdoor experiments are used for comparison where light condition can be different.

ToF and its comparison with other sensors

Time of Flight (ToF) LIDAR technology combines the strength of infrared and ultrasonic sensors in order to overcome their weaknesses. It uses light rays (similar to infrared ranging but a different spectrum) and considers the time taken by light rays to travel back and forth to the object (similar to ultrasonic ranging). The sensor then calculates the distance based on the time taken by light to travel. The reading obtained is for twice the real distance as the sensor calculates the time consumed by the light to reflect back, so the final reading is halved to get the actual distance (Fürsattel, et al., 2016). The ToF sensors are more accurate as the speed of light is much higher than other measuring methods.

The infrared sensor does not perform well when exposed to sunlight, but the VL53L0X ToF sensors operate in a different spectrum of light that is less affected with sunlight and uses phase detection to distinguish between the sent light rays and disturbance. Ultrasonic ranging sensors cannot perform well in harsh environments such as in windy condition (Escolà, et al., 2011). In addition, they cannot be protected inside a casing, whereas the ToF sensors can be cased in glass and still work efficiently in harsher environments.

Applications of ToF sensor

Time-of-Flight ranging sensors can be used in a variety of machines and devices that need to measure the distance and/or detect objects within a specific range. It could be applied to many areas such as an automobile, medical and healthcare, military, robotics, and gaming. One of the areas that ToF ranging sensor could play a prominent role is robotics. For example, in robotic navigation, a robot can be designed and programmed to navigate through a maze path with walls and obstacles. The sensor can be used to detect any objects around itself and allow the robot to turn right, left, back, or just going straight ahead. ToF ranging sensor can provide accurate measurement of the distance between the object and the robot without physical contact. Li (2014) suggested that the application of ToF could be classified into two main categories. The first category is gesture which refers to human interactions and pace. On the other hand, the second category is about measurement precision which is called non-gesture. In medical and healthcare, gesture recognition can provide a sterilized environment because of the non-contact communication (Li, 2014). In addition, ToF can also be used instead of a mouse, keyboard, and gamepads while playing video games. For non-gesture application, ToF sensor can help the automotive industry to increase safety while driving.

Materials and Methods

The ToF ranging sensor in this study is VL53L0X by STMicroelectronics which is the breakout board that was obtained from Pololu. The study was conducted on 19 different materials varied in colors (if available) such as brick, cardboard, foam, plastic, and steel. The test was conducted with the same materials in two environments, indoor and outdoor under sunlight. In the study, the sensor was connected to a microcontroller board (Arduino) in order to read distance measurements from the sensor. The actual distances between the sensor and testing materials were set in two ranges, at 500 and 800 mm. These distances were selected based on the documentation of the sensor that states its maximum ranging capability for outdoor usage (800 mm).

All components such as an ISO certified measuring tape, laptop, cable, sensor, microcontroller (Arduino board), and wooden plank used in the experiment are identical in both indoor and outdoor conditions. Also, the utilization of these components was identical for both conditions. The sensor with microcontroller was linked to a laptop and was placed on a wooden plank for stability. The measuring tape was used to measure the distance between the sensor and the testing materials. The distanc-
es of 500 mm and 800 mm were marked on a plank and the sensor was placed accordingly. The indoor tests were conducted inside a room during the day with normal light conditions. The outdoor tests were conducted during the day with clear sky and sunlight with no other distracting condition. Approximately 40 readings were obtained in one second during the testing. An average of 100 readings was considered for the study.

Results
Table 1 shows the result of the average reading measurements for all testing materials. From a total of 3,800 readings taken during the tests, the average reading deviations from the actual target distance of 500 mm and 800 mm (i.e., the average reading error of the ToF sensor) across all testing materials were 3.99% and 4.61% for indoor and outdoor environments, respectively. Analysis of Variance (ANOVA) showed a significant difference (p-value < .05) in the readings between materials used for 500 mm and 800 mm distances (Table 2). Compared to all other materials, white cloth had the lowest reading deviation in both environments (0.81%). On the other hand, black foam had the highest error in measurements in both indoor and outdoor environments (10.81%).

![Table 1: Sensor Readings](image)

<table>
<thead>
<tr>
<th>Material</th>
<th>Indoor 500 mm</th>
<th>Indoor 800 mm</th>
<th>Outdoor - Sunlight 500 mm</th>
<th>Outdoor - Sunlight 800 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall (Dark)</td>
<td>538</td>
<td>852</td>
<td>542</td>
<td>867</td>
</tr>
<tr>
<td>Brick Wall (White)</td>
<td>534</td>
<td>853</td>
<td>547</td>
<td>875</td>
</tr>
<tr>
<td>Cardboard (Brown)</td>
<td>517</td>
<td>827</td>
<td>522</td>
<td>834</td>
</tr>
<tr>
<td>Cardboard (White)</td>
<td>512</td>
<td>819</td>
<td>517</td>
<td>826</td>
</tr>
<tr>
<td>Cloth (Black)</td>
<td>482</td>
<td>770</td>
<td>486</td>
<td>777</td>
</tr>
<tr>
<td>Cloth (White)</td>
<td>494</td>
<td>790</td>
<td>498</td>
<td>797</td>
</tr>
<tr>
<td>Foam (Black)</td>
<td>428</td>
<td>732</td>
<td>432</td>
<td>746</td>
</tr>
<tr>
<td>Foam (White)</td>
<td>504</td>
<td>805</td>
<td>508</td>
<td>812</td>
</tr>
<tr>
<td>Mirror</td>
<td>514</td>
<td>822</td>
<td>519</td>
<td>829</td>
</tr>
<tr>
<td>Paper (Black)</td>
<td>488</td>
<td>779</td>
<td>492</td>
<td>786</td>
</tr>
<tr>
<td>Paper (White)</td>
<td>502</td>
<td>803</td>
<td>507</td>
<td>810</td>
</tr>
<tr>
<td>Plastic (Grey)</td>
<td>537</td>
<td>858</td>
<td>541</td>
<td>865</td>
</tr>
<tr>
<td>Plastic (White)</td>
<td>515</td>
<td>823</td>
<td>519</td>
<td>830</td>
</tr>
<tr>
<td>Rubber (Grey)</td>
<td>532</td>
<td>850</td>
<td>536</td>
<td>857</td>
</tr>
<tr>
<td>Rubber (White)</td>
<td>508</td>
<td>811</td>
<td>512</td>
<td>819</td>
</tr>
<tr>
<td>Steel</td>
<td>513</td>
<td>820</td>
<td>518</td>
<td>828</td>
</tr>
<tr>
<td>Stone</td>
<td>527</td>
<td>842</td>
<td>531</td>
<td>849</td>
</tr>
<tr>
<td>Wax</td>
<td>511</td>
<td>816</td>
<td>515</td>
<td>824</td>
</tr>
<tr>
<td>Wood</td>
<td>528</td>
<td>843</td>
<td>532</td>
<td>851</td>
</tr>
</tbody>
</table>
Although, the difference between dark- and light-colored materials was not statistically significant as shown in Table 2 (p-value > .05), in general the ToF sensor provided lower reading error for light-colored objects as compared to its dark-colored materials. Several materials (i.e., mirror, steel, stone, wax, and wood) were excluded in this ANOVA test due to lack of color comparison. Figure 3 compares the results obtained by the sensor versus the actual distance in indoor condition. The VL53L0X sensor measured the distance between itself and white paper accurately with reading error of 0.39%. On the other hand, the sensor did not measure the black foam distance very well (11.45% reading error). The sensor worked well to measure the distance of other materials such as white foam, white cloth, and white rubber with just 0.71%, 1.23%, and 1.49% respectively. 

Table 2: Analysis of Variance (ANOVA)

<table>
<thead>
<tr>
<th>Description</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials at 500mm</td>
<td>99.982</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Materials at 800mm</td>
<td>46.056</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Dark- and Light-colored Materials at 500mm</td>
<td>0.456</td>
<td>0.506</td>
</tr>
<tr>
<td>Dark- and Light-colored Materials at 800mm</td>
<td>0.139</td>
<td>0.712</td>
</tr>
<tr>
<td>Indoor and Outdoor Conditions</td>
<td>0.446</td>
<td>0.508</td>
</tr>
</tbody>
</table>

Figure 3: Measurements in Indoor Conditions

Regarding outdoor condition, the measured distance to white cloth had the lowest reading error with only 0.40% average discrepancy from the actual distance whereas the measured distance to black foam had the highest reading error with 10.18% average discrepancy from the actual distance. Other materials that the sensor provided good measurements were white paper, white foam, and black paper with the average reading error of 1.33%, 1.55%, and 1.68% respectively. Figure 4 compares results obtained from the sensor and the actual distance in outdoor condition.
Figure 5 shows the accuracy in percentage for different materials. From the graph, it can be seen that reading error does not vary drastically between indoor and outdoor conditions. The ANOVA in Table 2 confirms that the means of those two conditions were not significantly different (p-value > 0.05). Thus, it can be concluded that sunlight has little effect on the measurement of VL53L0X sensor.
Conclusion
This study investigates the effectiveness of Time-of-Flight (ToF) sensor in various environments that ToF sensor might be utilized. The experiment results indicate that the sensor can operate reliably and consistently in both indoor and outdoor conditions. This suggests that the ToF sensor may be a viable alternative for users who want to utilize sensor in highly changing environments such as robotics. This study also indicates that measurement results can vary by the type of materials that the sensor-light reflects, whereas the measurement results of dark and light color materials remained the same. Future work can further investigate the properties of materials such as porosity, reflection, and transparency which may influence the sensor’s performance.

References
Teaching Process Simulations in Manufacturing and Technology Programs

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Introduction
Webster's Dictionary (2017) defined simulation as “the imitative representation of the functioning of one system or process by means of the functioning of another”. In other words, simulation functions to imitate a process or system by acting as the system's elements to yield similar results as the system it is imitating or representing. California Analysis Center, Incorporated (here referred to as CACI, 2017) defined process simulation more broadly as the technique that allows representation of processes, people, and technology in a dynamic computer model. CACI's definition broadens simulation in such a way that it can be applied to systems, processes, people, businesses, ideas etc.

A good model, when simulated, mimics the operations of the system it represents. This is accomplished by stepping through the events in compressed time while displaying an animated picture of the flow. Because simulation software keeps track of statistics about model elements, performance metrics can be evaluated by analyzing the model output data. Manufacturing and technology systems and their subsystems and processes are very suited for simulation applications of this nature.

This report will provide an overview of the potential role, benefits and applications of simulation in manufacturing and technology programs. It will also illustrate, with an example, how simulation is taught at one American university’s Manufacturing System's program in which a popular software called SIMPROCESS is used. It is also noted here that this American university has a license to this software. The shortened example teaching methodologies provided in this report are based on how this software is used at the university. A free trial version of it can be downloaded from http://simprocess.com/trial-version/.

The Role and Benefits of Simulation in Manufacturing and Technology programs
Process simulation has many uses and benefits. All its benefits are very important, especially to industry and technology professionals. For example, simulation saves money in studying typical proposed manufacturing facilities. Manufacturing facilities are expensive initiatives. It is in the best interest of manufacturing companies to use simulation studies to understand how to build better, more efficient and least expensive facilities, systems, and processes. Such simulated feasibility studies can help in better determining the usefulness, profitability, and efficiency of such manufacturing projects.

Simulation software like SIMPROCESS offers the ability to visualize and evaluate the results of process changes before expensive resources, time, and money are expended.

Simulation can be used to predict how a proposed facility will function. It can reveal problem areas in time before they occur. For example, potential areas for bottleneck and safety concerns can be revealed and corrected in time before implementation. Also, once designed, a simulation can be easily modified and updated. It can be saved on a file so that it can be replicated and modified for future studies. This saves time and money in designing a new process simulation.

Simulation can help to predict and adjust the amount of resources (personnel, machines etc.) needed to yield required capacity. This is exactly one of the main objectives of aggregate planning in manufacturing - the productive utilization of both human and equipment resources (Jacobs, Berry, Whybark & Vollmann 2011). Process simulation helps to support or confirm the integrity of a system's schedule, irrespective of the planning system used - whether it is material resources planning (MRP), just in time (JIT) or others.

In addition, process simulation studies are the fastest ways to show management the design and potential results of a project. Management wants immediate answers to their questions. Simulated presentations can help to show them the logistics of a manufacturing or technology plan in a near-real world presentation. Graphical and analytical representations and results can
be generated in a matter of seconds or minutes, so that management can get a picture of what the bottom line looks like. And management’s suggestions can be added or input into the model and results generated immediately. These results can be sent to any location in the company as needed for company official and other stakeholders to see and give their feedback.

**Potential Areas of Applications of Simulation in Manufacturing and Technology Programs**

Process simulation provides a rich array of integrated functions for modeling and analysis of engineering and business functions, from customer service to product development, from administrative to production processes, for every business process (CACI, 2017). Thus, there are opportunities for just about every area or component of manufacturing and technology systems to be programmed and simulated.

For example, since manufacturing systems, by nature, are made up of systems components (Obi, 2013), simulation can be effectively designed for the various components or subsystems which have promising potential for reaping the benefits of simulations. And for all other Technology programs, simulation can be applied to different processes, including specific areas like circuit board design and operation; personnel or labor management of input, output and analysis; and the overall management of any system. Some of the examples of potential areas identified by Obi (2013) include the following that are discussed in this section.

**Products and Manufacturing Materials**

Most application areas here are in supply chain logistics, management and scheduling. In material and product purchases, distribution and acquisition, purchasing will need to know when to expect orders and how efficient the plan or schedule is, for example. They will also need to know where each entity (order) is in the system at any specific time in the schedule, as well as who to contact if need be. A good simulation design can show or predict all this information.

**Equipment and Facilities**

Machines, tooling, equipment and facilities, as applied in material processing and facility layout, are critical application areas for manufacturing simulation. Material processing rates, resource utilization and flow analysis need to be identified for capacity planning, takt time etc. There is also the need to identify potential areas where bottleneck may develop so that the system can be improved.

**Production Methods**

There is need to develop and compare different production methods so that the most optimum system can be selected. Different comparative process analysis options, like 3-D printing Vs machining, can be accomplished by process simulation studies. This may involve relative automated cost analysis, resource analysis, and equipment utilization analysis. Simulation studies of this nature often help to determine the most cost effective option to use.

**Material Handling**

There is need to study material handling or material moving systems so that a better and most efficient system can be developed. This kind of study can reveal factors like flow rates, which can be adjusted to optimize capacity planning for a manufacturing plant. Also, cost analysis can be undertaken in the process to justify the least expensive option.

**Labor**

Like other manufacturing resources, there is need to use simulation to determine how busy personnel are at each workstation. Adjustments can be made as needed for optimal utilization. This also applies to personnel scheduling, management and performance of work.

**Brief Description of SIMPROCESS Simulation Tool**

According to CACI (2017) which developed the software, SIMPROCESS is a graphical block diagramming tool for modeling, analyzing and simulating. Its main characteristic is that it can be used for making abstract models that may help to learn more about activities based on objects, services, resources or supply. These models can take place in situations when engineers are
trying to understand some specific problem about activities which mainly need some resources. SIMPROCESS allows one to create a computer simulation model and see what happens if changes are made in the abstract model. It is a representation of the system of interest and is used to investigate possible improvements in the real system, or to discover the effect of different policies on that system.

Programming in SIMPROCESS is facilitated by the availability of a tool pallet shown in Figure 1. The programmer simply clicks at any of its pallet tools and places it on the layout area as needed. Each of the tools can be further defined and equipped with further capabilities to behave as the programmer wants. These tools can be linked to function as a system and also to resemble a layout as shown in Figure 2. In addition, SIMPROCESS also has many other pull-down menu tools which the programmer can use to define, describe, extend, add, or supplement the tools in the pallet.

General Description of How to Teach Process Simulation

The case example presented here is a typical student assignment which focuses on production of steel hammers. The production system requires only a few processing machines, entities, storage and two operators. A simple scheduling technique is used here. Jacobs et al (2011) described a schedule as having two stages; first, tasks must be assigned to machine tools, and, second, the assigned tasks must be sequenced. Students plan, sequence and follow these tasks throughout the simulation programming.

The entities represent the number of hammer parts (hammer head stock material, hammer handle stock material, finished hammer heads and finished hammer handles) and the assembled hammers. Each of these entity types must be defined and represented in the model. The hammer head stock material and hammer handle stock material will be machined into the finished hammer head and handle shown in Figure 3.
As is also shown in Figure 2, colored dots are used to represent different entities. Black dots are used to represent the hammer head stock material at the generation point. Blue dots represent hammer handle stock material. After being machined at the CNC lathe workstations, the parts are now transformed into finished hammer heads and finished hammer handles respectively. At this point, their entity colors change to red for the head and yellow for the handle. The last change in color takes place after the head and the handle are assembled. This is represented by green dot. The hammers are then moved to a location where they are stored.

The CNC lathe operator attends to the two CNC lathes where he alternates in unloading, inspecting, loading and restarting each machine in the order of its need. He uses any in-between time to clean the machined parts and to manage (monitor) the workstations. The CNC lathe operator is scheduled to be available for the two CNC machines at all time during the work day. The CNC lathe for the head is scheduled to operate a total of 4.75 minutes per cycle, and then to wait for 1 minute to allow the operator to unload a finished part and load another workpiece material. The CNC lathe for the handle is scheduled to operate for 5 minutes and to wait for 1 minute to allow the operator to unload a finished handle and to load another material for the next handle. The calculated machining times are shown in Figure 4.
The role of the Joining station is simply to ensure that there is one head and one handle passing through to the assembly station at all time. This is to ensure that the assembler gets the correct parts for assembly. At the assembly station, the assembler uses the heading machine to assemble the heads and the handles. He also sands and buffs the assemblies to finish them. Assembling one hammer head and one handle into one finished hammer takes 4.5 minutes.

**Steps in Simulation Programming**

While some simulation systems use more than 10 steps to program (AcqNotes, 2017 & WikiHow, 2017), SIMPROCESS uses 10 specific steps to guide its users during simulation programming (CACI, 2017). In the steel hammer case example, students would normally follow these steps to ensure that nothing is missed or left unattended. These steps are briefly summarized in this section using the hammer production example.

**Step 1: Build Process Flow**

A process flow chart or layout will help the programmer to visualize the model. Figure 2 and Figure 4 show how the layout and processes are mapped out. This is very important in visualizing what is being programmed. It is also a good step to determine the process duration element of every process at this point. Use of time studies or standard times is helpful here.

**Step 2: Define and Generate Entities**

Entities represent the order or quantity of items to acquire, produce or manage. They must be clearly defined and generated. In this case example, the dots with different colors must be defined and generated as needed, i.e., quantities needed, rate of movement, destinations etc.

**Step 3: Define Resources**

Resources are the machines and personnel needed to accomplish the production tasks in creating the hammers. Like Entities, these resources must be defined so that they can be assigned. Definition here includes processing time per item, cost per unit of time usage etc.
Step 4: Add Resources to Model
The defined resources must be assigned their tasks within the process model. In this, the entities must be assigned to specific machines, and attendant operators must be assigned to specific machines.

Step 5: Add Delays to Model
A delay models any activity that takes time to complete. These delays represent the duration of each process in the system. They are shown as processing times shown in Figure 4.

Step 6: Define Statistics Collection
The programmer indicates which type of statistics that are needed at each phase. The logic in the simulation software will track, gather and analyze all the data. These statistics will show how the model performed and how effective it is.

Step 7: Define Costing
This is a technique for accumulating cost that represents the resources required or consumed by the object. The systems logic will track, gather and analyze data to show cost based on the duration and usage of each process and resource in the system.

Step 8: Define Real-Time Plots
Real-Time Plots allows live simulation charts to be seen during a simulation. This is helpful in visually showing the programmer how the process is progressing.

Step 9: Define Run Settings
Before the simulation is run, it is necessary to define its run settings so that it will generate the required results. Specific areas of interest such as resource types, spreadsheet format, standards report, and other options of interest can be set at this time.

Step 10: Run Model and Analyze Results
The simulation is run by selecting Run from the simulate pull-down menu or by clicking the Run icon on top of the window. The simulation will run as designed and set. If the entities, clock and counters are set to operate, then they will be seen moving and counting on the screen. The colored dots (or entities) will be seen moving. During a simulation run, SIMPROCESS collects statistics for all entities, resources, activities, attributes, and connectors in the model that have been designated for statistics collection. These statistics are displayed in the standard report when the simulation is complete.

| Table 1: Hammer Assignment Resource Utilization from SIMPROCESS Standard Report |
|---------------------------------------------|--------------|
| Type of resource                          | % Utilization|
| CNC lathe for hammer head                 | 50           |
| CNC lathe for hammer handle               | 49           |
| CNC lathe operator                        | 99.99        |
| Heading machine                           | 97.84        |
| Hammer assembler                          | 54.44        |
Some of the key results of the hammer case example are summarized in Table 1. SIMPROCESS normally generates about 17 areas of report, but, in this study, only one area of interest has been selected for example, i.e. resource utilization. Table 1 shows specific utilizations of the resources used in the production of the steel hammers.

