Inquiry in Differential Equations: A Teacher’s Reflections

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Traditional DE

• “Typical” Classroom
  • Terminology, Definitions, Classification
  • Closed form solutions to DEs
  • Emphasis on modeling/solution/computer analysis
  • Lots of independent work

• “Typical” Outcomes
  • Weak conceptual understanding
  • Recipe-driven philosophy
  • “Mile wide, inch deep”
Inquiry DE (Research)

• Inquiry-Oriented Differential Equations (IO-DE)
  • Realistic Mathematics Education (Freudenthal, 1991)
  • Emergent Models Perspective (Gravemeijer, 1999)
• IO-DE (Chris Rasmussen & colleagues)
  • Open-ended, contextually-based tasks
  • Classroom negotiation of meaning
  • Terminology/main results emerge through group work, whole class discussion, oral presentation, etc.
• Similar approaches are being implemented in the teaching/learning of linear algebra (e.g., Wawro, Rasmussen, Zandieh, Sweeney, & Larson, in press)
Inquiry DE (The Reality)

**YES**
- Guiding students with questioning, prompting, and useful feedback
- Asking for reasoning and justification
- Listening to students: Using their ideas to teach
- Open-ended instruction...sometimes unpredictable

**NO**
- Sending students down aimless pathways
- Hand-holding
- Discovery learning
Typical Day in IO-DE

• Assign a recorder. Give the groups a task. Discuss the task to ensure everyone understands the purpose of the task as well as what they are required to produce.
• Groups begin working. Teacher navigates from group to group, steering groups back on course if necessary.
• Near the end of class, several groups present their findings. Students are encouraged to critique other groups’ work and to ask questions.
• Teacher makes summative remarks connecting the different presentations.
• The next day: All classmates get a record of the day’s events.
How Many Bugs?

A group of biologists is studying a particular bug population in a rainforest. They gathered data about these bugs for different population values, \( N \), at different times, \( t \). The scientists reasoned that the rate of change depended only on the population and not on time. They approximated the derivatives \( \frac{dN}{dt} \) (as was done with the cooling coffee from before) and plotted \( \frac{dN}{dt} \) versus \( N \), as seen below:

![Graph of dN/dt vs. N](image)

For the following initial population of bugs, use the above graph to predict what the ultimate fate of the population will be. Describe (in words) the long-term behavior of each solution corresponding to the given initial condition. In addition, illustrate your conclusions with a suitable graph.

a) \( N(0) = 2 \)
b) \( N(0) = 3 \)
c) \( N(0) = 4 \)
d) \( N(0) = 4.5 \)
e) \( N(0) = 6 \)
f) \( N(0) = 8 \)
Student Work

Example: for $N(0) = 4$, $N(t) \rightarrow 6$ (increasing)

Diagram:

- Vertical axis: $N$
- Horizontal axis: $t$
- Points: (0, 4), (3, 3), (6, 6)
- Arrows: pull, push
Barriers to Inquiry

Resistance from students
- Students like lectures, spoon-feeding, etc.
- Students want the teacher to organize the content

Lack of time
- Inquiry takes far longer to implement
- Coverage is slow but more in-depth

Teacher discomfort
- This is not traditional “teaching”
- Spontaneity can be threatening
- To be successful, teachers must give up some authority (not to be confused with subject-matter expertise)
Reactions from Students

• I like this class because it makes me think more. It’s different from other math classes that I took before.”
• “It’s neat to hear what other groups came up with. I’ve always been used to ‘my way or the highway.’”
• “I’ve never done math like this. It is very interesting.”
• “This is sweet as hell. Instead of telling us how to think you let us figure out how to approach the problems.”
• “I actually remember this stuff later on and I’m not bored.”
Personal Reflections

• The bottom line: Inquiry is HARD.
• Inquiry requires deeper content knowledge on the part of the teacher.
• Adequate knowledge of how to teach mathematics effectively (e.g., Pedagogical Content Knowledge) is critical to successful implementation of inquiry-oriented instruction (Rasmussen & Marrongelle, 2006; Wagner, Speer, & Rossa, 2007).
• Inquiry is slow to unfold & assessment is messy.
• “Coverage” results in knowledge that is qualitatively different from what results in “traditional” instruction.
• Students might not “get it” at first. Be patient!
Questions?
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