Conclusions and Implications

Because process simulation programming in manufacturing and technology programs has many benefits, it is important that the subject be taught to manufacturing and technology majors. One of the best things professors in these programs can give to these students is the concept of continuous improvement through manufacturing simulation exercises. Because of the nature of today’s competitive manufacturing and technology industries, all students should be informed that everything in the system is there to be improved on a continual basis. Process simulation makes that practice within reach of educators and students. This will make manufacturing and technology programs more functional, and students will more easily relate to the realities of the modern industry.

As shown in Table 1, some of the resources have high utilization, others do not have as high. That is one of the typical situations where this kind of study finds its usefulness. Managers can do necessary adjustments to achieve their ideal objectives. Perhaps, a resource is being overutilized or underutilized. It is clear that the CNC lathe operator is so overutilized that an adjustment would be in order. On the other hand, the utilization of the two CNC lathes would need to be increased for better productivity. This type of exercise can be integrated into technology team projects so that students can determine how to improve certain system resources, or determine certain unknowns of the system in order to achieve stated objectives. Also, it is important to note that SIMPROCESS tool pallet can be used to design the physical layouts of manufacturing and technology facilities.

Moreover, improvements can generally be made in the design as needed based on the result of the simulation run. For example, bottleneck issues can be removed or minimized by making necessary adjustments. It is known that queue time is a critical element and accounts for 80% or more of total lead time (Jacobs et al 2011). It is also the element most capable of being managed, and reducing its time means shorter lead time and, therefore, reduced work-in-process inventory.

References


Virtual Commissioning for Industrial Automation.

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Abstract:
Most of the recent international manufacturing enterprises have recurred in the last decade to have fully automated and flexible plants to achieve their expected results. However, before the fully operational plant starts working, the process of commissioning represents a very complex step in many aspects, like how incorrect machinery handling, installation and operation can directly generate a negative effect on the efficiency of the plant; since this equipment is composed by expensive, fragile devices, a wrong implementation of them can significantly delay the ongoing process. Virtual commissioning has been a favorable solution to these issues, saving a high amount of economic resources for both the commissioner and the enterprise. In this research, a case study is presented for the automation industry, in which a safe and efficient virtual scenario was designed along with a physical interface easily to handle that allows to work with digital and analog signals, as well as having a generalized communication protocol that is compatible with any class of programmable logic controllers (PLCs).

Introduction:
Modern automation systems are highly integrated and consists of fully automated workstations. A workstation may have robots with tool-changing capabilities, handling systems, storage systems, and computer control system (Chryssolouris, 2013; Schriber, Brunner, & Smith, 2012). If manufacturers are to remain competitive in an ever-changing marketplace, they must continuously improve both the products and the production systems. Thus, an efficient prototyping environment for production systems is crucial, which leads to the notion of virtual automation system (virtual commissioning), a computer based environment to simulate individual automation processes (Liu, Suchold, & Diedrich, 2012).

Virtual commissioning enables the full verification of a manufacturing system by performing a simulation involving a virtual plant and a real hardware controller (PLC) (Lee & Park, 2014; Strahilov & Damrath, 2015). This requires the virtual plant model to be fully described at the level of sensors and actuators. A recent study showed the positive effect of working with virtual commissioning, reducing costs and adding weight to value creation in comparison to traditional commissioning (Shahim & Møller, 2016).

In the last five years, a wide variety of projects have been realized, in which the creation and implementation of virtual reality technologies have helped to improve the plan commissioning process (Süß, Strahilov, & Diedrich, 2015,2016). In the same way, some activities like training and industrial machinery maintenance have been replicated in an optimal way thanks to the creation of virtual scenarios (Ortega-Moody, Sánchez-Alonso, González-Barbosa, & Reyes-Morales, 2016).

This article details the development of each of these function steps and addresses issues associated with controller system. The effectiveness of the developed Virtual commissioning system is demonstrated to conclude the research paper.
Methodology:
The proposed methodology (see fig. 1) is composed of the stages described below:

In this stage, industrial kinematic 3D virtualized plant and mechatronic plant model simulates the behavior of the real physical plant. It should respond correctly to the PLC control signals just as real systems. Besides the whole process, the behavioral model simulates the uncontrolled behavior of the system and it should react to the control signals (PLC output signals) according to the physical feature of the plant and gives the feedback signal (PLC input signals) back to the PLC-just as the behavior of the real control system (Zheng Liu, 2014).

B. 3D modelling of the system.
Much of the realistic experience of a virtual environment depends on the effort that is concentrated in the elaboration of the 3D models present in the scene. The kinematic 3D-model can be understood as a geometric model, which is based on the 3D CAD model using SolidWorks and mesh editing in the 3DS max enriched with additional information. In contrast to today’s mechanical CAD models, the objects in VR scenarios do not just solely consist of the pure 3D CAD model, but also kinematic (including end positions) information.

C. Electronic and PCB design.
In this stage, an electronic design must be created in order to accomplish an interaction between real-life components and the scenario that is intended to be developed. One must take into consideration all sorts of recommendations and, most importantly, the electrical rules that are needed for the circuit to be correctly designed and implemented.

D. Virtual Scenario modeling of physical behavior.
In this stage, it is necessary to manually allocate actuator functions such as translation, rotation, gripping etc. and sensor functions to selected parts of the geometrical models, which results in the definition and parameterization of integrated functional models such as cylinder, turntable, sensor, gripper and so on (Peter Hoffmann, 2012).

E. Configuration and Interfacing of the components.
In this stage, the real control system (PLC) is connected to the virtual plant model with a DAQ interface, internally converting the physical signals to virtual signals. Afterwards, the PLC and the simulation systems are interconnected via the communication system or direct wiring. The I/O lists of the simulation system and the I/O lists of the control program must be properly connected with each other. The information which is extracted from existing data sources by using the virtual plant...
model can represent the structure of the workstation (3D dynamic system and behavioral simulation, PLC program, link-up between PLC and virtual simulation model).

**F. Implementation of the Virtual Commissioning.**

After the interfacing of the real control system and virtual plant model, it worked according to the design specifications, virtual commissioning can be implemented.

**Case Study: Virtualization of the Industrial automation.**

For this case study, the virtual development platform used is Unity 3D version 5.5, which contains the physics engine. This platform allows the user to develop the programming code in high level languages such as C#, Java script which can be elaborated in IDEs such as Microsoft Visual Studio. The following is the development of this case study.

**A. Design and Specifications.**

**System requirements.**

For this investigation, the proposed system consists on a bottle filling and taping automated plant, in which the main purpose is to have plastic bottles go through a process in which liquid coming from a mixer tank is deposited inside them; then, the bottles will go across a conveyor in which a pneumatic actuator will put and tighten a plastic cap on top on each one. The system will not only contain the plastic bottles filling and taping processes, as a dynamic system will also run alongside. Each one of the I/O that are part of the systems will interact all the time, to a communication protocol in which the virtual world interacts with the physical world. To make this a more practical application, and interface will be constructed, so that a programmable logic controller (PLC) can interact with the virtual world. This scenario can be seen in fig. 2.

![Diagram of a bottling plant](image_url)

**3.1.1. Dynamic system design.**

The bottle filling plant has inside of it a mixing process, in which two liquids will be deposited inside of an isolated tank. Then, the mix will be heated until a certain uniform temperature set by the operator of the plant. Therefore, a temperature control system is desired to be implemented during the time the VR is running. Assumptions like no heat storage inside of the isolation material that composes the tank were taken into consideration, and a representation of such system can be seen in fig. 3.
Figure 3: Thermal dynamic system.

From the illustration, we can define the transfer function determined for this process:

\[
G(s) = \frac{T(s)}{Q(s)}
\]

\[
q_l - \frac{1}{R}(T - T_i) = C \frac{dT}{dt}
\]

Applying the Laplace transform to the energy balance equation:

\[
\frac{T(s)}{Q(s)} = \frac{R}{\tau s + 1}
\]

A similar process is followed to obtain the Laplace transform of the relation between the initial temperature of the incoming liquid and the temperature of the mix, resulting in:

\[
\frac{T(s)}{T_i(s)} = \frac{1}{\tau s + 1}
\]
3.2 3D CAD Modeling.
The process to create any virtual object must begin by obtaining all the physical dimensions and properties that are present in its real-life counterpart. After acquiring the dimensions of a desired object, the next step translated them into a CAD software that would allow to create a three-dimensional model, along with properties like local positions and rotation according to a frame in a virtual space, as well as a mesh. One of the approaches in creating the 3D models for this scenario was to delete elements that could be easily interchangeable with much simpler geometrical forms inside the game engine, mainly because the lasts don't have a very detailed mesh. Once the 3D models were accordingly constructed like in fig. 4, they are exported into the game engine Unity 3D in an FBX (Film Box) format.

![Figure 4: Mesh editing of 3D model.](image)

3.3 Electronic and PCB Design.
Recent research has been able to present practical cases in which the game engine is able to interact with different hardware, and communication protocol that can be shared with other devices like PLCs. The work on this research further expands in this capability and established a way to not only interact between digital inputs and outputs, but also analog ones as well. For this, an electronic interface was designed and implemented to fully take advantage of the PLC functionality. The proposed interface, represented in fig. 5, is composed of an array of relays that are used to send digital signals coming from a microcontroller towards the PLC, as well as opto-couplers that can provide electrical isolation for incoming digital signals of the PLC. It also contains many operational amplifiers that allows to send and receive analog signals into the microcontroller.

![Figure 5: PCB design and tracing.](image)
3.4 Virtual Scenario setup.

Each object in the Unity 3D game engine are configured as “Game Objects”, which are the basic elements of the software. A “Game Object” has a “Transform” component, which determines its three-dimensional position, rotation and scaling. For objects to be animated, one can simply modify these values according to the desired movement. However, for objects that also respond to a specific dynamic interaction, there needs to be another component called “Rigid Body”. This will allow the object to be affected by other physical properties like gravity and joints. In the case of the bottle plant, an example of this would be the pistons that control the movement of the liquid dispatching valves showed in fig. 6.

A collider allows the shape of the element to interact with all the elements of the scenario by limiting a covering surface around the desired object. This surface can take the shape of different geometrical figures like spheres and cubes, or even take the full mesh shape of an object. Another important process inside the virtual scenario step-up is the creation of scripts. These are programming instructions that can be assigned to Game Objects taking full advantage of object-oriented programming languages like C#. Multiple scripts can be assigned to the same object, and the fact that they use object-oriented programming, makes the interaction between multiple elements at the same time relatively easy.

3.4.1 Oculus Rift Hardware.

The ever-increasing field of VR has demanded the development of specific hardware that allows the user to easily interact with these scenarios. One of the most potent and accessible devices is the Oculus Rift, which consists on a headset and hand controllers that are linked to fixed-position sensors. Another advantage of the use of Oculus Rift is the compatibility with game engine software like Unity 3D thanks to open access drivers that can be easily installed. For the process described, the user can fully operate inside the scenario by inserting a first-person object that is linked with the headset and the hand controllers, making familiar hand movements easily executable, as seen in fig. 7.
VR-Electronic interfacing.
As it was mentioned earlier, one of the main purposes of this paper is to show the results of the interaction between a virtual reality scenario setup and how it can be linked with real-life electronic circuits that can handle the reception and emission of both digital and analog I/O. Digital input signals are sent by activating relays which in turn can let pass the required voltage to the PLC inputs. Digital output signals are received through an opto-isolated circuit, in which the output signal coming from the PLC is transmitted thanks to an opto-coupler. As for the analog input and output signals that the microcontroller receive and send respectively, they go through an operational amplifier that can reduce or increase the voltage at its output. On the other side, the VR scenario is configured so that it can access each and every single I/O that is going to interact with the system. By sending the data through the serial port, the type of signal is then deciphered by the script, which then will be assigned to a different element on the arrays. The number of digital and I/O will depend of the number of inputs and outputs inside the microcontroller. This is seen in fig. 8.
Figure 8: I/O table of the electronic-VR interface.
After the configuration of the I/O was made, the next step was the interaction between the interface of the electronic components and the VR plant bottle scenario, seen in Fig. 9. Finally, the code for the systems control parameters and the time conditions was built onto the PLC, which could be seen when running the scenario.

Figure 9: Actuators game objects.
Results.
In this research, the results were that the interaction between the real control system and the VR automation plant was possible and also, that it was a high-performance scenario. The real control system inputs sent physical signals to the microcontroller (DAQ board), which in turn, it converted internally into the virtual signals that were read by the Unity 3D interface. Likewise, Unity 3D wrote a virtual signal to the Microcontroller (DAQ), which converted the virtual digital signals to real physical signal (PLC).

Conclusion.
A systematic methodology was presented for the implementation of virtual commissioning to reduce the commissioning time, improving the coding in PLCs without damaging the hardware, interactive education training to teach the students how the line of production works in the automation industry, and the most important application, which is safe maintenance operations. The methodology is based on the characterization of the physical properties of all the elements embedded in the scenario, from the real control system to the dynamic model of the sensors, actuators used for the control and operation of the whole process. After successfully interfacing the real control system to the virtual automation plant, it worked according to the dynamic system design specifications.

Augmented Reality can also be implemented by using same virtual scenario by implementing the change of view it appears to be real world environment whose elements are augmented by sensory input such as audio, graphic video data. Virtual reality is better than augmented reality since the field of view is better in VR. For educational purposes VR is better used to see the whole line of production and interaction. AR is better for observing scenario in the real environment but cannot see the full automation process since it has low processor.

Acknowledgements.
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References.
Peter Hoffmann, R. S. (2012). VIRTUAL COMMISSIONING OF MANUFACTURING SYSTEMS A REVIEW AND NEW APPROACHES FOR SIMPLIFICATION . VIRTUAL COMMISSIONING, I.
CLASSIFYING AND PREDICTING OCCUPATIONAL INCIDENT SEVERITY

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Dr. Steven Freeman, Iowa State University, Ames, IA
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Abstract
The focus of the study is to build a predictive model and assess its performance in classifying the financial severity of occupational injuries in agribusiness bulk storage facilities (i.e. grain elevators). The data specifically look at food processing and feed milling operations within these facilities. The severity of occupational injuries is determined by the total dollar amount incurred on medical costs, indemnity costs and other expenses in workers’ compensation claims. The data is available from an agribusiness insurance provider in Midwest USA. First, the most important independent variables that affect the total cost of claims are extracted from the original dataset. The claims cost variables are then applied as input factors in constructing a classification decision tree and random forests trees with the claims classified as severe and non-severe. Claims over ten thousand dollars are considered severe while those with zero to ten thousand dollars are classified as non-severe. For the purpose of balancing model overfitting and prediction accuracy, the data is partitioned to training, validation and test sets. The results show that the decision tree and random forests trees have accuracy rates of 94% and 93% respectively in predicting that a future claim will be classified as severe or non-severe based on characteristics of the injury. In addition, incident location and injured worker demographics do not have a significant effect on predicting claim severity. The presented model identifies higher injury risk groups and prevalent causes of incidents in work environments, allowing a more focused intervention effort in the food processing and feed milling sectors. In addition, it is applicable in forecasting cost of future claims and identifying factors that contribute to escalation of claims costs.

Keywords: Classification Decision Tree, Random Forests Trees, Occupational Injuries

Introduction
Occupational incidents are a major problem in agribusiness industries. The data from a major insurance company includes more than 6,000 incidents in the food processing and feed milling sectors which incurred loss over 18 million dollars from 2008 to 2016. In the U.S., workers’ compensation coverage has been in place for more than 100 years (Baldwin & McLaren, 2016). There are three main types of workers’ compensation claims: medical only, temporary disability, and permanent disability, among which the greatest costs are imposed by permanent disability. The most common claims are “medical only” even though they represent a small share of the overall payments. Sources of workers’ compensation insurance consist of private insurance carriers, state funded, or self-insured (Baldwin & McLaren, 2016).

The purpose of this study is to investigate the application of classification as a machine learning technique in predicting the financial severity of occupational incidents in food processing and feed milling in grain elevators. The confusion matrix is used to assess model prediction accuracy. Finally, the classification tree is used to explain the factors that lead to severe and non-severe incidents. This will contribute to identifying higher injury risk groups and determining more prevalent causes of incidents in work environments to focus on intervention efforts.

Decision Trees for Classification Purposes
A decision tree is a commonly used methodology for building classification systems based on multiple covariates for the development of a predictive model for a target variable (Lu & Song, 2015). Decision trees are among the most popular predictive analytics techniques among practitioners due to being relatively straightforward to build and understand, as well as handling both nominal and continuous inputs (Abbott, 2014). Other advantages of decision tree classification methods include the support for multi-level classification and nonlinear classification capability. Some important examples of decision trees include random forest and gradient boosted trees as they are considered as the best classifiers (Cui, Chen, He, &
Tree algorithms simply split the dataset hierarchically and can be applied as a replacement for logistic or multiple regression and ANCOVA (Lavery & Mawr, 2012). According to SAS Institute (2016), in classification trees where the response variable is categorical, the decision criteria for choosing the best split is the likelihood ratio chi-square and node splitting is based on the LogWorth statistics which is defined as [-log10(p-value)]; where the p-value is calculated so that it takes into account the number of different ways splits can happen. The calculation includes an unadjusted p-value, which supports input variables with many levels, and the Bonferroni p-value, which favors input variables with small number of levels. The optimal split is the one that maximizes the LogWorth.

Random Forest Trees
The Random Forests (RF) method is a machine learning technique that is useful in prediction problems (Bharathidason & Venkataeswaran, 2014). The RF method has a set of characteristics that makes it advantageous (Polley, Goldstein, & Briggs, 2011). As a powerful data driven method, random forest is non-parametric, has high predictive accuracy, and determines variable importance which contributes to better understanding of the individual role of each input factor (Rodriguez-Galiano, Mendes, Garcia-Soldado, Chica-Olmo, & Ribeiro, 2014). RF trees consist of a collection of arbitrary simple trees used to determine the final outcome. According to (Görmping, 2009), RF trees are random since a subset of the observations is used to build each individual tree, and also each split within each tree is created based on a subset of input variables, not all. As a large number of trees is made, the overall prediction of the forest is the average prediction of all individual trees. In classification, the ensembles of simple trees vote for the most popular class while in regression problems, the responses are averaged to obtain an estimate of the dependent variable. Applying the RF method will significantly improve the prediction accuracy (Hill & Lewicki, 2007). Using RF trees, the input variables that are significant in predicting the response variable are also identified.

Materials and Methods
Predictive modeling is the adopted methodology for this research. Predictive modeling is the use of data to forecast future events by relying on capturing relationships between explanatory variables and predicted variables from past events and applying them to predict future outcomes (Frees, Derrig, & Meyers, 2014). Although predictive modeling is heavily dependent on statistics, the major fundamental difference is that in statistics, a model is used to test a set of hypotheses, while in predictive analytics, data mining is done by building nonparametric and distribution-free models. (Abbott, 2014). There are various techniques in applying predictive modeling in a given dataset. In this research, classification via random forest trees and classification trees is done. The target variable is claim severity which has the binary classification of severe (S) and non-severe (NS). The reason for such classification is that the severity of claims in insurance analytics is determined based on the total dollar amount which is incurred on medical costs, indemnity costs, and other relevant expenses. For claims with the total amount between zero to ten thousand dollars, the level is considered non-severe (NS) and claims with cost over ten thousand dollars are considered as severe (S).

According to Mattew (2016) in classification methods, confusion matrix is the basis of the predictability power of the model. A confusion matrix shows the correct and incorrect number of cases classified under a defined target. It is used to calculate the accuracy of the prediction (See Table 1).

<table>
<thead>
<tr>
<th>Test</th>
<th>Predicted N (Negative)</th>
<th>Predicted P (Positive)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed N (Negative)</td>
<td>True Negatives (TN)</td>
<td>False Positives (FP)</td>
</tr>
<tr>
<td>Observed P (Positive)</td>
<td>False Negatives (FN)</td>
<td>True Positives (TP)</td>
</tr>
</tbody>
</table>
Data Processing
The data shows the insurance company has had a loss of 18 million dollars over eight years. The amount is paid on both claims that are closed, and those open which will continue to cost for the parties involved. In more than 6000 incidents, 87% have closed claims, and 13% of claims are open. However, 60% of the total amount incurred is paid on open claims and only 40% on closed claims. In this study, all claims (both open and closed) are analyzed and predictive models are built to forecast the probability of a claim ending in severe or non-severe based on workers' compensation information. Injuries are categorized in five groups: medical only, permanent partial disability, temporary total or temporary partial disability, minor permanent partial disability and death. The distribution of types of injuries in this dataset for closed and open claims are shown in Figure 1.

Response and Input Variables
The variable of interest in this study is the outcome of a claim which is determine by the total amount paid on expenses, medical costs and indemnity costs. Looking at this total amount, claims are categorized as severe (S) and non-severe (NS). This research focuses on application of data mining in predicting that a claim will be classified as either S or NS based on the workers' demographics, incidents location, and characteristics of the injury in open claims dataset. The variables that are used as input variable from the original dataset are shown in Table 2.

Table 2: Description of the Independent Variables in the Dataset

<table>
<thead>
<tr>
<th>Input Variable</th>
<th>Variable Type</th>
<th>Input Variable</th>
<th>Variable Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of Worker</td>
<td>Continuous</td>
<td>Injured Body Part</td>
<td>Categorical</td>
</tr>
<tr>
<td>Tenure of Worker</td>
<td>Continuous</td>
<td>Cause of Injury</td>
<td>Categorical</td>
</tr>
<tr>
<td>Type of Injury</td>
<td>Categorical</td>
<td>Nature of Injury</td>
<td>Categorical</td>
</tr>
<tr>
<td>Occupational Class Code</td>
<td>Categorical</td>
<td>Injured Body Group</td>
<td>Categorical</td>
</tr>
<tr>
<td>Incident State</td>
<td>Categorical</td>
<td>Cause Group of Injury</td>
<td>Categorical</td>
</tr>
<tr>
<td>Gender of Worker</td>
<td>Categorical</td>
<td>Nature Group of Injury</td>
<td>Categorical</td>
</tr>
</tbody>
</table>
Partitioning Data
Data for this analysis is divided into three parts: training set, validation set, and test set. The training set includes 60% of the data points. This set is used to fit the model of interest and estimate model parameters. The validation set includes 20% of the data points. The model fitted to the training set is applied into the validation set to assess the predictive ability of the model that is useful for selecting the better model. Finally, the test set, includes 20% of data points that have not been used in the training or the validation sets, and is used to assess the generalization error of the final model. The decision about the usefulness of a predictive model is made based on the performance of the model in the test set only.

Results & Discussions
Two types of analyses are done. First, a decision tree was built aiming at classifying the binary S/NS response with all independent variables from Table 2. Second, the RF method was applied to classify the response. The results on all training, validation and tests are presented. Finally, both models are compared and assessed.

The Classification Decision Tree Summary Analysis
The results from this analysis indicate that the most influential predictor of a claim severity is type of injury. Claim status (open/closed), nature of injury, cause group of injury, and injured body group are other important factors respectively. The details of the analysis are shown in Table 3. The accuracy of the predictive model is determined from the confusion matrix for each set. The model did well on all training, validation and test sets. The overall accuracy rate of the test set indicates that the model can correctly classify and forecast future claims severity in almost 94% of the cases based on injury type, claim status, nature of injury, cause group of injury and injured body group.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Training</th>
<th>Validation</th>
<th>Test</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entropy RSquare</td>
<td>0.5785</td>
<td>0.6099</td>
<td>0.619</td>
<td>$1 - \log_{10}(\frac{\text{likelikelihood}}{\text{null likelikelihood}})$</td>
</tr>
<tr>
<td>Generalized RSquare</td>
<td>0.6843</td>
<td>0.7154</td>
<td>0.7212</td>
<td>$1 - ((1 - \text{likelikelihood}) \times (1 - \text{null likelikelihood}))$</td>
</tr>
<tr>
<td>Mean - Log p</td>
<td>0.1903</td>
<td>0.1822</td>
<td>0.174</td>
<td>$\sum_{i=1}^{n} \log(p_i)$</td>
</tr>
<tr>
<td>RMSE</td>
<td>0.2378</td>
<td>0.2323</td>
<td>0.2247</td>
<td>$\sqrt{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}$</td>
</tr>
<tr>
<td>Mean Absolute Dev</td>
<td>0.1136</td>
<td>0.1137</td>
<td>0.1067</td>
<td>$\sum_{i=1}^{n}</td>
</tr>
<tr>
<td>Misclassification Rate</td>
<td>0.0752</td>
<td>0.063</td>
<td>0.0619</td>
<td>$\sum_{i=1}^{n} (y_i - \hat{y}_i)$</td>
</tr>
<tr>
<td>Prediction Accuracy</td>
<td>92.48</td>
<td>93.7</td>
<td>93.81</td>
<td>$\frac{(\text{TP} + \text{TN})}{(\text{TP} + \text{FP} + \text{TN} + \text{FN})}$</td>
</tr>
<tr>
<td>N</td>
<td>3682</td>
<td>1253</td>
<td>1243</td>
<td>n of total observations in each set</td>
</tr>
</tbody>
</table>
Random Forests Trees Summary Analysis
In this part, the random forests tree method is applied to the data. The analysis indicates the most contributing factors in predicting the target of claim severity are type of injury and claim status (open/closed). Incident state, cause of injury, body part injured, and class code are less significant contributors. The analysis details are shown in Table 4. The prediction accuracy rates of the random forests trees on all training, validation and test sets are close to those of the decision tree analysis in section 0. Although the prediction accuracy is high, the variables that are selected as the most contributing ones have too many levels which makes interpretation of the trees difficult and tedious. In data mining, it is regular to repeat some steps many times to make the final decision of a model (Hidayatul Qudsi, Kartiwi, & Binte Saleh, 2017). Simple interpretation of a model is as important as its applicability. Thus, the random forests tree analysis is done again with the most contributing variables in the decision tree analysis method. Body group and cause group of injury have fewer levels and make the interpretation easier. The results show that the new model accuracy is a bit lower (training set 87.8%, validation set 87.15%, test set 88%).

<table>
<thead>
<tr>
<th>Measure</th>
<th>Training</th>
<th>Validation</th>
<th>Test</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entropy RSquare</td>
<td>0.6944</td>
<td>0.5647</td>
<td>0.5683</td>
<td>1-Loglike(model)/Loglike(0)</td>
</tr>
<tr>
<td>Generalized RSquare</td>
<td>0.7833</td>
<td>0.6752</td>
<td>0.6762</td>
<td>(1-(L(0)/L(model))^2/n)/(1-L(0)^2/n)</td>
</tr>
<tr>
<td>Mean -Log p</td>
<td>0.138</td>
<td>0.2033</td>
<td>0.1972</td>
<td>Σ -Log(p[i])/n</td>
</tr>
<tr>
<td>RMSE</td>
<td>0.1879</td>
<td>0.2439</td>
<td>0.238</td>
<td>√(Σ(y[i]-p[i])^2/n)</td>
</tr>
<tr>
<td>Mean Abs Dev</td>
<td>0.108</td>
<td>0.1436</td>
<td>0.1385</td>
<td>Σ</td>
</tr>
<tr>
<td>Misclassification Rate</td>
<td>0.0378</td>
<td>0.075</td>
<td>0.0668</td>
<td>Σ (p[i]≠pMax)/n</td>
</tr>
<tr>
<td>Prediction Accuracy</td>
<td>96.22</td>
<td>92.5</td>
<td>93.32</td>
<td>(TP/(TN+TP+FN+FP)</td>
</tr>
<tr>
<td>N</td>
<td>3682</td>
<td>1253</td>
<td>1243</td>
<td>n of total observations in each set</td>
</tr>
</tbody>
</table>
Model Comparison

Both models perform well in predicting the severity level of the claim based on type of injury, claim status, injured body group, cause group of injury, and nature of the injury. The final decision tree shows the following:

- Open claims are all predicted to end as severe claims.
- Medical injuries have 0.78 probability of ending non-severe, while minor/major permanent or temporary partial/total disabilities or death have 0.97 probability of ending as severe.
- Medical injuries caused by burn or scald, heat or cold exposure, cut, puncture, strain, fall, trip and motor vehicles have almost 100% chance of having a total incurred cost of 0 to 10,000 dollars.
- Minor/major permanent or temporary partial/total disabilities with nature of amputation, inflammation, contusion, crushing, tear or strain have 85% chance of turning severe and costing over $10,000.
- Minor/major permanent or temporary partial/total disabilities with nature of dislocation, fracture, concussion, laceration, hernia, and carpal tunnel syndrome have equal chance of becoming severe or non-severe.
- Temporary partial/total disability Injuries in head and upper extremities body groups are more severe than those in trunk, neck, and lower extremities.

Conclusion

The initial intent of this study is to predict what factors in workers' compensation data affect the financial severity of the claims. The results of this study can be applied in identifying higher injury risk groups and more prevalent causes of incidents in work environments to focus intervention efforts in food processing and feed milling sectors. Future studies will focus on separate analyses of open versus closed claims and medical injuries versus other types of injuries to investigate any other significant patterns in workers' compensation claims.

References


CLASSIFYING AND PREDICTING OCCUPATIONAL INCIDENT SEVERITY


Augmented Reality in the Classroom:
Development of a stationary bicycle with virtual environment for new learners

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Introduction
Through a virtual classroom (Nolin, Stipanicic, Henry, Lachapelle, Lussier-Desrochers, Rizzo & Allain, 2016) it is possible to assess students’ sustained attention and inhibition. This provides instructors tools to demonstrate spatial orientation 3D modeling concepts for first year engineering students. Through the virtual reality (VR), users navigate and interact within three-dimensional environments.

Earliest indications of virtual reality attempts date back to nineteenth century, where the panoramic illustrations attempted to deliver illusion of places where one is at a time. More recent development of virtual reality in twenty first century involved application in an I/O Home to recruit students into STEM fields (Riera, Empirin, Annebicque, Colas & Vigario, 2016). Virtual reality projects are intended to fill the viewer’s entire field of vision, making them feel present at some event or scene. An example of such sense of depth and immersion was the development of View-Master stereoscope for “virtual tourism” in late 1939s (Mazikowski & Lebiedz, 2014). The stereoscope combines two different images so the human eye generates a sense of immersion (Figure 1).

\[ G(s) = \frac{T(s)}{Q(s)} \]

Intended population for the project
Leaving a family to live in a nursing home environment is a major life event for an elderly, which requires them to lose their familiar surroundings and adaptation to a new environment. Often, the decision to move to a nursing home is a necessity than a choice (Serow & Sly, 1987), and the destabilized in social relationship newcomer must build new relationship as well as adapt to the unfamiliar environment. Previous research has repeatedly emphasized the adaptive function of leisure activities in older age (Leitner, 2017; Griffith & Jain, 2015). The researchers indicate that the importance for the elderly to participate in leisure activities is consistent with the necessity to organize them according to their expectations (Griffith & Jain, 2015). Additionally, Coleman & Iso-Ahola (1993) indicate that the participation of elderly in leisure activities is associated with better integration of an individual to the group. Therefore, it is imperative that the augmented reality is integrated in the nursing home for easier adaptation of an individual to a new environment and participate in the leisure activity that provides the familiar surroundings he/she came from. The purpose of this study is to discuss a classroom project to construct a stationary bicycle, develop virtual maps of bicycle trails, streets, environment for nursing homes. It is the intent of the researchers to develop additional leisure activity for elderly in augmented reality on a safe environment. This project involves collaboration...
from mechanical engineering, computer science and industrial management students and faculty to design and construct the VR Bicycle. Our first aim in the present study is to develop a virtual map with bike riding rules and regulations. To achieve this, we used a free version of Unity game engine that can be downloaded from unity's website. As a second aim, we construct a stationary bicycle from a bicycle trainer, which provides safe and comfortable pedaling experience.

**Concept of VR Bike**
The task of developing a stationary model of a VR Bike has been undertaken at the College of Engineering of XXX University. One of the main assumptions of the VR Bike development is to ensure the highest possible degree of “immersion” with maximum amount of physical comfort to provide impression of natural activity. The construction of the stationary bicycle included an exercise bicycle with a desktop computer and the VR equipment mounted on the bicycle. The three-dimensional vision is related to the projection of images in slightly different perspective to observer's each eye separately. These slightly different images are interpreted as an impression of depth in the observer's brain. Construction of these separate images requires developing 3D maps of environment and transmitting them to a VR headset, which projects the 3D environment separately to each lens. Unity game engine, therefore, is capable of importing 3D modeled environment to edit for VR production. First person character (FPS) asset in unity is controlled with keyboard, mouse, and the virtual reality headset for moving, jumping and three-dimensional orientation. The authors, however, needed to convert forward movement of the observer’s point of view to the stationary bike's wheel rotation. Therefore, the acceleration of the augmented environment, turnings left and right and stopping are controlled on the bicycle to imitate the real-world experience.

**Methodology**
Presentation of a dynamic 3D environment with smooth synchronization to the stationary bicycle and its controls is a basis for obtaining a reliable impression of riding in virtual environment. Construction of such environment requires 3D modeling of objects, assembling into the map, and scripting to interact with the hardware to improve interaction with the surroundings. Development of VR Environment Graduate students developed majority of the 3D objects such as roads, skyscrapers, vehicles, traffic lights etc with Creo Parametric 3.0. Required dimensions for the objects were retrieved from online resources. Additional decorative dynamic fixtures such as fountains, trees and clouds can be imported directly from Unity's asset store free of charge. Virtual bicycle movements are controlled through the keyboard inputs. Additionally, the VR bike controls such as acceleration, braking, left and right turns are transmitted from the stationary bicycle. Character visual movements such as look 360 degrees, up and down are controlled through the VR headset.

Figure 2: Virtual environment with third person character.
Construction of Bike Station

Undergraduate students developed a 3D model of a bicycle and the stand to keep the bicycle stationary. Students were split into multiple groups to develop various parts and drawings of the bicycle. For the duration of a month, students disassembled the physical bicycle, measured dimensions of parts, and assembled in Creo Parametric 3.0 as shown on Figure 3.

![Image of fully assembled bicycle from independent group parts](image)

Further construction of bicycle station carried out in the wood workshop, where students developed physical stand to hold the bicycle stationary. Development of the three-dimensional model of the stand and the physical construction of the bicycle stand were completed by two different groups. This represented the real-time manufacturing environment with various departments such as product development division (3D modeling and prototyping) and the natural workgroup personnel (construction of the bicycle). One of the biggest challenges between these two groups was the communication, as expected. Some of the parts did not contain all required dimensions while others did not provide complete information on the fasteners. These two groups spent approximately a week to resolve misalignment of the parts before the construction team could start the building process. Due to time constraints and lack of experience, the construction group provided ninety (90) percent of the required product as shown on Figure 4.

![Image of construction of bicycle stand in the laboratory setting](image)
Results and Conclusion

The purpose of the study was to involve undergraduate and graduate students to develop an augmented reality bicycle station. The goal of the project was to introduce a strategy to improve spatial orientation learning for freshmen and sophomore engineering technology students. Conventional way, demonstration of orthogonal views from a physical part, takes 2-3 weeks of the semester to comprehend. Lack of hands on experience in new engineering technology students increases the spatial orientation skill. Authors developed augmented reality environment to provide immersive experience, where the students could visualize various orthogonal views, as well as three-dimensional part features. Authors hypothesized that the significant level of computer literacy of millennial students may be advantageous in 3D modeling tools. Pretest and posttest t test analysis revealed that the introduction of virtual environment to illustrate the environment improved students' spatial orientation significantly as shown on Table 1. Nineteen undergraduate students completed brief spatial orientation test online at the beginning of semester. All students were asked to ride the bicycle in the virtual environment to visualize various views of the parts from the test. Same test was distributed to the students to document and conduct analysis to investigate the influence of augmented reality.

Table 1. Descriptive Statistics, Paired Samples Test

<table>
<thead>
<tr>
<th>Paired Samples Statistics</th>
<th>Mean N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 Pre-Test</td>
<td>1.421</td>
<td>19</td>
<td>.692</td>
</tr>
<tr>
<td>Post-Test</td>
<td>8.578</td>
<td>19</td>
<td>.837</td>
</tr>
</tbody>
</table>

Introduction of virtual environment to demonstrate orthogonal views of parts improved students' understanding on correct orientation. According to initial survey, students score average was 1.421. However, the bicycle riding within the virtual environment increased the score mean to 8.578, making it a significantly different from the pretest (Table 2).

Table 2. Paired Samples t-Test for Spatial Orientation in CAD class.

Table 2 shows that there is significant difference (p< alpha level =0.05) between two mean values (m1=1.421, m2=8.578). Overall, the project was interesting for students and they were excited to see how the 3D model can become a virtual environment as well as physical object. One of the student's comment was: "I think everyone should experience what we did during this class regardless of their major. 3D modeling and augmented reality development rock".
References
Potential Health Impact of Radiofrequency Radiation on Humans

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Abstract
Despite broad applications that range from mobile phones to even children toys, wireless technologies have received multiple critiques regarding safety of their users based on consistent and aggressive exposure of electromagnetic field. Some authors have reported that before presenting new products on a market, well-known wireless providers spend decent amount of their budget sponsoring research studies that mistakenly confirm the absence of harmful effect of RF radiation. Since majority of bio-chemical processes in humans are based on electrical processes, consistent exposure to electromagnetic field (EMF) brings negative impact on many biological functions. It also appears to stimulate irreversible processes in developing brain tissues of young children. This paper presents a literature review of multiple academic sources with the purpose of creating awareness for a large audience of Wi-Fi and mobile phone users. This paper also discusses some of the limitations of the current literature, and how these limitations can be addressed in the future research.

Introduction: Hidden RF Exposure
Giving a guest speech at University of Melbourne on November 30, 2015, Dr. Debra Devis, a distinguished Professor and Founding Director Board on Environmental Studies and Toxicology, National Research Council, pointed that there are approximately six billion of cellphones, eight million of transmitted devices, fifteen billion of internet connected devices, and “we need to say that we do not know a lot about public health effect of this radiation” (Devis, 2015). Mobile phone radiation provokes many unanswered questions. These questions should be asked, making deep research studies in this area a high demand.

At the present time, majority of cell-phone manufactures are well informed about potential harm of wireless devices, but this information usually is not publically released. Data about radiation exposure of smartphones is hidden under the long menu list, making clients unaware of this subject, or creating public perception of insignificance of this issue. As an example, for Apple iPhone, this information can be found following menu commands: Settings-General-About-Legal-RF exposure. The similar long chain of commands have to be performed for other cellphone brands. Although the majority of cellphones are coming with information, which can be outlined as “do not keep it in your pocket next to your body without exceeding exposure”, this information is unseen by customers. On the other hand, very slowly, and in a majority of cases outside of the United States (such as in Europe, Australia, and in Israel), wireless providers have started informing their customers about consequences of inappropriate use of cellphones and exceeded EMF radiation. The main concern for public safety is that EMF radiation exposure must be significantly reduced.

A Few Words about Existing Standards, and not only …
The majority of current standards for wireless devices are based on outdated assumptions and data, staying unchanged for two decades. For example, in 1997, when the first standards for cellphones were established, a typical user was a male
military, medical, or business person, with approximate wait of 200 lb. Standards have been recommended to avoid heating of the head after six minutes of the cellphone call. At that time, the main concerns of cellphone side-effects were focused only on heat exposure. The current situation is significantly different from the communication market twenty years ago. It should be pointed, that majority of population has smaller heads, including women and youngsters. Old standards do not take into account that modern children are heavy users of cellphones, and their developing brains are under consistent exposure of harmful level of EMF radiation. Despite that, the one of the most growing communication markets is a market of wireless toys for young children (Devis, 2015).

A contemporary population of children are disproportionately affected by environmental exposures. In December 2012, the American Academy of Pediatrics released an open letter from its President Dr. Thomas K. McInerney, saying that the variances in bone density and the amount of fluid in a child’s brain compared to an adult’s brain could allow children to absorb larger quantities of RF energy deeper into their brains than adults. “It is essential that any new standards for cellphones or other wireless devices be based on protecting the youngest and most vulnerable populations to ensure they are safeguarded through their lifetimes” (American Academy of Pediatrics, 2012, p. 1).

Despite the intense changes in mobile phone industry and the associated social behavior, the Federal Communications Commission (FCC) has not revisited the standard for cellphone radiation exposure since 1996. The current FCC standards for maximum radiation exposure levels are still based on the heat emitted by mobile phones. These guidelines specify exposure limits in terms of the Specific Absorption Rate (SAR), which measures the rate the human body absorbs RF radiation. The current acceptable SAR limit = 1.6 watts per kilogram (W/kg) of tissue. Although wireless devices sold in the US must guarantee that they do not exceed the maximum allowable SAR limit, multiple concerns have been raised that longstanding RF exposure affects the brain and other tissues, and leads to types of brain cancer, including glioma and meningioma (The American Academy of Pediatrics. On the Cellphone Right to Know Act, 2012).

Communication Monopolies and Industry-Funded Research

At the present time, communication industries, which are often consolidated into local monopolies, strictly regulate pricing and customers’ choices leaving them with a minimum of control. It relates not only to the selected internet packages or cellphone services. The Telecommunication Act of 1996, also called ‘the most lobbied bill in history’, states in the Section 332(c)(7)(B)(iv) that the local government authority does not proceed on installation of new cell-towers. Obviously, any public health concerns about the effects of tower radiation cannot be sound to deny tower licenses as long as the towers comply with the regulations of the Federal Communications Commission:
No State or local government or instrumentality thereof may regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions [The Telecommunication Act of 1996, Section 332(c)(7)(B)(iv)].

After this act, industry had an open green light to install those facilities at more than 300,000 sites at any selected location, including churches, school yards and even trees. Alster (2015) has presented a clear documented evidence of a strong industry influence on the American Federal government with consistent lobbyist strategies of wireless market frontrunners: Wireless market leaders AT&T and Verizon work through the Cellular Telecommunications Industry Association (CTIA). But they also do their own lobbying, spending nearly $15 million through June of 2014, according to data from the Center for Responsive Politics (CRP). In all, CTIA, Verizon, AT&T, T-Mobile USA, and Sprint spent roughly $45 million lobbying in 2013. Overall, the Communications/Electronics sector is one of Washington’s super heavyweight lobbyists, spending nearly $800 million in 2013–2014, according to CRP data. (p. 4).

There is a valuable question to ask how the relatively low level of radiation of cellphone towers contributes to a public health? Historically, the main concern about RF emission relates to cellphones closely located to the head of a human. Since RF emission strength is proportional to the distance between the device and the head, some scientists have declined to talk about the likelihood of the direct health effect from the cellphone towers. “But this issue might be not so simple to solve. There is an increasing evidence suggesting that exposure to even low emission levels at typical cellular frequencies between 300 MHz and 3 GHz can have a wide range of negative effects” (Alster, 2015, p. 11).

Levitt and Lai (2010) compared the health condition of 530 people leaving within 300 meters from cell towers with the control group of participants who lived more than 300 meters away. The authors pointed that symptoms of nausea, loss of appetite, and difficulties in moving were as stronger as closer a person lived to the cell tower. Participants who lived closer than 100 meters, had significant depressive tendencies, loss of memory, and problems with concentration. Silvany (2012) raised red flags with similar questions, saying that “based on current available literature, it is justified to conclude that RF-EMF [electromagnetic fields] radiation exposure can change neurotransmitter functions, blood-brain barrier, morphology, electrophysiology, cellular metabolism, calcium efflux, and gene and protein expression in certain types of cells even at lower intensities” (p. 202). The author described cellphone towers effect not only on humans, but on other living organisms as well: top of trees were dried out facing directly the tower, birds embryos of fifty eggs were damaged after EMF exposure, as well as 32% of calves developed nuclear cataracts. Alster (2015) referred to his interview with Dr. Leif Salford, a former President of the European Association for Neuro-Oncology: “In the spring of 2000, Professor Salford told me that wireless usage constituted the world’s largest biological experiment ever” (p. 22).

At the present time, numerous medical professionals, engineers, and scientists (including experts in interdisciplinary areas) who are involved in research related health impact of wireless exposure raised important and even provocative questions about industry-funded (by wireless providers) studies. Typically those studies confirm null-hypotheses, such as “there is no effect” or “there is no correlation” between RF-EMF radiation and public health. Multiple studies, which report the alternative-hypotheses of “there is effect” or “there is a correlation”, often did not have (or lost) a required funding to continue their work in this area. Alster (2015) referred to the words of one of his interviewees: “There is no money to do research, and it is not going to come from government, because government is controlled by industry” (p. 28). Another reason that creates difficulty for deep quantitative research studies is impossibility of finding an appropriate population for the control groups, the people who do not use cellphones for a significant period of time, and do not live under any exposure of electromagnetic fields or wireless devices from any directions or facilities. The text below is a direct quotation from the book of Norm Alster (2015) published by Center for Ethics, Harvard University:

Dr. Henry Lai, emeritus professor of bioengineering at the University of Washington, has reviewed hundreds of published
scientific papers on the subject. He wanted to see how many studies demonstrated that non-ionizing radiation produces biological effects beyond the heating of tissue. This is critical since the FCC emission standards protect only against heating. The assumption behind these standards is that there are no biological effects beyond heating. But Dr. Lai found that just over half—actually 56%—of 326 studies identified biological effects. And the results were far more striking when Dr. Lai divided the studies between those that were industry-funded and those that were independently funded. Industry-funded research identified biological effects in just 28% of studies. But fully 67% of non-industry funded studies found biological effects (Insert Slide—Cellphone Biological Studies) (p. 20).

Huss et al. (2007) analyzed how the funding sources impact on conclusions and interpretation of the research results in studies related to health impact of cellphone usage. They noticed that “industry-funded studies were least likely to report a statistically significant results compared to studies privately funded, publicly funded, or funded with mixed sponsorship. Thus, interpretation of results should take sponsorship into account” (p.1).

Davis (2015) stated that despite good awareness of wireless providers about potential harm and health impacts of EMF exposure, governmental policies towards increasing safety standards are not purposively changed from 1996, because it will create a high financial risk for communication industries, facing future astronomical expenses towards compensations for public health harm. Dr. Devis makes a direct analogy between wireless and tobacco industry strategies. It took almost two hundred years for the government to put a label on a cigarette box about potential health damage.

**Wireless Population of Youth and Children**

In May 2016, Pediatric Societies Annual Conference (in Baltimore, MD) released a video file, called ‘Doctors Present Evidence of Wireless Radiation Impacts on Children'. Most distinguished specialists presented their opinions on contemporary changes of public health, and social behavior associated with aggressive wireless environment. One of the concerning issues is a dramatically increasing number of neurodevelopmental disorders such as Autism and Attention Deficit Disorder (ADD or ADHD) in children and adults.

According to Dr. Martha Herbert, contribution of electromagnetic exposure is a very important factor in autism development. Throughout the last decade, autism became a very common and expensive global disease to treat. During the same period, according to Dr. Herbert, there is an enormous increase of EMF exposure based on routinely used gadgets and internet devices. Chemical and molecular activity in brain identifies how the brain will generate its own electromagnetic waves. There is an evidence, that at the molecular and metabolic level Wi-Fi (and EMF in general) coming into interference with brain-generated waves can cause breakages in DNA and create mutations. It was reported that a certain percentage of autism patients have unusual mutations in DNA that their parents do not have. After mutations are generated, they can be carried out on subsequent generations. Dr. Herbert also indicates that after continuous EMF exposure, proteins and cell membranes are damaged and become stiff and more brittle. Thus, information channels in a cell do not work appropriately, and a cell became inefficient. Thus, people with autism can became worse, as well as wireless radiation can provoke autism (Pediatric Societies Annual Conference, 2016). Similar results were reported by Amen (2013), a neuropsychiatrist, and one of the most recognizable national experts in treating ADHD. Dr. Amen called Attention Deficit Disorder as a national health crisis that continues to grow, pointing out observable relationship between over-using of wireless devices (including toys and games) and increasing number of ADHD patients. As a result of a heavy wireless abuse, Dr. Herbert points out behavior problems, sleep difficulties, as well as problems with the whole entire immune system. “Underlined level of environmental vulnerability causes catastrophic healthproblems. Electromagnetic exposure (which documented in many studies) makes it worse. Our addictive care-free use of Wi-Fi all over the places is a main contributor for healthcare crises in US and in the World” (Pediatric Societies Annual Conference, 2016).

American Academy of Pediatrics has a stated policy recommending NO screen time for children under two years old. This
policy is based on two different considerations. First, on developmental impact: meaning that every growing brain needs interaction with parent to develop a critical bonding, which is a very important for the child in a sense of developing the sense ‘my-self’ and connections between people. When these parent-child relationships are threatened by the device, it immediately provokes aggression from the child towards parents: ‘you betray me for the device’. Returning to a critical question about updating safety standards, it remains a significant problem. Majority of the safety standards have been written two decades ago, and nobody ever dreamed that millions of toddlers would have access to internet sitting on a potty and playing those gadgets. For that reason, we need to recognize that 20-year-old standards are not adequate for the current settings and the devices we employ these days.

**Household Reduction of Exposure …at no cost…**

A few practical recommendations are presented below to reduce environmental impact of wireless devices. Those recommendations came from reviewing multiple online sources, as well as verbally communicating with medical providers: (1) reduce exposure during the nighttime. Unplug router and sleep without EMF interference. (2) For men, a very important factor is an avoidance of carrying cellphone in a pocket or near belt. The affected area is associated with sperm activity reduction, and possible DNA mutations. (3) For both men and women, avoid carrying a wireless device near chest and breast, since breast cancer is not only female disease. (4) Greatly limit exposure in children by decreasing a playtime with gadgets and Wi-Fi-connected games. (5) Eat healthy antioxidant diet. Melatonin (showing in multiple studies) is a good source to provide a needed protection. (6) Last but not least, we have to consider alternatives to wireless connections, such as wired internet without exposure to environment.

**Limitations of the Current Literature**

Based on the literature reviewed for this paper, there is a paucity of longitudinal studies on the health impact of RF radiation on humans. There is a serious need for more longitudinal research, thus, the effects of longtime exposure to Wi-Fi signals on human health can be studied. Main reasons of the absence of longitudinal studies, the authors of this paper refer to the absence of appropriate independent funding, and difficulty of finding a population of non-Wi-Fi-users that might serve as control groups.

**Conclusion**

In today’s world, technologies based on transmission of radio frequencies, such as Wi-Fi, have multiple applications in many sectors of industry, science, medicine, military, and education. However, multiple studies report that those new wireless discoveries have potential negative effects on biological processes in human bodies, as well as brain activity, and even emotional state. With the purposes of creating public awareness and creating a baseline theoretical framework for future research, the authors have addressed provocative questions related to the impact of RF, wireless radiation and electromagnetic fields on public health. This paper looked at few interconnected topics, such as (a) existing standards for electromagnetic field (EMF) exposure; (b) effect of wireless radiation on brain, specifically for most vulnerable population of children and youth, and (c) a very complicated topic of ‘industry-sponsored’ research, and lobbyist attempts in the US government allowing main wireless market-players (such as AT&T, Verizon, and others) to control pricing, standards, and content selection, leaving customers without alternative choices.
References


Developing Effective Visual Representation Schemes to Improve and Measure Student Skills in Circuit Analysis Education

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Abstract
Analytical skills are important for student success in STEM (Science, Technology, Engineering & Mathematics) education along with verbal and spatial skills. However, developing analytical skills is challenging and requires considerable effort and instructional support at college level Electrical Engineering. Many major engineering principles are based on fundamental laws of physics, and most typical engineering textbooks begin with an introductory pictorial representation of relevant physics. The pictorial representation then converts to functional relations among multiple circuit parameters such as voltage, current, magnetic flux, etc. The functional relations are then summarized as formulae for problem solving procedures. Students, however, often get lost during the transition from pictorials to mathematical representations and have difficulty applying formulae to new engineering analysis tasks. It is of critical importance to help students build a strong connection between pictorial analogies and mathematical abstractions. This paper demonstrates an exploratory effort to develop a software tool to investigate the following research questions regarding the effects of representation schemes on students’ analytical skill improvements in electrical circuit analysis: 1) Does the visualization of animated electron flow or change of electric potential (i.e., at physics-level representation) of a given circuit enhance students’ understanding of circuit analysis? 2) Do graphical representations of current and voltage profiles over time (i.e., at engineering-level formula representation) enhance students’ understanding of circuit description in functional format? 3) When does the transfer of knowledge occur between physics-level versus engineering-level understanding, and with what kinds of representation schemes? Do students’ analysis skills improve if they practice more with multiple representations? For such investigation, we developed a Java-based GUI software tool that interacts with students by providing multiple layers of animated representations of circuit behaviors. The software also assesses students’ circuit analytical skills. The software’s instantaneous feedback regarding student performance is expected to motivate students to master analytical skills and support the instructor with empirical data.

Introduction
The National Science Board (2010) asserts that mathematical/analytical skills are required for success in STEM education, along with verbal and spatial skills. Rigorous analytical skills are indeed considered some of the most important aspects of college level learning in the field of engineering technology. However, developing analytical skills is challenging and requires considerable effort and instructional support. Engineering technology is a complicated subject matter; many engineering principles are based on diverse laws of physics (Feltovich & Glaser, 1981). Typical engineering textbooks (Floyd, 2012; Razavi, 2014) often begin with introductory explanations of relevant physics with pictorial descriptions as representations. The initial representation serves as a building block to describe the characteristics of the engineering systems that follows. The textbook’s representation scheme quickly shifts its paradigm from simple pictorial description to graph representation of engineering characteristics and to more rigorous mathematical derivation.

Figures 1 shows an example of a diode model (Razavi, 2014) represented in a pictorial analogy. The diode is a unidirectional device depicted as a water pipe with a valve system. When the current flows in the Reverse Bias mode, the valve closes and blocks the current flow. When the current flows in the Forward Bias mode, the valve opens and the current flows freely. Figure 2 shows a relevant V-I characteristic curve of a diode. The plot region between A and B corresponds to the Forward Bias mode.
and the current increases rapidly. The plot region between C and the origin corresponds to the Reverse Bias mode and the current is almost nonexistent. This graph is used for Equation 1 and describes the formula for conductance G and resistance R in terms of the current change and voltage change in a diode circuit.

It has often been observed that students get lost during the transition from the pictorial to the graph and to the mathematical explanation, and often, students simply try to apply memorized formulae to new engineering analysis in a blind manner, often in vain. Why is it difficult for students to achieve the transition? One explanation is that students do not have the skills that last and systematically transfer to new tasks (Tomic & Kingma, 1996).

Multiple Representations

It is important to help students build a strong connection from the pictorial analogy to the mathematical abstraction (Gentner, 1983). Students should build and elaborate a 'big picture' view that holds multiple layers of representations (Fischer, 1980) for the fundamental physics principles and the applied engineering practices. One way of providing such support has been laboratory practices (Buchla & Wetterling, 2011) guided by an instructor according to an 'experiential learning' pedagogy (Kolb, 1984). Hardware-based labs are often supplemented with simulation-based labs (Brauer, 2008), and commercially-available computer simulation software tools (e.g., 'NI Multisim') have been used actively in engineering labs. Many studies show that hands-on experience has measurably enhanced students' learning outcomes significantly (Brauer, 2008; Haden et al., 2009; Pablo, 2012). Most educational simulation tools are, however, simply a learning tool to supplement the traditional

\[
G = \frac{1}{R} = \frac{\Delta I}{\Delta V} \quad \text{Equation 1}
\]
lectures and hardware labs on site. For evidence-based education, an integrated tool that can simultaneously teach and assess students’ analytical skills is needed.

**Pedagogical Design**

Many traditional assessment methods in engineering education are focused on student performance as a result of learning. A review of the pertinent literature indicates there are few, if any, methods of assessment that focus on the process of learning. This paper addresses the need of investigating the process of learning. We propose an approach that can shed a light on evidence-based education in engineering domain and provide some clues about what kind of a representational scheme is effective to support students’ learning.

The proposed overall system diagram is depicted in Figure 3, above. In this evidence-based education session, students participate in a pre-test, simulation practice, and post-test activities in a serial manner regarding a course topic. The purpose of the pre-test is to assess students’ pre-existing level of knowledge regarding the topic and is used as a baseline for comparison. The simulation practice is used to support student learning according to ‘learning-by-doing’ pedagogy. The simulation function supports several visual representation schemes, depending on the needs of the instructor. Different levels of richness in circuit-behavior representations can be selected during the simulation practice. It is expected that richer representation will enhance learning. The post-test is used to assess learning achievement after the simulation practice. The post-test uses slightly modified versions of the circuits from the pre-test. The overall transition is managed by the software configuration and control unit hidden behind the GUI frontend.

The conventional criteria used to assess student learning is the hit rate of the student’s answers to problems. In addition to the hit rate, the reaction time of the student’s answer after the exposure of the given question is utilized. The rationale is that as the students learn the topic, they will answer quicker, as well as more accurately. It is also proposed to measure the student’s preference of visualization types provided to assist student learning. Pre-assessment, simulation, and post-assessment functions are integrated into a unified software. Instructors can select the topic of circuit analysis by modifying the input configuration file. They can also control the overall operation of the overall session by changing the input control file. The question and answer options are determined by an input questionnaire file. These three files comprise the input files for the system. The student’s actions such as answer choice, reaction time, and visualization preference are recorded as the output user-data file. All files are encrypted to protect user privacy and to guard against data compromising.

**Implementation**

In this paper, an exploratory effort to develop a software tool that facilitates and assesses students’ analytical skills in the context of electronics engineering is described. A software program that can be used as an evidence-based education tool to simultaneously support students’ learning and assess their performance in analog electronic circuit courses is developed. The software can provide students with different kinds of representation schemes regarding circuit operation and can also assess
students’ performance by asking questions about the circuit analysis. Students’ reaction time, their answer choices, and their preference of circuit representation styles are recorded and analyzed by the software to provide the evaluator with evidence-based assessment data. The software is written in Java language and incorporates the circuit simulation engine from (Falstad, 2014). The new contribution from this study includes the addition of the ‘pre- and post-test engines’ and ‘configuration & control logic’ described in the Figure-3 caption. Pedagogical discretion of engineering education is also reflected in the design of the software.

A student takes the pre-test for circuit analysis using a static display in assessment mode shown in Figure 4. The questionnaire file used in Figure 4 displays: Question: Calculate the maximum and minimum voltages measured at the node between the load resistor R and the diode D. V = 5 VAC (10 Hz), R = 100 Ohms, D: silicon diode. After submitting your answer, Simulation will be available. Choose the closest answer.

The questionnaire file also displays the Answer Choices: “max: 5, min: -5 Volts [tab] incorrect [tab] max: 5, min: 0 Volts [tab] incorrect [tab] max: 4.3, min: -4.3 Volts [tab] incorrect [tab] max: 4.3, min: 0 Volts [tab] correct.” The answer format syntax that is similar to that used in the Blackboard Learn (Blackboard Learn, 2016) multiple-choice script is used. Once the students submit their answer of choice, the software automatically corrects it by comparing it with the simulation results and saves the student’s grade.

The assessment mode disables circuit simulation until the student chooses an answer and submits it. The reaction time and score are also recorded in the user data.

The simulation engine is based on the SPICE (Nagel & Pederson, 1973; Nagel, 1975) algorithm with the circuit schematic represented by the netlist syntax. The visualization of circuit behavior is provided to the student user during the simulation after the student submits their answer. The visualization in the simulation has three modes, and the instructor can choose the sequence of simulation modes. Simulation mode-I in Figure 5 visualizes the change of voltage polarity over time in each circuit component. Simulation mode-II in Figure 6 adds to Simulation mode-I, the visualization of the oscilloscope waveform profile of circuit components. Simulation mode-III in Figure 7 adds to Simulation mode-II, the visualization of the current flow along every branch of the circuit.
An example of how this software works is that a student goes into 'Simulation mode-I' after the pre-test. The display visualizes the voltage changes of circuit elements over time to support student learning. After the pre-determined duration of the 'Simulation mode-I', the student takes a post-test with an equivalent circuit. The post-test uses the assessment mode that displays a new circuit of the same category with element values randomly modified within tolerance range.

The instructor can adopt a different simulation mode (i.e. 'simulation mode-II'), as shown in Figure 6. The Simulation mode-II provides oscilloscope wave forms of voltage and current that are probed at selected elements of interest. This mode is richer in information and provides the student with a more dynamic display. After the pre-determined duration of Simulation mode-II, the student takes another post-test.
There is another option for the simulation (i.e., 'Simulation mode-III'), as shown in Figure 7. The Simulation mode-III adds the visualization of current flows through all circuit elements to the Simulation mode-II. This mode is the richest environment for simulation in the current stage of this paper. Another post-test follows the Simulation mode-III.

For an additional example of circuit analysis that can be developed with the software, refer to Figures 8 and 9 for a bridged full-wave rectifier circuit. Notice that the animation of the current flow in 'Simulation mode-III' is particularly effective to describe the behavior of the individual diodes (i.e., closed or open state) in the complex circuit.
The new questionnaire describes Question: “Calculate the peak output voltage measured at the load resistor. $V = 5$ VAC (40 Hz), $R = 100$ Ohms, D: silicon diode. After submitting your answer, Simulation will be available. Choose the closest answer. [10 points].” Changes of the input files generate different circuit schematics and question/answer pairs.

**Discussion and Research Questions**

The original simulation tool by Falstad has been used in a Circuit Analysis course and an Analog Electronics course for circuit visualization purposes before the current revision in this paper was made. The original tool does not have any function for data collection. Students showed more attention and motivation when the lectures were made with the simulated demonstration than without it. Our observations indicated that the animated demonstration of circuit behavior helped students gain insight on the overall circuit mechanism. However, it was also observed that the instructor’s step-by-step intervention and structured explanation are still necessary when the simulation is presented. This is because the simulation tool requires knowledge on how to use it and how to interpret its output, which is not established yet in the students’ learning process. It is expected that students will build such knowledge as they study related course content while practicing with the tool. The following research questions motivated the current study to modify the simulation software to an evidence-based education tool to support and assess student learning:

**Question 1:** Does the visualization of animated current flow or change of electric potential (i.e., at physics-level representation) of circuit behavior enhance students’ understanding of circuit analysis?

**Question 2:** Does graph representation of current and voltage profiles over time (i.e., at engineering-level formula representation) enhance students’ understanding of circuit description in a functional format?

**Question 3:** When does transfer of knowledge occur between physics-level versus engineering-level understanding with different kinds of representation schemes? Do students’ analysis skills improve more if they practice more with multiple representations?

Analytical skills in Electrical Engineering require acquisition and understanding of the strong bond among the multiple representation levels. The developed software was designed to emphasize and strengthen the relations among the representations and to motivate students to gain such understanding.

**Future Research**

There are much more questions that must be addressed for this research. Again, the main objective of this paper is to propose a framework for developing an evidence-based education tool for circuit analysis courses at university level. Our future research will include experiments and observational studies to investigate the effect of the proposed framework and software tool, compared with the effects of traditional lecture- and lab-based instruction, on student learning in circuit analysis courses. Another future research will be associated with pedagogical strategies to facilitate the transfer-learning among the multiple representations employed in engineering problem solving. No matter what technology is integrated into teaching and learning, proper pedagogical strategies are essential in facilitating student engagement and empowering student learning.

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References


Performance Analysis of Stand-Alone Hybrid Energy Systems in Rowan County Kentucky

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Abstract
Climate change, high operating costs on established energy sources and increased energy demand are motivating factors driving the development and use of renewable energy sources. Solar, wind and storage systems are fast becoming sustainable alternatives with potentials to satisfy the load demand of the future. However, single renewable sources have time-varying characteristics without the potential to meet the energy demand over a year, hence the hybrid energy systems become even more desirable.

To expand the use of renewable energy system, it is important to optimize the energy production at a municipal level by combining the different mix of renewable energy sources. This paper presents a performance analysis for modelling, configuration and sizing of standalone hybrid system consisting of wind turbine, photovoltaic (PV) and battery storage for ten homes in Rowan County community, Kentucky. The average home in Rowan County has an estimated average load of 30KWh/day, 1,500KWh/day for the 50 homes. This study aims to evaluate and optimize the performance of hybrid system in the region using Matlab/Simulink Analysis.

1.0.0 Introduction
Our environment has been grossly affected by uncontrolled greenhouse gas emission majorly from fossil fuel combustion. This according to IPCC will raise the concentration of carbon dioxide to 1000ppm and will end in a 4oC or 7oF by 2100. The unchecked effect of our actions can create major trouble to economic and social activities and could be difficult or unbearable to reverse the effects.

However, investments on renewable energy has been very significant within the last decade with alternative and renewable energy taking center stage in delivering safe energy for the future. Chiefly among the reasons are they are now cheaper to install, scaled down for standalones and are more sustainable when combined as hybrid systems. Since the common disadvantage of both wind and solar power plants are that the power they generate are unreliable, hybrid system solves this by incorporating different renewable energy sources to improve the reliability of power.

Using hybrid energy system is important to local communities like Rowan county because renewable energy sources are widely distributed in low densities and has a potential to maintain the green nature of the county. However, to achieve the stability in supply from the efficient, low emission hybrid system, battery storage backups will be needed to maximize the output from the wind turbine and solar energy. The available renewable energy from solar irradiation and wind speed will be used to analyze the model for reliable, feasible, safe and less expensive energy system for Rowan County community.

1.1 Objectives
1. In this paper, design schemes of hybrid system comprising solar, wind, storage and natural gas generator is discussed. It includes annual data resources of solar irradiance and wind speed for Rowan County.

2. The study use Matlab/Simulink model to observe the behavior of the available energy source

1.2 Statement of the Problem
Rowan County, an eastern region in Kentucky is a class 1 zone in the solar-wind resource needed to generate renewable energy. This paper is geared towards the design, optimization and simulation of a hybrid energy system using the available
data. The research will solve the following questions: What is the feasibility of hybrid renewable power system in Rowan County, Kentucky? What mix of the hybrid system is needed to meet the energy demand?

2.0 Model Development

2.1 Rowan County, KY Overview

The Appalachian community of Rowan County Kentucky is on the eastern part of Kentucky. The community is surrounded by hills, some which are flat and are ideal location to put wind turbine and solar panels. The population of the community totaled 24,451 (2016 Census Estimate), and a residential household of 8,5423.

2.2 Energy Demand

It is assumed in this paper that the boundary of energy demand is limited to household energy consumption in the Rowan County Community. This assumption was made because the electricity consumption demand data is not available, hence the electricity demand for a household is got by adding up load used in a house and multiplying by number of houses in study 4.

2.3 Potential Hybrid Energy Supply

Renewable energy is increasingly embraced because our environment needs to be protected and increased electricity demand need to be met. The harmony that exists between solar and wind energy resources, makes them suitable for sustained power generation5. Occasionally, wind and sun are not present at the same time which gives the hybrid system significant advantages over singular system of either solar energy system or wind. First, greater reliability of the system and second is the possibility of a compact battery storage size.

2.3.1 Wind Turbine

There are several types of wind turbines used for electrical systems depending on the size and use, as standalones or connected to the grid. Large turbines are typically between 10 kW to 500 kW6, uses induction generators and requires to be matched to the frequency network it will be connected to. Smaller turbines on the other hand with suitable controls uses converters to operate the DC or AC loads.

The wind turbine operates by using its propeller to capture the wind’s kinetic energy which can later be converted to mechanical power or electrical power. The generator uses the turning motion of the shaft to rotate a rotor which has oppositely charge magnets and its surrounded by copper wire loops7. The electromagnetic induction created inside the spinning core generates electricity.
Wind generation of electricity places an unusual set of requirements on electrical systems. To produce electricity from generators, a constant torque is required, but the wind is usually uneven. The turbine operates at a very high aerodynamic and electrical efficiencies to squeeze out every kilowatt-hour of the available resource.

Figure 1 Output Power of Wind Turbine at different Wind Speed

The US department of Energy and the National Renewable Energy Laboratory (NREL) published wind resource maps for the United States and Kentucky. This map figure 2, highlights the air density above 50m sea level. Above 50m, the wind speed in Rowan County is between 0 and 12.5 mph, a class 1 wind that is poor to rely on. However, air density alone is not the only desired factor in citing a wind turbine. Wind speed, the model of the turbine are other desirable factors are to be considered.

Figure 2 Kentucky Wind Map above 50m

2.3.2 Solar Energy

Energy from the sun is abundant and the radiation from it can be converted to generate electricity from doped semiconductors (Silicon). The solar irradiance is the intensity of electromagnetic radiation incident on a surface of 1 square meter (KW/m2).

Power from the solar panels are controlled using an inverter and an LC filter circuit. To get maximum power from the PV module under any condition, the maximum power point, MPPT technique is used. The MPPT calculates at every instant the values of Voltage and Current where the maximum power will be available and adjust to the varying load demand.
Standalone PV plant like the one shown in figure 3 below has a DC power source which can be used directly for DC loads through a separate DC bus or stored to be converted for direct use. It can also be used with dedicated inverter for larger power systems that will use AC power source.

\[ I = I_{ph} - I_n - I_m \]

\[ I = I_{ph} - I_0 \left( \exp \left( \frac{qV}{nkT} \right) \right) - \left( \frac{V_o}{R_i} \right) \]

**Power output of Solar cell is, \( P = V \times I \)**

Estimating the size of the solar panels will require us to know the annual demand, average solar hours and the de-rate factor. The de-rate factor is the influence of environment on the efficiency of PV system, it is calculated by the percentage of available AC energy compared to the DC rating of the array. The NREL list the following as de-rate factors that can affect the efficiency of the system, they are PV module and nameplate DC rating inverter and transformers, mismatch, diodes and connections, DC wiring, AC wiring, soiling, system availability, shading, sun-tracking and age. The de-rate factor considered for this paper is 0.75 for all the Rowan county community.

\[ P_s = \frac{E_L}{365 \times S_H \times D_F} \]

Output power from a PV system is where \( E_L \) is the annual load demand (kWh), \( S_H \) is the peak average solar hours per day, and \( D_F \) is the derate factor. The equation is used to get an approximated value for PV sizing. Other factors like the efficiency, based on location and the hourly variation of temperature and solar flux are considered during the simulation.

### 2.3.3 Battery Storage

Battery storage is very common to hybrid power system, especially smaller systems. Although the larger system with isolated AC networks uses it too but they are usually used to smoothen out power fluctuation. However, in smaller systems especially in hybrid system set up, it is needed as a buffer and back up to use when the two main sources are not available for direct use. The size of the battery is dependent on the excess energy generated by the combination of the two sources such that the
battery can store the excess energy, and utilize when needed. In hybrid system where the wind and solar PV are coupled together, the battery storage should quickly respond and neutralize change in the output power from the wind or solar system. A ramp rate control is installed with the coupled system to even out the variation. The battery storage system uses a controller that determines the state of charge (SOC) of the battery cell, and prevent them from operating out of specification.

In choosing the size and type of battery, these factors are to be considered; discharge rate, nominal capacity, cell stack lifetime, energy density, charge or discharge density, maintenance factors, cost, round trip efficiency, life cycle and compactness. For instance, high discharge rates are achieved by Lead-Acid batteries while Nickel Cadmium has minimal maintenance.

2.3.4 Converters

DC outputs from either of the PV panel or Wind turbine need to be converted before it can be used with AC networks or AC loads. Alternatively, AC supply need to be converted to DC components for storage on DC loads. The two types of power conversion significant to hybrid systems include rectifiers and inverters. They are sometimes embedded into one single device or assembly; some other times they are not. Inverter converts DC to AC power and are used to supply AC loads from a DC source. Rectifiers convert AC to DC power and are commonly used to charge batteries from AC source. They are cheap, simple, and efficient devices.

2.3.5 Natural Gas Generators

The presence of natural gas generators is to ascertain that at any time, the availability of power is 100%. When batteries are running low as a result during times when there the solar cells or wind system are not producing, the generator can come in handy to recharge the batteries, or serve as back up for the battery. Since the generator is natural gas powered, there is a considerable low greenhouse gas emission that will be expelled to the environment, making the hybrid system sustainable and environment friendly.
3.0 Methodology

This chapter analyzes the load compared to the data obtained from the natural renewable sources, solar and wind speed, design the component and configuration of the system and identify useful optimized model.

3.1 Collection of Data

3.1.1 Collection of Wind Speed Data

<table>
<thead>
<tr>
<th>Month</th>
<th>Wind Speed (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>5.622</td>
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<tr>
<td>February</td>
<td>5.638</td>
</tr>
<tr>
<td>March</td>
<td>5.601</td>
</tr>
<tr>
<td>April</td>
<td>5.500</td>
</tr>
<tr>
<td>May</td>
<td>4.432</td>
</tr>
<tr>
<td>June</td>
<td>4.218</td>
</tr>
</tbody>
</table>

3.1.2 Collection of Solar Radiation Data

<table>
<thead>
<tr>
<th>Month</th>
<th>Clearness Index</th>
<th>Daily Radiation (kWh/m²/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>0.435</td>
<td>1.996</td>
</tr>
<tr>
<td>February</td>
<td>0.461</td>
<td>2.746</td>
</tr>
<tr>
<td>March</td>
<td>0.494</td>
<td>4.006</td>
</tr>
<tr>
<td>April</td>
<td>0.545</td>
<td>5.320</td>
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<tr>
<td>May</td>
<td>0.530</td>
<td>5.860</td>
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<tr>
<td>June</td>
<td>0.555</td>
<td>6.430</td>
</tr>
<tr>
<td>July</td>
<td>0.552</td>
<td>6.236</td>
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<tr>
<td>August</td>
<td>0.540</td>
<td>3.280</td>
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<tr>
<td>September</td>
<td>0.553</td>
<td>4.700</td>
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<tr>
<td>October</td>
<td>0.526</td>
<td>3.420</td>
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<tr>
<td>November</td>
<td>0.464</td>
<td>2.260</td>
</tr>
<tr>
<td>December</td>
<td>0.428</td>
<td>1.780</td>
</tr>
</tbody>
</table>

3.1.3 Battery

By using batteries to deliver energy captured from the sun and the wind in a consistent and reliable form, renewable power enthusiasts will not be left dependent on the whims of nature as they attempt to leave the electrical grid behind them.

3.2 System Component Part

The hybrid system model is depicted in figure 4. It contains the two renewable sources, solar PV and wind turbine and a generator in the supply and the consumer load in the power output. In addition, AC – DC rectifiers and regulators are installed to convert, smoothen and regulate the DC output from the Wind turbine, PV and Generator. Also, a lithium-ion bank battery of 260kWhr is installed to store power and deliver when needed.
4.0 Results and Discussion

The systems were found to be functional with the model in Homer, 1500KW house can be effectively powered by the hybrid mix, with a reasonable battery system. Although the economics is left for a future research, however, the sizing of the system is explored with the available data. The data resources are plotted for the wind and solar in fig 5, and fig. 6. It can be observed that the wind resource in this region is average 5m/s which classified Rowan county as a class 1 area, with a poor wind rating. It can also be observed that the wind deficiency can be compensated for with PV as they alternate in values during the year. It can however be observed that the load demand throughout the year will be fulfilled.
Simulation

The complete hybrid system design is simulated using Matlab/Simulink and Simscape Power system. The hybrid system allows maximum utilization of the available sources by making use of the adaptive MMPT algorithm in the system. With this set up, the two sources used supply the load separately or simultaneously based on the source availability. While the wind power is determined by the speed of the rotor, the solar panel depends on the sun's intensity.
Conclusion

Energy and power system is an integrated part of our lifestyle; hence a sufficient and reliable source is needed. Hybrid energy system is an excellent choice in providing electricity especially on off grids. Furthermore, the challenge of reliability based on time-varying characteristics on single renewable system makes hybrid more desirable. In this paper, a hybrid standalone system was designed and simulated for households in Rowan county community. The design was optimized for the resource data (wind speed and solar), because of the renewable energy source, the output is titled towards the availability of solar energy, as the wind power is not an effective source.

Reference

Etcher Z-Axis Adjustment

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Introduction and Background
This etcher as shown in Figure 1 is a commonly used piece of machinery at B & H Tool Works, Inc in Kentucky. It gets used multiple times a day and costs around $7,000 to buy new. One would think that the manufacturer of the etcher would include some type of adjuster to make this expensive machine do its job better.

The etcher is frustrating and somewhat difficult to adjust in the Z-Axis. The etcher head weighs approximately 15lbs. This causes fatigue in the operator’s limbs while trying to adjust the height of the head. If a person had three hands, this operation would be much easier and simpler.

The idea behind this new process is that one can do the adjusting with only one hand and little effort.

How can the etcher be adjusted easier in the Z-Axis? Few have tried to fix this issue, and those few have run into some problem or another. One tried a gearing system; another tried a worm gear type system. They all ran into the same problem- the screws that attach the etcher head to the upright hold the head too tight which causes the gears to strip out.

The scope of this project is to overcome what others have failed to achieve and to prove that there can be a mechanism to easily adjust the height of the etcher head designed and manufactured. This project is expected to increase speed, decrease aggravation, and decrease fatigue when attempting to operate and adjust the etcher.

Idea Development and CAD Design
Research

During the research process, it was found that there were two types of gears that could be used (Mayuram, 2000). The two options were a spur gear and worm gear. These two types of gears should work well with the application. The great thing about the worm gear is that the block that the head is attached to doesn’t have to stay still in the X and Y-Axis. With the spur gear, the block can move in X and Y-axis very little. If the spur gear is used, tolerances will have to be kept very tight. With the worm gear things can be kept quite open. The worm gear is by no means a new development. The worm gear has been around for a long time and is used in many common applications such as drivetrains in automobiles, conveyer belts, elevators, lifts, and many, many more. The great attribute of worm gears is that they have their own locking mechanism. In many applications a brake won’t have to be added to the design, just as the design for the etcher won’t. The way the worm gear is designed such that power can be transmitted into the primary shaft to turn the secondary, yet the secondary shaft can’t turn the primary. This works well for the etcher application to avoid having to design a locking mechanism (Kota, 2001).

Material Selection

Ultra High Molecular Weight Polyethylene (UHMW)- The UHMW was selected due to the slick and tough properties of its surface (Richardson, 1989; Strong, 2006). UHMW is a material that B&H uses often. One of the great characteristics of UHMW is that it is quite slippery, often times UHMW is used for conveyer belt applications due to the slipperiness of it (James A. Jacobs, 1997). The slippery material will allow the etcher head to slide vertically without hanging up. This material will work as a bearing, and avoid using expensive bearings. UHMW isn’t new; it is a material that has been around for years. It is easy to machine and is quite affordable. The dimension of slide is shown in Figure 2.

Ball Bearings- The 1/4” Shaft Diameter, 7/8” OD bearing was chosen to be used because of the small size and being sealed bearings would never have to be greased or oiled. The drawing of ball bearing is shown in Figure 3.
Aluminum Block- The aluminum block was chosen because of the ease of machining of the aluminum as well as the weight (mazurek, 2012). Aluminum is strong enough to withstand the small amounts of torque applied from the bolts while still being light enough in weight that it wouldn’t affect the sliding of the block. Isometric view of block is shown in Figure 4.

6"-13 All Thread Rod- The All Thread Rod as shown in Figure 5 was chosen because it would be more efficient to buy the rod than to spend the time designing and machining a threaded long rod.
CAD Results
The design process worked out quite well with few problems. The only problems that arose were from the bolts that attach the etcher head to the upright. The other issues that arose were that of the UHMW being so thick that it changed the Y-Axis. This is not a good thing, because the head can’t be moved easily. If the Y-Axis 0 is moved, the 0,0 will not be the same in relation to the vise that holds each part that is being etched. The final assembly is shown in Figure 6, and orthographic drawing of each part is shown in Figure 7, Figure 8, Figure 9, and Figure 10.
Motion Analysis

After final assembly done which is shown in Figure 11, the motion analysis is performed using SolidWorks. The Motion Analysis turned out quite well. The major problem that arose was getting the screw mate to work out the first few times. Once this issue was overcome, everything seemed to work out well. There were no interference problems with any bolts not lining up, which was somewhat of a surprise. Most of the time, the design process has to work around the problems of holes not lining up or having some type of interference with bolts. The video of motion study is posted in the following link: https://www.youtube.com/watch?v=on6Fccceb0c

Machining

A Proto-Trak Milling Machine was used to machine all materials. The Aluminum Block was machined on a Proto-Trak.

The machine operation video is posted in the following link: https://www.youtube.com/watch?v=CK1esTNyJuQ
Conclusions and Future Work
All of these materials machined quite well and most operations moved quite well. There was quite the holdup on the manufacturing process, which slowed the project down significantly. Once the design process was completed (which took longer than expected), the drawings were completed such that all the components could be ordered and machined. The final revised etcher works well as expected as shown in the video. Many appreciations to Mr. Poynter, Mr. Estep, Mr. Smith, and Mr. Williams for their knowledge support. The further design of this project is automation control. And authors will work with Network professor Mr. Chandra to design and perform the electric part.

Reference
Modeling and Improvement of Transmission

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Acknowledgement
I want to express gratitude to all who have provided me the opportunity to do and complete this project. A special thank you to my instructor, Dr. Ni Wang, whose contribution to the success of this project in terms of suggestions, guidance and encouragement, helped me complete this project and in writing this report of the findings.

Furthermore, I would like to express my appreciation to my family and friends. With their help, I could complete this project. A huge thank you to my father, Jeremiah Davis, and my grand-father, Will Davis for their constant guidance in showing me just how exactly things work underneath the seat of a tractor. Without them and their knowledge of the machinery, none of this would be possible. I would like to thank the faculty and staff of the Applied Engineering and Technology Department here at Eastern Kentucky University and their constant suggestions and allowing me to use the appropriate materials and software necessary to complete this project.

Abstract
The intent of this project is to determine if increasing the number of teeth, the width or pitch diameter of a spur gear in a 1958 Oliver Super 99 diesel tractors transmission is beneficial to the tractors frame or if the torque will be too strong and the frame will give. Tractor pulls in the late 1980s and early 1990s used to be about how far a tractor could pull a weighted sled down a dirt track. Now, tractor pulls have become how fast teams or individuals can get their initial wheel speed. Using SolidWorks, mostly with the ToolBox function, a similar version of the original transmission will be created, assembled, and put through a motion analysis. After this is completed, a re-creation of the transmission will be made, but this time with a larger spur gear, resembling the increased tooth count and overall size of the gear. The same motion analysis will be conducted along with calculations of torque for both simulations.

Before any creations can even begin, research must be conducted. The original transmission must be looked at thoroughly to get an accurate count of the tooth count and pitch diameter which will take about one to two weeks. Next comes the making in SolidWorks of the original and improved/adjusted transmission. Here is where the creation of the gears, shafts, and the placement of the gears will take place. Mates for this project are complex, so every little measurement counts. This process will take three to six weeks. Combined with the creation step is the motion analysis step. This step will require the mates to be accurate so the transmission simulations will run properly. If not, then the simulation will fail. This step will take one to two weeks. Next is the calculation of the torque. Using a website to first find the actual amount of torque that is originally emitted from the transmission and then finding the amount emitted from the improved model will be done through SolidWorks which will take one to two weeks.

Introduction
Tractor pulls in the 1980s through the early 2000s were all about how far an old, antique tractor could pull weighted sled down a dirt track. No one was worried about placement, just about what the tractor could do. Now, tractor pulls are no such thing. Tractor pulling teams now have succumbed to putting larger and larger gears into the transmission of an old tractor, making it gain more wheel speed and torque along the way. Why do teams do this type of thing to ruin a perfectly good tractor?
In the engineering field, especially from the automotive side of things, transmission science has become a large part of the schooling for future technicians and engineers. If someone knows how a transmission works and where to place everything, making sure it runs correctly “in theory”; then a job is right around the corner. With tractors, it is the same concept. It takes many hours and lots of science to place everything correctly.

The question that troubles many people is, “How much more torque is added to the tractor when a larger gear is added?” or “How does adding one or two more teeth to a gear help with wheel speed on take-off?” That’s what is going to be found out in the project. By creating an original model of an Oliver Super 99 diesel tractors transmission, then, recreating that same model with a larger forward and reverse gear and finding the difference in horsepower and torque. With the creation, simulation, and calculation, the question that has bothered farmers across the nation will be answered, why do people add teeth or increase the overall size of a gear to increase the speed on take-off and torque throughout the frame of a tractor? And how is it beneficial to the team or individual in the long term?

Background Theory

The Applied Engineering and Technology concept of Computer Aided Drafting and Design is used throughout this project. The software used in this project is SolidWorks. SolidWorks allows for different variations in sizes of gears in the ToolBox function. The ToolBox function in SolidWorks has all types of different objects used in daily life, such as screws, nuts, bolts, etc. Along with this, the ToolBox can change the color of any object, much like painting.

SolidWorks is used throughout the courses in the Applied Engineering and Technology department to teach students how 3D modeling is done. The first course is a beginner course in what SolidWorks is, how it is used, where it is used, etc. What happens is students learn how to design different objects in a 2D sketch, then extrude into a 3D model, along with going back into the sketch and make changes where necessary. The next level is about learning the motion study part of SolidWorks, mostly about how to do different scenarios. The main project wanted to be completed is how to 3D print different parts for an automotive vehicle. The last level of the course is the advanced course where to same concepts from the previous level course are still used, however, the level of difficulty increases. The class teaches students about gear mates, how to set up gears so they can run properly, which is what this project is about.

After hours and hours of learning and training, a person can become certified in using SolidWorks. Becoming certified in this software allows an individual to use the software in many job applications. SolidWorks proves to be a vital software for the 3D imaging process many companies use now.

Methodology

Research

The first step is an accurate count and measurement of the transmission gears. For an Oliver Super 99 diesel tractor, made from 1957-58, there are six (6) forward and two (2) reverse gears (tractordata.com). The average horsepower from the PTO (Power Take-Off) shaft for this tractor is 80, so, by using spicerparts.com, a horsepower to torque calculator website, an accurate calculation will be given in the torque amount from the original transmission. From tractordata.com, the website will give all the information needed to become accurate with the project development.
As shown in Figure 1 and Figure 2, these are overhead pictures of the original transmission with the main forward, reverse and pinion gears. The cover was taken off so the gears could be shown. Along with this, the tractor itself had to be lifted off the ground for the wheels to turn, allowing the gears to rotate to get an accurate count of the teeth. Without this, the tooth count could be skewed. Rotating the tires to get the count of teeth and to see how the gears worked with each other, really made a difference in the creation.

**Creation**

There will be two models created in this step, one being the original transmission and the second model is an improved/adjusted version of the original with a larger forward and reverse gear. The improved forward and reverse gear will not be a massive increase in size for wanting to be realistic with the time frame and the size of the original gear. There is, however, a slight adjustment to the creation. Being that the forward and reverse gear as shown in Figure 2 work with one another with the same smaller spur gear on the back of the main pinion gear shown in Figure 1, the creation is smaller. By placing Figure 3, Figure 4, Figure 5, Figure 6, Figure 7 in an assembly, mating them together so they could work together properly, the movement is smooth. Follow the link provided to see the full video of how the gears work together as shown in Error! Reference source not found.: https://www.youtube.com/watch?v=Lg0fmOu4LI&feature=youtu.be.

In the second creation, Figure 3, are used throughout the second creation, however, there is a slight change in the forward and reverse gear, as noted in. With this increase, notice how much larger the forward and reverse gear is compared to the original version, Figure 4 and Error! Reference source not found.. Follow the link provided below to see the second model in motion as shown in Figure 10: https://www.youtube.com/watch?v=NoJjDVAg7AA&feature=youtu.be. The concept of the figure and video is the same just with a larger gear in terms of face width and number of teeth.

**Motion Analysis and Torque Calculation**

Along with the creation of the two models is the motion analysis and calculation of torque. These steps tie in together because SolidWorks can do both steps, along with spicerparts.com. The motion analysis will conduct how the gears work together at a certain RPM rate for both scenarios. For the second scenario, the RPM rate will remain the same to keep in line with the original scenario. The point of rotation will be on a helical gear placed below a main pinion gear that drives a smaller spur gear with the forward and reverse gear. The calculation of the torque through SolidWorks will be placed at the same place as the RPM location for no confusion.

**Calculations**

There are several calculations that went into placing the gears in the correct spot so they could run properly. The center to center distance calculation is the main...
calculation that was needed to make the model come together. The first calculation needed is the center to center distance from Figure 3 and Figure 6, shown attached together in Error! Reference source not found.. The calculation for this included knowing the number of teeth for each part, dividing them by the pitch diameter of each gear, adding the two results together and dividing by two shown here: \((\text{Number of Teeth in Gear}) / (\text{Pitch Diameter})\) and \((\text{Result of Calculation}) / 2\). As shown by this equation for the center to center distance of the main pinion gear and the brake spline, \(262.75 = 9.45, 502.5 = 20, (9.45 + 20) / 2 = 14.725\). This was just the first of many equations to be used to mate the entire project together. However, adjustments were made accordingly so the mates did not overlap with each other. The second equation used was the center to center distance calculation for the forward and reverse gear with the tinier spur gear on the back of the main pinion gear shown as: \(74 / 3.5 = 21.1428571, 14 / 2.5 = 5.6, (21.1428571 + 5.6) / 2 = 13.3714286\). The last equation used is for the center to center distance for Figure 6 and Figure 7 shown as: \(15.6 = 2.5, 262.75 = 9.45, (2.5 + 9.45) / 2 = 5.975\). With these calculations and measurements for both Figure 8 and Figure 10, the motion analysis simulation runs smoothly.

**Results**

The results from this experiment were expected as shown between Figure 11 and Figure 12. In Figure 11, the horsepower is set to the specifications of the original transmission with 80 and the engine RPM level will stay the same through both scenarios. Notice, however, that with the increase in size of the forward and reverse gear for both scenarios, granted this is an estimate in how much more horsepower is added, the amount of torque is noticeably larger. Now, why does this matter? As stated earlier, the larger the gears, the more horsepower and torque going throughout the tractor and the transmission. Figure 8 and Figure 10 are the models that are considered here, Figure 11 relates to Figure 8 and Figure 12 relates to Figure 10. With the increase in horsepower and the RPM level the same, the difference in torque calculated is what was expected because if a larger gear is added, then the horsepower and torque will increase along with it. Tractor pulling teams will test the frames limits to know when the gear is too big before the frame breaks. But, from opinion, the concept of doing this does not make any sense.
Conclusions

In conclusion, antique tractors are a piece of machinery that do not need to be altered, especially just for fun and money. This equipment was used for many years for farming purposes and, occasionally, for fun on a Friday or Saturday night to let go of the stresses of the week. Why would somebody go around and alter a piece of equipment just to take a few extra bucks? Why has this sport or activity become so demanding of wanting the fastest tractor on the field? Antique tractor collectors do not agree with what these certain teams or individuals are doing to these tractors because they want to see an old antique stay the way it was intended to be: an old-style farming tractor.

Furthermore, the overall stress that the added size and tooth ratio to the tractor can be overwhelming to the frame of the tractor. If a team or individual were to put a gear that proved to be too much and caused the tractor frame and the engine to either: 1. Break from the overall stress and must rebuild the entire frame from the bottom up, or 2. Fry the motor, break every piece of the tractor to where there is nothing left to fix. The bad part about this is that many teams have resorted to doing this because the use of the old tractor isn’t worth it to them, whereas many other people would disagree. Breaking a tractor to these teams is just a way of knowing how much more the tractor can take before it finally cracks.

Look at Figure 11 and Figure 12 for example. These figures prove that adding an extra few teeth or increasing the overall size of a gear in a tractors transmission can really make a difference in the usage and life expectancy of it. With these adjustments, it is hard to determine how much these pieces of machinery can take before cracking under the stress, but, why waste the time in doing such a thing? Why do this to something so old, that it couldn’t take it for very long? It is not beneficial to either the tractor or the team because in the long term, there will be more money lost than earned.

References

GoEngineer (2012, April 10). SOLIDWORKS quick tip – motor torque and power. Retrieved from https://www.youtube.com/watch?v=w0jZE2c92zU
Appendix B: Problem Statement and Solution Approach

Problem Statement #1:
AEM 499: Problem Statement

Can Increasing the Teeth Count Help a Tractor Increase Speed?

Elliott Davis

Purpose and Intent: The purpose and intent of this project is to understand if increasing the teeth number or the pitch diameter of a tractor's transmission is going to increase the total speed of the tractor during a takeoff in a tractor pull.

Description of Problem: Tractor pulls used to be about how far a person could pull the weight. Now it's all about who has the fastest time. Some people have come to increasing the transmission pitch diameter to gain a higher speed. I want to find out how much more speed and torque a tractor is given when this occurs. Is it beneficial or will it cost the team because the tractor frame cannot hold that much torque?

Solution for the Problem: Using SolidWorks, I will design the frame of the tractor, along with using the ToolBox function to design the transmission gears (main and pinion(s)). There will be a before and after due to having to increase the gear size, while performing a Motion Study for both situations.

Steps to Approaching the Solution:

Count tractors transmission teeth to see how many it originally has. This step allows me to accurately depict how many teeth are in the gear. Estimated time: 2 days to 1 week

Design in SolidWorks and perform a motion analysis with similar frame. After finding the number of teeth, the rest can be designed with pure accuracy. Estimated time: 3 weeks to 1 month

Recreate the transmission gears with increased tooth count, along with performing another motion analysis. The motion study analysis will allow me to put the tractor at the highest RPM. Estimated time: 1-2 weeks
Calculate how much torque is being put out in each module (before and after). Estimated time: 1 week
Do tractors perform at a higher level with this increase or not? Estimated time: rest of semester

**Problem Statement #2**

AEM 499: Problem Statement

Modeling and Improvement to Transmission

Elliott Davis

Purpose and Intent: The purpose and intent of this project is to understand if increasing the teeth number or the pitch diameter of a tractor's transmission is going to increase the total speed of the tractor during a takeoff in a tractor pull.

Description of Problem: Tractor pulls used to be about how far a person could pull the weight. Now it's all about who has the fastest time. Some people have come to increasing the transmission pitch diameter to gain a higher speed. The main problem to be identified is how much more speed and torque a tractor is given when this occurs. Is it beneficial or will it cost the team because the tractor frame cannot hold that much torque?

Solution for the Problem: Using SolidWorks, the frame of the tractor, along with using the ToolBox function, the transmission gears (main and pinion(s)) will be created. There will be a before and after due to having to increase the gear size, while performing a Motion Study for both situations.

Steps to Approaching the Solution:

- Count tractors transmission teeth to see how many it originally has. This step allows me to accurately depict how many teeth are in the gear. Estimated time: one (1) to two (2) weeks
- Design in SolidWorks and perform a motion analysis with a similar frame. After finding the number of teeth, the rest can be designed with pure accuracy. Estimated time: three (3) to six (6) weeks
- Recreate the transmission gears with increased tooth count, along with performing another motion analysis. The motion study analysis will allow me to put the tractor at the highest RPM. Estimated time: one (1) to two (2) weeks
- Calculate how much torque is being put out in each module (before and after). Estimated time: one (1) to two (2) weeks
- Do tractors perform at a higher level with this increase or not? Estimated time: two (2) weeks

**Solution Approach #1**

AEM 499: Solution Approach

Can Increasing the Teeth Count Help a Tractor Increase Speed?

Elliott Davis

Gear(s) Tooth Count

The transmission of a tractor contains six (6) forward and two (2) reverse gears, along with several pinion gears to keep the track from slipping. For this step, which will take 1-2 weeks to become accurate. According to tractordata.com, the average horsepower for a Oliver Super 99 tractor, made in 1958, from the PTO (Power Take-Off) shaft is 54 horsepower. Using spicerparts.com and the horsepower to torque calculator, I should be able to find out, without taking the tractor apart, how many teeth the gears should have. From tractordata.com, the website will give me all the information I need to become accurate with the project development.
SolidWorks Creation

During this process, which will take roughly three (3) weeks to one (1) month, I will recreate, to the best of my ability, the actual layout of the Oliver Super 99 transmission. In this process, I will use the AEM concept of Computer Aided Design to design the six (6) forward and two (2) reverse gears, along with the pinion gears to keep the gears moving in the correct way. After creating the original model, I will recreate the same transmission but with a larger gear(s) to calculate the torque, which can also be completed in SolidWorks. I am not going to make the gears to the biggest extreme that SolidWorks allows, but, I will add one (1) to four (4) teeth so the difference isn't out of hand.

Motion Analysis

During the Motion Analysis process, still using SolidWorks, this process will allow me to make sure that the gears can move in the right direction and no problems occur. I must run two different motion analysis situations to see how much difference there is between the original design and the improved, larger design of the transmission. From tractordata.com, the website gives a range of RPMs from the lowest to the highest level, I will conduct these motion analysis situations with the highest RPM allowed because performing a motion analysis with an unreal RPM level would throw off the entire situation. The time to complete several different motion analysis problems should be around one (1) to two (2) weeks.

Calculating Torque

This process is tied in with the Motion Analysis because I can either use Spicerparts.com or I can use the YouTube video showing a quick tip on how to use SolidWorks to calculate torque after completing the Motion Analysis. I would expect that the larger version of the transmission will have a higher torque, but by how much? I have already used Spicerparts.com to find out how much torque the original tractor and transmission had. This part of the process is going to take one (1) to two (2) weeks for completion if no problems occur.

Final Step: Presentation

The final step of this entire project is making sure everything runs smoothly in a PowerPoint presentation, especially the animations videos, collapse and explode, along with the motion analysis. The other step in this final step is to find out if it is truly better to increase the transmission gear count to gain more speed from take-off or should tractor pulling teams sinking too much money and time into a project that will only give them problems and eventually, make them go bankrupt? This process will take the rest of the semester, about 15 weeks.

Solution Approach #2

AEM 499: Solution Approach
Modeling and Improvement of Transmission
Elliott Davis
Gear(s) Tooth Count

The transmission of a tractor contains six (6) forward and two (2) reverse gears, along with several pinion gears to keep the track from slipping. For this step, which will take 1-2 weeks to become accurate. Per tractordata.com, the average horsepower for an Oliver Super 99 tractor, made in 1958, from the PTO (Power Take-Off) shaft is 54 horsepower. Using Spicerparts.com and the horsepower to torque calculator without taking the tractor apart, how many teeth the gears should have. From tractordata.com, the website will give me all the information I need to become accurate with the project development.
SolidWorks Creation

During this process, which will take roughly three (3) weeks to one (1) month, the transmission will be recreated of the Oliver Super 99 tractor. The AEM concept of Computer Aided Design is to be used to design the six (6) forward and two (2) reverse gears, along with the pinion gears to keep the gears moving in the correct way. After creating the original model, a recreation of the same transmission will be made but with a larger gear(s) to calculate the torque, which can also be completed in SolidWorks. The gears will not be to the biggest extreme that SolidWorks allows, but, one (1) to four (4) teeth will be added so the difference isn’t out of hand.

Motion Analysis

During the Motion Analysis process, still using SolidWorks, this process will allow the gears to move in the right direction, making sure no problems occur. Two different motion analysis situations to see how much difference there is between the original design and the improved, larger design of the transmission. From tractordata.com, the website gives a range of RPMs from the lowest to the highest level, these motion analysis situations will be conducted with the highest RPM allowed because performing a motion analysis with an unreal RPM level would throw off the entire situation. The time to complete several different motion analysis problems should be around one (1) to two (2) weeks.

Calculating Torque

This process is tied in with the Motion Analysis because spicerparts.com or the YouTube video showing a quick tip on how to use SolidWorks to calculate torque after completing the Motion Analysis. The expectation for the outcome of motion analysis situations is the larger version of the transmission will have a higher torque, but by how much? Having already used spicerparts.com, the amount of torque the original tractor and transmission had has been obtained. This part of the process is going to take one (1) to two (2) weeks for completion if no problems occur.

Final Step: Presentation

The final step of this entire project is making sure everything runs smoothly in a PowerPoint presentation, especially the animations videos, collapse and explode, along with the motion analysis. The other step in this final step is to find out if it is truly better to increase the transmission gear count to gain more speed from take-off or should tractor pulling teams sinking too much money and time into a project that will only give them problems and eventually, make them go bankrupt? This process will take the rest of the semester, about 15 weeks.

Appendix C: Weekly Progress Reports

Weekly Progress Report #1

To: Dr. Ni Wang
From: Elliott Davis
Period Ending: February 15, 2017
Self-Assessment: Green

Work completed this Week: This past weekend, I went back home and took a second look at the transmission to gain a clearer identification of the size of the pitch of the gears, along with a second count of the teeth in the gears. I started to make a preliminary sketch of what and where parts need to be.

Work Planned for next week: The work planned for next week includes the beginning stages of the SolidWorks creation, as noted in my timeline. I gave myself six (6) weeks because of any problems I may come across in terms of the design of the transmission and frame of the tractor. It should not take six (6) weeks but I would rather be safe than sorry.
Open Issues: There are no open issues to discuss at this time.

Weekly Progress Report #2
To: Dr. Ni Wang
From: Elliott Davis
Period Ending: February 22, 2017
Self-Assessment: Green
Work completed this week: Created a hand-drawn sketch of the transmission for creation in SolidWorks. No work has yet been started for the SolidWorks creation, but that will be forthcoming. Should not be a difficult creation since the preliminary sketch has placement of gears.
Work Planned for next week: The work planned for next week continues to be the stages of the SolidWorks creation, as noted in my timeline. I gave myself six (6) weeks because of any problems I may come across in terms of the design of the transmission and frame of the tractor. It should not take six (6) weeks, but I would rather be safe than sorry.
Open Issues: Time management of other classes

Weekly Progress Report #3
To: Dr. Ni Wang
From: Elliott Davis
Period Ending: March 1, 2017
Self-Assessment: Green
Work completed this week: Returning home this upcoming weekend to have one final look at the transmission to make sure my placement is correct. Downloaded SolidWorks onto computer so I should have a basic layout of the transmission completed this weekend, leading into Monday, where final placements will be made.
Work Planned for next week: The work planned for next week continues to be the stages of the SolidWorks creation, as noted in my timeline. I gave myself six (6) weeks because of any problems I may come across in terms of the design of the transmission and frame of the tractor. It should not take six (6) weeks, but I would rather be safe than sorry.
Open Issues: Time management of other classes

Weekly Progress Report #4
To: Dr. Ni Wang
From: Elliott Davis
Period Ending: March 29, 2017
Self-Assessment: Green/Yellow
Work completed this week: The calculations for the center-to-center distance of the gears was completed as well as the making of the original transmission. Along with the making of the report for the presentation.
Work Planned for next week: The work planned for next week continues to be the stages of the SolidWorks creation, as noted in my timeline, along with the motion analysis of the original transmission. After this, the making of the improved transmission will be completed.
Open Issues: Time management of other classes
Curricula of ATMAE Accredited University Programs: Building a Composite

Author
Dr. Mark Doggett, Western Kentucky University, Bowling Green, KY

Introduction: The 2017 ATMAE Accreditation Handbook Standard 5 states that each baccalaureate program/option should meet minimum-maximum semester hour requirements in the foundational areas of general education, mathematics, physical (or life) sciences, management, technical, and electives. The specific credit hours required for each category has a specified range. This study attempted to answer the question of what courses typical ATMAE accredited university programs most frequently require. ATMAE accredits four-year manufacturing, industrial, construction, and information technology programs. To what extent are these accredited programs similar in content? Is there a representative convention of content for university courses?

The objectives of the research were to (a) determine the variety of ATMAE university programs and their constituent courses and (b) identify a composite curriculum for ATMAE university programs. Research was conducted using recent ATMAE accredited self-study reports of four-year programs. Specifically, the study sought to answer the following questions:
• What specific courses are self-reported by ATMAE accredited four-year programs?
• What courses are reported by ATMAE accredited four-year programs to maintain the reasonable balance between practical and conceptual application as stated in the Accreditation Handbook?
• Is there an identifiable composite curriculum for ATMAE accredited four-year programs?

Review of Literature: As outcomes-based accreditation and certification (e.g., SME, ASQ, APICS, PMI, etc.) have gained momentum, reviews of curriculum have become more frequent and useful. Meier, Williams, and Humphreys (1997) and Meier and Brown (2008) suggested an essential curriculum for the success of new employees in engineering and technology. Researchers Rifkin, Fineman, and Ruhnke (1999) developed an ordered model for a technical manager’s skills, knowledge, activities, and personal behaviors. Other published literature on curriculum included manufacturing (Payne, 2009; Waldrop & Jack, 2012), industrial engineering (Ferguson, 1991), safety (Blair, 1997), and project management (Golob, 2002).

Litowits (2014) proposed a composite curriculum for undergraduate technology and engineering teacher education programs, identifying three core areas: general education, professional (teacher) preparation, and technical study. This research found a composite in the technical coursework of two courses in energy and power, including electricity/electronics and transportation, and one course each in manufacturing, construction, design, material processing, and drafting/computer aided design.

The Society of Manufacturing Engineers developed the Four Pillars of Manufacturing Engineering using ABET accreditation criteria for manufacturing. The curricular areas identified were (1) materials and manufacturing processes, (2) product, tooling, and assembly engineering, (3) manufacturing systems and operations, and (4) manufacturing competitiveness (Mott, Jack, Raju, & Stratton, 2011). A variety of survey studies followed on student, faculty, and professional perceptions of the Four Pillars (Nutter & Jack, 2013; Nutter, Mott, Williams, Stratton, 2013; Doggett & Jahan, 2014).
Thus, the basis for this study is congruent with the literature where the curriculum is tied closely to desired competencies and there is sufficient data available on current course offerings. In addition, the validation of curricular models or a curriculum composite is frequently accomplished using survey research.

**Methodology:** ATMAE provided the researcher with aggregate data on the number of required credit hours for each foundational area as self reported by 53 universities having 163 accredited programs. Actual self-study report responses to Standard 5 were obtained from sixteen universities having 31 ATMAE accredited programs. The 31 programs were construction management (7), industrial technology (5), electronic technology (5), manufacturing (4), graphics/drafting technology (3), agricultural systems (2), aviation (2), computer technology (1), mechanical design (1), and automotive technology (1). The courses as reported by each program were loaded into an Excel spreadsheet and sorted under their foundational category. For example, if a particular program listed a course under the technical requirements of the Accreditation Handbook Table C-1 of the self-study, it was placed in the technical column of the spreadsheet. Courses listed in the management area were added to the management column and so forth. The findings of the study were strictly limited to the information reported on each self-study. The identities of the specific universities and programs were asked by ATMAE to remain confidential.

Under each foundational area, the courses were then sorted by subject name. Courses having similar titles were grouped using deductive reasoning. If a single course was listed multiple times across programs, it was counted once for each program. For menu-driven curriculum, where students would select a set of courses from a list, each course was placed in a group. After sorting and grouping courses by their titles, the findings were reviewed for content validity.

**Program Findings:** The range and average of the total number of hours by area required by ATMAE accredited university programs is shown on Table 1. The reported ranges that exceed the maximum or do not meet the minimum were not investigated as only the Standard 5 tables were provided, not the entire self-study. Prior to the outcomes-based standards, programs were not required to submit their self-study reports electronically. In addition, no historical record was required by or kept by ATMAE. The review of the available Standard 5 tables revealed inconsistencies and some duplication or omission of course reporting. These inconsistencies and errors might have been explained in the body of the self-report, but could not be clarified for this study.
Table 1
Average and range of semester hours required by university ATMAE accredited programs

<table>
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<tr>
<th>ATMAE Area</th>
<th>ATMAE Min/Max Semester Hour Requirements</th>
<th>Reported Hours Range</th>
<th>Average Hours</th>
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<td>General Education</td>
<td>18-36</td>
<td>18-75</td>
<td>33.8</td>
</tr>
<tr>
<td>Mathematics</td>
<td>6-18</td>
<td>3-18</td>
<td>8.5</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>6-18</td>
<td>3-22</td>
<td>9.2</td>
</tr>
<tr>
<td>Management</td>
<td>12-24</td>
<td>12-39</td>
<td>21.3</td>
</tr>
<tr>
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<td>12-69</td>
<td>37.3</td>
</tr>
<tr>
<td></td>
<td>0-18</td>
<td>0-42</td>
<td>11.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120 minimum</strong></td>
<td><strong>96-156</strong></td>
<td><strong>122.1</strong></td>
</tr>
</tbody>
</table>

The courses for each self-reported foundational areas listed in ATMAE Accreditation Handbook Table C-1 were compiled for the available 31 ATMAE accredited programs and courses with similar titles counted. Some assumptions were made regarding equivalency. For example, a course with the title *Elementary Statistics Concepts* was determined to be of similar type as a course with the title *Basic Statistics*, although the exact content might differ. Related topic courses were also grouped by type such as statics, strength of materials, and architectural structures courses. In this case, a course type was created called statics/strengths/structures. Pareto charts of the courses sorted by reported frequency for the 31 programs for each ATMAE foundational area follow beginning with mathematics (Figure 1). The most frequently appearing courses using the 80/20 Pareto Principle were algebra/trigonometry, statistics/SQC, calculus, and general math. The course types falling within the 80% rule are shown in the lighter shade. The average number of math courses per program was 2.7. The actual frequency for all reported courses is found in the Appendix.
The most frequently appearing courses for physical (life) sciences were physics, chemistry, and biology/ecology. The Pareto chart is shown in Figure 2. The average number of physical science courses per program with the addition of labs was 3.1. Not all programs listed labs as an additional requirement so it is uncertain if they were included. The frequency of reported courses and reported courses with labs is found in the Appendix.
The most frequently appearing courses for the management area were internships or work experience, followed by management/supervision, accounting, human resources and organizational behavior. A number of other course types were also reported frequently within the 80% rule. They were planning and operations, safety/ergonomics, senior capstone, project management, law or legal issues, and marketing/sales. The average number of management courses per program was 7.4. See Figure 3.
The most frequently appearing courses for the technical area were electronics/electrical or digital courses followed by methods/processes/materials type courses, drafting/graphics/CAD, and programming/computing or networking. The other courses frequently reported meeting the 80/20 criteria were industrial/product design, power and energy courses, senior capstone, introduction to technology, business/technical systems, and materials/statics or strengths-type courses. The average number of technical courses per program was 15.7. See Figure 4.

Figure 3. Pareto chart for the management area
Figure 4. Pareto chart for the technical area

The most frequently appearing courses for the electives area were drafting/graphics/computer-aided-design (CAD). This was followed by courses specific to mechanical or manufacturing technologies, architectural/civil or construction management, and health or safety. Some of the self-reported data did not call out specific courses. Rather, students were asked to select courses based on university or department/program approved lists. Other criteria for electives were by identified by a block concentration area such as management electives, technical electives, or non-technical. Other course types reported within the 80% criteria were industrial/product design and humanities electives. As the number of electives per program varied widely, an average number of elective courses per program was not calculated. See Figure 5.
Conclusion: Using a combination of the average number courses per areas, the average hours reported, and the Pareto charts, the most likely courses appearing in ATMAE accredited university programs is shown in Table 2. The three mathematics courses most likely to appear in a university program are algebra/trigonometry, statistics, and calculus. The calculus-based programs required either pre-calculus or combinations of algebra/trigonometry as prerequisites while the non-calculus-based programs required general math and algebra/trigonometry combinations. The three physical/life sciences courses most likely to appear are physics, chemistry, and biology.
For the management area, 11 courses fell within the 80% rule, but programs typically required between seven and eight courses. However, the frequency of four other courses above 70% was very close. Thus, Table 2 includes the top nine reported courses for management. While law/legal courses and sales/marketing courses were also within the 80% rule, they are not listed. It should be noted that quality/statistics courses were self-reported in both the management and technical areas, but more frequently in the management area. Capstone courses were also reported in both the management and technical areas, but more frequently in the technical.

Programs reported courses in higher frequency for the technical area. While the ATMAE maximum is 36 semester hours, the average hours were over 37 and the range maximum was almost double. In this case, it made more sense to use the 80/20 rule for the composite, which was 10 courses. Materials-type courses in the technical area were reported one of two ways. The first type was materials, methods, and processes, which was generally specific to a program discipline such as manufacturing, construction or graphics. The second type was related to materials science, statics or strength of materials, with the latter associated more with properties of materials. Drafting, graphics, and CAD courses were frequently reported, but also heavily reported as electives. As mentioned previously, capstone courses were reported in the technical area, but also in management. Introduction to technology courses were reported in both technical and management, but more frequently in technical. These introduction courses were also program specific with titles such as Introduction to [Computing, Construction, Manufacturing] etc.

For the electives, the average number of reported hours was between 11 and 12, but the reported range maximum was over twice the ATMAE maximum of 18 hours. However, eleven courses met the 80% rule. For this area, the ATMAE maximum of six courses (18 hours) was used as the cutoff. The most frequent type of elective was drafting, graphics, or CAD courses. This was followed by a variety of program discipline, department, or university-specific electives. Health and safety courses also appeared frequently.
Based upon the self-reported information, there does appear to be a generally accepted core of knowledge for mathematics and the physical sciences at the university level. The management and technical competencies required by accredited programs are less well-defined, but can be identified. Depending on the program, courses such as quality, statistics, introductory technology, and capstone may be reported as technical or management courses. The composite curriculum is shown in Table 3.
Table 3. ATMAE accredited university composite curriculum

<table>
<thead>
<tr>
<th>ATMAE Area</th>
<th>ATMAE Min/Max Semester Hour Requirements</th>
<th>Hours (courses)</th>
<th>Composite Curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education</td>
<td>18-36</td>
<td>33 (11)</td>
<td>Statistics (Calculus, PreCalculus) or (Algebra/Trig, General Math)</td>
</tr>
<tr>
<td>Mathematics</td>
<td>6-18</td>
<td>9 (3)</td>
<td>Physics, Chemistry, Biology</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>6-18</td>
<td>9 (3)</td>
<td>Internship Management/Supervision Accounting</td>
</tr>
<tr>
<td>Electives</td>
<td>0-18</td>
<td>12 (4)</td>
<td>Program Specific Electives Department Electives University Electives Mgmt./Technical Electives</td>
</tr>
<tr>
<td>Total</td>
<td>120 minimum</td>
<td>120 (40)</td>
<td></td>
</tr>
</tbody>
</table>

This composite used the average reported hours and the courses most likely to appear as a starting point while considering the ATMAE semester hour requirements. If any course type was duplicated across areas, the next unduplicated course type of higher frequency within the area was added. The effect of removing duplication resulted in two more course types being added to the technical area. Automation was the first unduplicated course type, but the next five courses were also duplicated in the management area. Thus, the last course in the technical area is undesignated.
In conclusion, the specific courses as self-reported by ATMAE accredited four-year programs can be sorted into course types that are congruent with the ATMAE Standard 5 areas. However, some universities may choose to place certain types of courses in the technical area while other universities choose to place them in the management area. Is there an identifiable composite curriculum for ATMAE accredited four-year programs? Yes. This study, using deductive reasoning and Pareto analysis, was able to identify a set of course types for each foundational area. Conversely, discovering if programs had a reasonable balance between practical and conceptual application as stated in the Accreditation Handbook were determined to be beyond the scope of this study. Each course would have to be evaluated for content; a task better suited for an on-site accreditation evaluator. However, self-reported information infers that ATMAE four-year programs are more practical simply given the number of hours in the technical competencies.

References:
## Appendix: Course Type Tables

### Table A1
*Courses self-reported in the mathematics foundational area*

<table>
<thead>
<tr>
<th>Course type</th>
<th>Number of times reported</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra/Trigonometry</td>
<td>25</td>
<td>28%</td>
</tr>
<tr>
<td>Statistics/SQC*</td>
<td>19</td>
<td>49%</td>
</tr>
<tr>
<td>Calculus</td>
<td>14</td>
<td>64%</td>
</tr>
<tr>
<td>General Math</td>
<td>8</td>
<td>73%</td>
</tr>
<tr>
<td>Pre-calculus</td>
<td>7</td>
<td>81%</td>
</tr>
<tr>
<td>Statistical Quality* Statics/</td>
<td>5</td>
<td>87%</td>
</tr>
<tr>
<td>Strength/Structures* Circuit/</td>
<td>5</td>
<td>92%</td>
</tr>
<tr>
<td>Digital Analysis* Financial</td>
<td>5</td>
<td>98%</td>
</tr>
<tr>
<td>Accounting* Computer Literacy</td>
<td>5</td>
<td>99%</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>100%</td>
</tr>
</tbody>
</table>

*indicates course-type duplication across areas

Average Number of Math Courses per Program: 2.7

### Table A2
*Courses self-reported in the physical sciences foundational area*

<table>
<thead>
<tr>
<th>Course type</th>
<th>Number of times reported</th>
<th>Cumulative %</th>
<th>Reported with lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics</td>
<td>31</td>
<td>46%</td>
<td>17</td>
</tr>
<tr>
<td>General/Intro Chemistry</td>
<td>21</td>
<td>76%</td>
<td>12</td>
</tr>
<tr>
<td>Biology/Ecology</td>
<td>13</td>
<td>96%</td>
<td></td>
</tr>
<tr>
<td>Geology</td>
<td>2</td>
<td>99%</td>
<td>2</td>
</tr>
<tr>
<td>Engineering Material Science*</td>
<td>1</td>
<td>100%</td>
<td>1</td>
</tr>
</tbody>
</table>

Average Number of Physical Science Courses per Program: 2.2

*indicates course-type duplication across areas
Table A3
Courses self-reported in the management foundational area

<table>
<thead>
<tr>
<th>Course type</th>
<th>Number of times reported</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internship/Work Experience*</td>
<td>26</td>
<td>11%</td>
</tr>
<tr>
<td>Management/ Supervision</td>
<td>25</td>
<td>22%</td>
</tr>
<tr>
<td>Human Resources/ Org. Behavior</td>
<td>21</td>
<td>31%</td>
</tr>
<tr>
<td>Accounting*</td>
<td>21</td>
<td>40%</td>
</tr>
<tr>
<td>Planning and Operations*</td>
<td>19</td>
<td>49%</td>
</tr>
<tr>
<td>Safety/ Ergonomics*</td>
<td>16</td>
<td>56%</td>
</tr>
<tr>
<td>Quality/ Statistics*</td>
<td>13</td>
<td>61%</td>
</tr>
<tr>
<td>Senior Capstone *</td>
<td>12</td>
<td>67%</td>
</tr>
<tr>
<td>Project Management</td>
<td>12</td>
<td>72%</td>
</tr>
<tr>
<td>Law/ Legal Issues</td>
<td>11</td>
<td>77%</td>
</tr>
<tr>
<td>Marketing/ Sales</td>
<td>10</td>
<td>81%</td>
</tr>
<tr>
<td>Technical/Business Writing*</td>
<td>9</td>
<td>85%</td>
</tr>
<tr>
<td>Specifications, Codes, Regulations*</td>
<td>7</td>
<td>88%</td>
</tr>
<tr>
<td>Intro Technology*</td>
<td>7</td>
<td>91%</td>
</tr>
<tr>
<td>Economics</td>
<td>6</td>
<td>93%</td>
</tr>
<tr>
<td>Engineering Economy/ Costing</td>
<td>5</td>
<td>96%</td>
</tr>
<tr>
<td>Communication</td>
<td>4</td>
<td>97%</td>
</tr>
<tr>
<td>Business Information Systems</td>
<td>3</td>
<td>99%</td>
</tr>
<tr>
<td>Programming*</td>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>Applied Creativity</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Average Number of Management Courses per Program</td>
<td>7.4</td>
<td></td>
</tr>
</tbody>
</table>

*indicates course-type duplication across areas
Table A4
Courses self-reported in the technical foundational area

<table>
<thead>
<tr>
<th>Course type</th>
<th>Number of times reported</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronics/ Electrical/ Digital*</td>
<td>90</td>
<td>18%</td>
</tr>
<tr>
<td>Methods/Processes/ Materials</td>
<td>69</td>
<td>33%</td>
</tr>
<tr>
<td>Drafting/ Graphics/ CAD*</td>
<td>62</td>
<td>45%</td>
</tr>
<tr>
<td>Programming/ Computing/ Networks*</td>
<td>41</td>
<td>54%</td>
</tr>
<tr>
<td>Industrial/ Product Design*</td>
<td>38</td>
<td>62%</td>
</tr>
<tr>
<td>Power and Energy</td>
<td>27</td>
<td>67%</td>
</tr>
<tr>
<td>Senior Capstone*</td>
<td>20</td>
<td>71%</td>
</tr>
<tr>
<td>Intro Technology*</td>
<td>18</td>
<td>75%</td>
</tr>
<tr>
<td>Business/ Technological Systems</td>
<td>18</td>
<td>79%</td>
</tr>
<tr>
<td>Materials/ Statics/ Strengths*</td>
<td>15</td>
<td>82%</td>
</tr>
<tr>
<td>Automation</td>
<td>14</td>
<td>85%</td>
</tr>
<tr>
<td>Safety/Risk*</td>
<td>14</td>
<td>87%</td>
</tr>
<tr>
<td>Operations*</td>
<td>12</td>
<td>90%</td>
</tr>
<tr>
<td>Quality/ Statistics/ Analysis*</td>
<td>12</td>
<td>92%</td>
</tr>
<tr>
<td>Internship/Work Experience*</td>
<td>11</td>
<td>95%</td>
</tr>
<tr>
<td>Specifications, Codes, Regulations*</td>
<td>8</td>
<td>96%</td>
</tr>
<tr>
<td>Project Controls</td>
<td>8</td>
<td>98%</td>
</tr>
<tr>
<td>Machine Tool</td>
<td>5</td>
<td>99%</td>
</tr>
<tr>
<td>Law/Legal</td>
<td>2</td>
<td>99%</td>
</tr>
<tr>
<td>Management/Supervision*</td>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>Written Communication*</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Average Number of Technical Courses per Program</td>
<td>15.7</td>
<td></td>
</tr>
</tbody>
</table>

*indicates course-type duplication across areas
Table A5

*Courses self-reported in the electives area*

<table>
<thead>
<tr>
<th>Course type</th>
<th>Number of times reported</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drafting/ Graphics/ CAD*</td>
<td>13</td>
<td>16%</td>
</tr>
<tr>
<td>Mechanical/ Manufacturing</td>
<td>9</td>
<td>27%</td>
</tr>
<tr>
<td>Architectural/ Civil/ CM</td>
<td>8</td>
<td>37%</td>
</tr>
<tr>
<td>Health and Safety*</td>
<td>8</td>
<td>46%</td>
</tr>
<tr>
<td>Program/ Dept. Electives</td>
<td>8</td>
<td>56%</td>
</tr>
<tr>
<td>University Electives</td>
<td>7</td>
<td>65%</td>
</tr>
<tr>
<td>Management</td>
<td>5</td>
<td>71%</td>
</tr>
<tr>
<td>Technical Electives</td>
<td>4</td>
<td>76%</td>
</tr>
<tr>
<td>Industrial/ Product Design*</td>
<td>3</td>
<td>79%</td>
</tr>
<tr>
<td>Humanities</td>
<td>3</td>
<td>83%</td>
</tr>
<tr>
<td>Writing*</td>
<td>2</td>
<td>85%</td>
</tr>
<tr>
<td>Social Science</td>
<td>2</td>
<td>88%</td>
</tr>
<tr>
<td>Business*</td>
<td>2</td>
<td>90%</td>
</tr>
<tr>
<td>Technical or non-technical</td>
<td>2</td>
<td>93%</td>
</tr>
<tr>
<td>Quality*</td>
<td>2</td>
<td>95%</td>
</tr>
<tr>
<td>GIS</td>
<td>1</td>
<td>96%</td>
</tr>
<tr>
<td>Programming*</td>
<td>1</td>
<td>98%</td>
</tr>
<tr>
<td>Intro to Higher Ed</td>
<td>1</td>
<td>99%</td>
</tr>
<tr>
<td>History of Technology</td>
<td>1</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Indicates course-type duplication across areas*
Meeting the Future Educational Needs of Manufacturing Today

Author(s)

Mr. Jake Hildebrant, Murray State University, Murray, KY
Mr. Sidney Martin, Murray State University, Murray, KY

Abstract: The Commonwealth of Kentucky has aggressively pursued measures, both educationally and legislatively, to attract and retain manufacturing in the state. Governor Bevin reports that recent additions to the Commonwealth's manufacturing base will add 9,500 positions. Many of these positions are directly related to the manufacturing technology field. This paper outlines the requirements for a Manufacturing Engineering Technology program, which would include: programs that are based on online or hybrid learning opportunities; a curriculum that leads to and development of methods of working with nontraditional students to support lifelong learning. This manufacturing degree program includes an emphasis on internships and mentorships for students. The program utilizes faculty to provide degree programs that result in programs beneficial to manufacturing employees and the industry, and these higher education programs will collaborate with industry organizations that are offering credentialing to blend these traditional credits to be able to offer a degree to the student.

Introduction:

Problems in Manufacturing: During the recession of 2008-2009, many manufacturers decided to offshore production to other countries that could produce their products cheaper. That has changed recently as many companies have decided to reshore their production back to the United States of America (USA). Although reshoring is having a positive impact on the economy, the new face of manufacturing has presented some complications to the USA’s workforce. In order to compete globally, American manufacturing has become more automated and required a workforce that has a higher skill level than manufacturing of the past. This skills gap is predicted to be a barrier to expanding manufacturing in the United States in the near future. According to research sponsored by The Manufacturing Institute of Deloitte (2015), three and a half million manufacturing jobs will need to be filled, and two million of those jobs will go unfilled because of worker skills gaps. There are some states that are trying to address the growing skills gap dilemma to attract and retain manufacturing companies.

In 2013, manufacturing accounted for 18.3% of the total output of the state of Kentucky and 12.38% of the state workforce (NAM, 2015). Motor vehicle and parts were the largest number of manufacturing sectors in the state, followed very closely by food, beverage, and tobacco products. According to the National Association of Manufacturers (2015), manufacturing output has increased by 41% in Kentucky from 2009 to 2013. Because of this steep increase in manufacturing output, skills gaps within the state are becoming increasingly problematic.

Research completed by Key Links Incorporated (2013) found that 88% of manufacturers in the South Central Kentucky Regional Development Authority area discovered the following outcomes

- 88% report limited access to skilled workers as a barrier to expansion
- 74% are concerned about maintaining a skilled and motivated workforce
- 67% can’t find skilled candidates for critical positions
- 63% worry about the employability and work ethic skills of available candidates
Overview:
Combating the Skills Gap in Kentucky: In 2015, an organization received its non-profit status through a partnership with Kentucky legislators, manufacturers, and several educational partnerships to help combat the skills gap in the state. The organization is called the Kentucky Federation for Advanced Manufacturing Education (KY FAME) and, at the time of the writing of this paper, has 10 regional chapters throughout Kentucky (KY FAME, 2015). KY FAME has a mission "to be the catalyst for developing world-class technical talent for manufacturing" (FAME, 2016). According to their website, KY FAME partners regional manufacturing and educational programs to implement “Apprentice-style” training that will create a pool of highly skilled workers. KY Fame currently utilizes the Kentucky Community and Technical College System’s (KCTCS) Advanced Manufacturing Technician Program (AMT). There are other KCTCS programs that regional chapters utilize for dual credit that this paper will introduce at a later time.

Advanced Manufacturing Technology: KY FAME chose the KCTCS AMT program as its standard for manufacturer’s apprenticeships curriculum. Apprentices are hired through a regional manufacturer and then enrolled in the local KCTCS community college as an AMT student. The apprentices will spend two days a week in class and then 24 hours a week working in their sponsor’s facility. The AMT curriculum was created by a National Science Foundation grant proposal titled The Automotive Manufacturing Technical Education Collaborative (AMTEC). The funded grant allowed several community colleges in multiple states to partner together to complete a Developing A Curriculum (DACUM) that established a gap analysis from current associate degree manufacturing programs and the larger automotive manufacturers’ needs. The result of the grant was the AMT curriculum that is administered throughout the state at the KCTCS community colleges.

Advanced Integrated Technology: One of the 16 KCTCS community colleges, Madisonville Community College (MCC), created a similar program to meet manufacturer’s needs on a micro level. The college received a NSF grant in 2009, Creating an Advanced Integrated Industrial Technology Program, to complete a DACUM with industry in the Madisonville, KY region. Madisonville Community College is located in the far western Delta Region of the state (Figure 1) and has an enrollment of 4,522 students (US, n.d.). The Delta Regional Authority lists all counties in MCC’s service region as economically distressed counties. This means that one of the following criteria must be met in each county (DRA, 2014):

- Unemployment rate of one percent higher than the national average for most of the 24-month period; or per capita income of 80 percent or less of the national per capita income.

Figure 1
Because of the uniqueness of the MCC service area, the results of the DACUM were quite different from the AMTEC DACUM. In addition to the DACUM, MCC surveyed 26 regional manufacturers to identify educational barriers that could be overcome with the new AIT curriculum. The result was a program that was created to meet the needs of its local industries.

- The lectures for the core classes are offered online.
- The AIT program utilizes flexible laboratories that students schedule around their schedules.
- The courses are divided into smaller modules that allows industry to select smaller training courses that are credit-bearing.
- The program has 3 stackable certifications that lead to an Associate’s of Applied Science Degree.

The results of the program have proved to be very successful to both the college and local industries. The AIT program began in 2009 with 29 students enrolled in the program, and by 2013 that number had increased to 89 students enrolled in the program. The increase was due to the fact that manufacturers started enrolling their employees into the AIT program for their training needs. Traditionally, industry would contact the college’s Workforce Solutions office to meet their training needs. Companies still contact the Workforce Solutions office, but now the office enrolls the students into the AIT classes. This gives the employees the advantage of earning college credentials that can lead to a degree while being trained for their company. Many students chose to continue to finish their degree after they completed the company’s training.

In 2015, the AIT program was accepted as the local KY FAME chapter's program to be utilized for local apprenticeship curriculum. By creating a program to meet their local industries' needs, MCC has experienced a sharp increase in applied technology enrollment and has experienced a greater industry “buy-in” to their programs. One local industry recently donated two plastic extrusion machines to the program in hopes of narrowing the skills gap in the plastic's industry. Both the AMT and AIT programs are considered mechatronic programs that combine electrical, mechanical, fluid power, and PLC programming within the same program.

Methodology:
The methodology in the P-20 education realm is to tie education to government and industry (Gartel & Rich, 2017). The combination of high school, higher education, and manufacturing program described in this paper. The implemented program uses the P-20 concept to integrate program requirements to allow access to a four-year manufacturing education degree. Effective training options, networking options among employers and teachers as well as frequent communication among governments leaders would certain help P-20 manufacturing education to be what it needs to be.

Because of the success of KY FAME and programs like the AMT and AIT programs, two universities have sought partnerships to meet industry’s needs of employees who transition from technicians to engineers or managers. One such program is the Bachelor of Science degree in Technology Management offered at Western Kentucky University. The program was created as a 2 + 2 program so students with a technical Associate’s of Applied Science degree can complete their BS in Technology Management in 2 years.
Another program is the Manufacturing Engineering Technology program at Murray State University. The degree was recently revised to partner with AMT and AIT graduates so they can complete their requirements for the BS in Manufacturing Engineering Technology degree in 2 years or less. The program is an AMTEC partner, and the goal of the University is to also partner with KY FAME as a 4-year partner school.

Implementation of this program can be done in other states by contacting FAME-USA (2017). The pathways for high school students to have access to more manufacturing based engineering programs are important. FAME aids in the connection between industry and education, the organization is an important part of the integration of these organizations.

**Literature Review:**

There is currently a growing trend for manufacturing to stop outsourcing to foreign countries. With the focus of manufacturing organizations concentrating on high-end skills and technology, workers need to have skills, education, and precision in applying their knowledge (McNelly, 2017). There is also a move to locate manufacturing within the United States (U.S.) (Todd, Red, Magleby, & Coe, 2001). Currently, the cost of production in China’s coastal cities is 10% to 15% less than in areas of the U.S. where companies are most likely to be located. States, such as Tennessee, South Carolina, and Alabama are predicted to be in the list of the least expensive production sites in the world. This will result in companies building manufacturing organizations in these states to supply North America (Sirkin, Zinser, & Hohner, 2011). In Kentucky, Governor Bevin touts that Kentucky is one of the world’s premier manufacturing sites. Governor Bevin has traveled outside the U.S. to showcase the Commonwealth of Kentucky as the site of their companies’ next manufacturing project (Finley, 2016).

The Manufacturing Institute Reports found that 84% executives state that there is a talent shortage in the U.S. (Giffi, 2017). These executives are worried that the workforce they need is not able to keep with the sophisticated and advanced needs of the manufacturing industry. The reason that the talent is not available is that manufacturing programs are often still focused on welding and metalworking. Education does not place emphasis on continuous or connected flow manufacturing, advanced material development, digital design and smart manufacturing (Giffi, 2017; NAMRI/SME, 2015).

In the US there are 41 ABET-accredited manufacturing engineering programs that offer a bachelor’s degree. Most universities with mechanical engineering programs have an underrepresentation of faculty who specialize in manufacturing. Manufacturing has not been an emphasis for the U. S. universities, primarily because these higher education institutions have not been receiving money for manufacturing research. Thus, there has been little effort to hire faculty with manufacturing expertise or provide laboratory or teaching space. NAMRI/SME (2015) recommends that an expansion of programs be funded and prioritized, but only to those institutions who state that there will be a long-term commitment to manufacturing education and research. The programs that are existing and established for manufacturing education need to be updated, and funds should be made available to these universities to support this effort.
The gap in providing manufacturing education requirements and skills will continue. The gap will only have a chance to close if universities take a new approach and redefine how students get to a degree, which includes more online instructional approaches to education, including having the students publish the results of what products or projects they have made in online classes. Industry hiring managers are going to put a value on workers who have pursued external opportunities to obtain an education (Swearer, R., 2016).

There is a need for a manufacturing higher education program that incorporates present trends in manufacturing. This manufacturing program will require students to participate in product teams. Engineering programs have adopted capstone projects that are multidisciplinary, and this experience is helping to improve the reduction of product development cycles (Todd et al. 2001). Universities need to embed industry-based certifications into programs of study which will ensure that engineering students are graduating with the skills needed by manufacturers (McNelly, 2017). The undergraduate program should have Lean Manufacturing methods as a topic, some graduate programs in manufacturing address this need, and however, very few undergraduate programs are addressing this need by adding a course in Lean Manufacturing to their curriculum. Agile manufacturing, which is flexible manufacturing able to supply multiple versions of products, needs to be included in the undergraduate programs as very few schools are currently including this in their program (Todd et al. 2001). The university manufacturing program should have business incubator capability, entrepreneurship programs, and focus on community colleges to have a direct articulation into bachelor’s degree of manufacturing engineering or manufacturing engineering technology programs (McNelly, 2017).

As higher education institutions implement, or increase the emphasis, in manufacturing engineering and engineering technology programs, there is a high potential for research and development opportunities. The institutions will take advantage of the significant impact of the growth of the manufacturing industry in the future. Academic institutions have the opportunity to work with manufacturing to participate in the growth of the industry by educating the workers and participants (Todd et al. 2001).

**Discussion:**

A need exists to work with training and education providers to create career pathways to address manufacturer’s needs (Key Link Inc., 2013). Key Links reports that there is a need to create a manufacturing career system within the two-year and four-year colleges to have articulations to support the transfer of credits from one institution to the other. The National Science Foundation has worked to develop the Advanced Technological Education (ATE) program which awards a two-year technician degree (Patton, M., 2014) in Kentucky. The solutions presented in this article support the articulation issues and provide a solution for the two-year degree student to move forward with their program.

According to the International Labour Office (ILO) (2010) how many men and women are employed and how productive they are at work is related to their ability to maintain and acquire relevant skills. The G20 leaders determined that there is a need to strengthen the manufacturing workers ability to adapt to the marketplace as it evolves. A recommendation to improve the worker’s ability to be successful is to develop lifelong learning opportunities for the workers.
This will enable to the manufacturing enterprises to have the skilled labor force to meet their increasing need to adapt to change.

Many urban areas offset the loss of traditional jobs in manufacturing by creating innovative service sector opportunities (World Economic Forum, 2017). The World Economic Forum suggests that the private sector is incentivized to provide lifelong learning opportunities to their employees. The integration of state and federal government resources with education and academia is needed to developed the extensive learning solutions needed for manufacturing organization growth (Mosier, Richey, McPherson, Eckhol, & Cox, 2006). The P-20 approach to providing a three-prong approach to education advancement by the alignment of goals for manufacturing, education, and government will be supported by the addition of these manufacturing Bachelor degree programs. Combining these programs with other commonwealth assets such as FAME, the Kentucky university system and the strong manufacturing base will lead to strong future growth. The expectation is that these systems and programs developed in Kentucky are extendable to other states and commonwealths in the United States.

**Conclusion:** Manufacturing is important to increased growth of the US economy, and the Commonwealth of Kentucky has taken the responsibility of reducing skills gaps amongst its workforce very seriously. The implementation of the FAME program to support P-20 activities in the integration of education programs supporting industry needs has been very successful throughout the commonwealth. Other states could replicate the steps that Kentucky has taken and also implement similar programs to meet the future needs of manufacturing today.

**References**


FAME. (2016). To remain competitive, manufacturers must create a pipeline of highly-skilled workers.
As retrieved [www.kyfame.com/about](http://www.kyfame.com/about)


Using Device Level Ring Topology to Increase Network Reliability in Mission Critical Industrial Control Systems

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Distributive Control Systems (DCS) are now a standard means of handling complex manufacturing processes. A DCS involves a distribution of labor approach to control system operations where several programmable controllers operating independently to perform essential control tasks are linked by a network interface to accomplish a sophisticated control network. Typically the DCS is supervised at the enterprise level by a host computer which in addition to performing supervisory control functions manages the collection and storage of process data as part of a Supervisory Control and Data Acquisition (SCADA) system.

While there are several industrial networking protocols currently available which lend themselves to DCS operation, the most prevalent is Ethernet Industrial protocol, or Ethernet/IP. Ethernet/IP is now a standard communications protocol for connecting industrial controllers and other smart devices needed in control systems such as graphic terminals used in the creation of human machine interfaces (HMI), motion control systems, and variable speed motor drives (Petruzella, 2016).

One great advantage of using EtherNet/IP is that it shares operational characteristics with the popular Ethernet protocol which is a standard for use in traditional enterprise information technology (IT) networking operations which have rapidly become integrated with the operational technology (OT) networking used in industrial control systems. Ethernet has many inherent advantages in a networking system, it is easy to install and operate, network components are relatively inexpensive, and troubleshooting problems is comparatively easy. The technical advantages are a high bandwidth to move data quickly, and a high degree of operational reliability using differing types of transmission media (optical fiber, copper, or wireless) (Tang, 2015).

Industrial Ethernet carries these benefits into the industrial workplace with additional characteristics. EtherNet/IP equipment is manufactured to deal with harsh environments with hardened enclosures, shock and vibration protection, and DIN rail mounting capability. The discrete components are rated to create a high mean time between failure (MTBF) to ensure reliable operation in a situation where 24/7 operation is required (Aladro, Desai, & Lounsbury, 2008).

While a networked DCS is capable of controlling complex systems with a high degree of reliability and accuracy of operation with minimal human operator intervention the concern that accompanies this is what if a failure of some part of the DCS creates a collapse of the operation. This is known as a mission critical failure, the mission of the system, its operation, has ceased to function. While unexpected shutdown of the process in some operations may not have catastrophic consequences there are a growing number of situations in manufacturing and critical infrastructure where sudden failure can have unacceptably high business and financial results. Mission critical control system failures can also lead to a chain of other failures related to business, safety, and security critical failures (Cisco Systems, Inc. and Rockwell Automation, 2015).
As in all complex systems not all component parts of that system are created equal in the importance they play in operation, or the potential hazards they pose. In an automated control system the most vulnerable part to damage is typically the input and output devices, and the wiring which connect them to the controllers. This is because they are the most exposed to potential damage. Controllers and similar electronic devices (HMI panels, motion control, motor drives, etc.) are typically encased in secure metal enclosures in a separate area from the actual production area. This provides a measure of protection from physical damage, as well as the effects of heat, moisture, and vibration.

The characteristic of a DCS is that it is an interconnected system of multiple control units which are required to constantly interact, exchanging data between them in the form of produced and consumed tags, for the process to operate correctly. Individual controllers may have subsidiary input/output modules (known as remote I/O, or flex I/O) to supplement onboard I/O capability of the controllers. This constant interaction required to maintain operation is carried out by the network using the physical layer cabling media which connects the controllers and other devices together to allow the exchange of data and control commands (Petruzella, 2016).

Just as with the wiring connecting the sensor and actuator devices to the controller, this network infrastructure is susceptible to damage or interference. In a DCS the loss of the network connectivity will result in the failure of the control system, and halting the operation. This makes maintaining the network a mission critical operation. The purpose of this paper is to examine a design methodology whereby the network physical layer in a DCS using Ethernet/IP can be made more resilient against damage and operational failure.

**Resiliency against failure in control systems by the use of redundancy**

Mission-critical systems should be designed and operated to cope with all foreseeable accidental and deliberate events that could bring down the system. Realistically, it is impossible to anticipate all such events, however there are a set of general precautions that can utilized to handle most fault inducing events. One standard measure against breakdown in any critical system is to have a backup, or redundant, system in place that immediately takes over the failed component’s function without loss of service. Redundancy of design creates fault tolerance in operation. One of the most common examples of duplication is the use of uninterruptable power supplies (UPS) with computers and servers to maintain the system power in the event of electrical grid failure. In DCS design it is often advisable to use redundant hardware components such as backup CPU modules in PLC’s, or redundant I/O modules which support essential functions (Pietrzyk, 2014).

**The importance of a network topology in a resilient system design**

The choice of a network topology plays a crucial role in determining the overall reliability of the system and the productivity. There are several types of network topologies in use for industrial networks. A common topology is the called the “Bus” system where all devices are connected to a linear trunk line that allows them to share data. A popular industrial network which utilizes this system is Allen-Bradley’s DeviceNet system. The problem with this system is that if the central connector is damaged loss to all devices beyond the break point is also lost.
The common means of deploying an Ethernet/IP network is by means of a Star topology. The Star topology utilizes a central hub which is usually a switch. Ethernet/IP compatible cabling such as Cat5E twisted Pair wiring is then strung from the switch ports to each device. All communications from the device nodes must travel through the central hub to be directed to their destination point. This has the same potential problem as the Bus topology, a break at one point can isolate a critical device, or a subnet of devices, connected to that cable (Petruzella, 2016).

There are multiple methods of implementing resiliency to physical layer damage in EtherNet/IP systems. The Redundant Star method creates an entire second Star topology infrastructure with each device on the network connected back to two separated switches through separate cabling. While this method can be effective it is also more costly to implement, and more difficult to maintain. In addition, expanding the network to install additional devices becomes more expensive (Aladro, Desai, & Lounsbury, 2008).

Device Level Ring design and operation

A second method, and the focus of this paper, is the implementation of a Device Level Ring (DLR) topology, which provides network redundancy without requiring a second network infrastructure be installed. DLR topology connects the control system into a loop whereby there are always two paths to every device, and a single break cannot cause the network to lose communications with vital devices. Implementation of DLR requires that all devices are compatible with DLR protocol, or have an intermediary module to make them compatible. DLR compatible devices have two Ethernet ports, and have some embedded switch technology to reduce the need for external switching. This capability can be built in to the device by the vendor, and marketed as DLR compatible. In the case of a legacy device made prior to DLR protocol, or a specialty device from a vendor whose products are not DLR compatible a communications module can be installed to manage interfacing with the network. These modules can be referred to as DLR Taps, or E-Taps depending upon the vendor. The Taps have three connections, two for the DLR connections, and a third output that connects to the device. The switching capability is designed into in the Tap (Cisco Systems, Inc. and Rockwell Automation, 2017).

Figure 1 shows an example of a simple five node DLR configuration for an industrial control network where a ControlLogix Programmable Automation Controller (PAC) is operating two AC motor drives. Operator interface data is displayed on the shop floor via a PanelView Graphic display (commonly referred to as a Human-machine Interface, or HMI), which is connected to the DLR via an interface module, or tap. The motor drives are assumed to be performing a function critical to the operation. The DLR network is connected back to the DCS through a DLR tap to a port on an industrial switch. At this point the system reverts to a more traditional Star Ethernet topology which connects back to the enterprise operation and to other independently operating control networks.
Modern DCS often have critical mission operations which cannot be allowed to fail without unacceptable consequences. Redundancy of components is a commonly used tool which can allow for inevitable equipment failures without collapse of the process control. Of equal importance is the resiliency of the network which interlinks all the components, it must not only have the ability to generate an awareness of the fault point, but also to heal itself and remain in operation until maintenance to restore normal operation can be effected. One effective, and economical, tool for accomplishing this for smaller networks is the DLR network protocol.

Figure 1: Example of a simple DLR industrial control system to operate two motor drives
References


ODVA, Inc. (2017). PUB00316R0: Guidelines for using Device Level Ring (DLR) with EtherNet/IP. Retrieved from ODVA:
https://www.odva.org/Portals/0/Library/Publications_Numbered/PUB00316R0_Guidelines_for_Using_Device_Level_Ring_(DLR)_with_EtherNetIP.pdf


Tang, S. (2015, March 24). Advantages of Ethernet vs SONET/SDH. Retrieved from TC Communications: