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

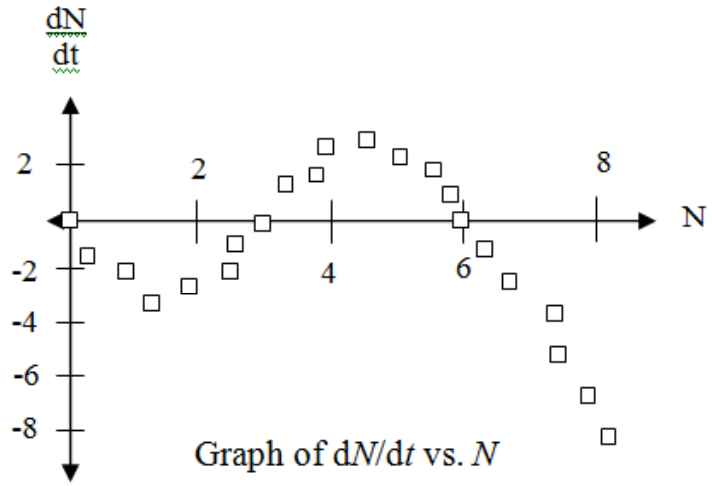
- Sending students down aimless pathways
- Hand-holding
- Discovery learning

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:

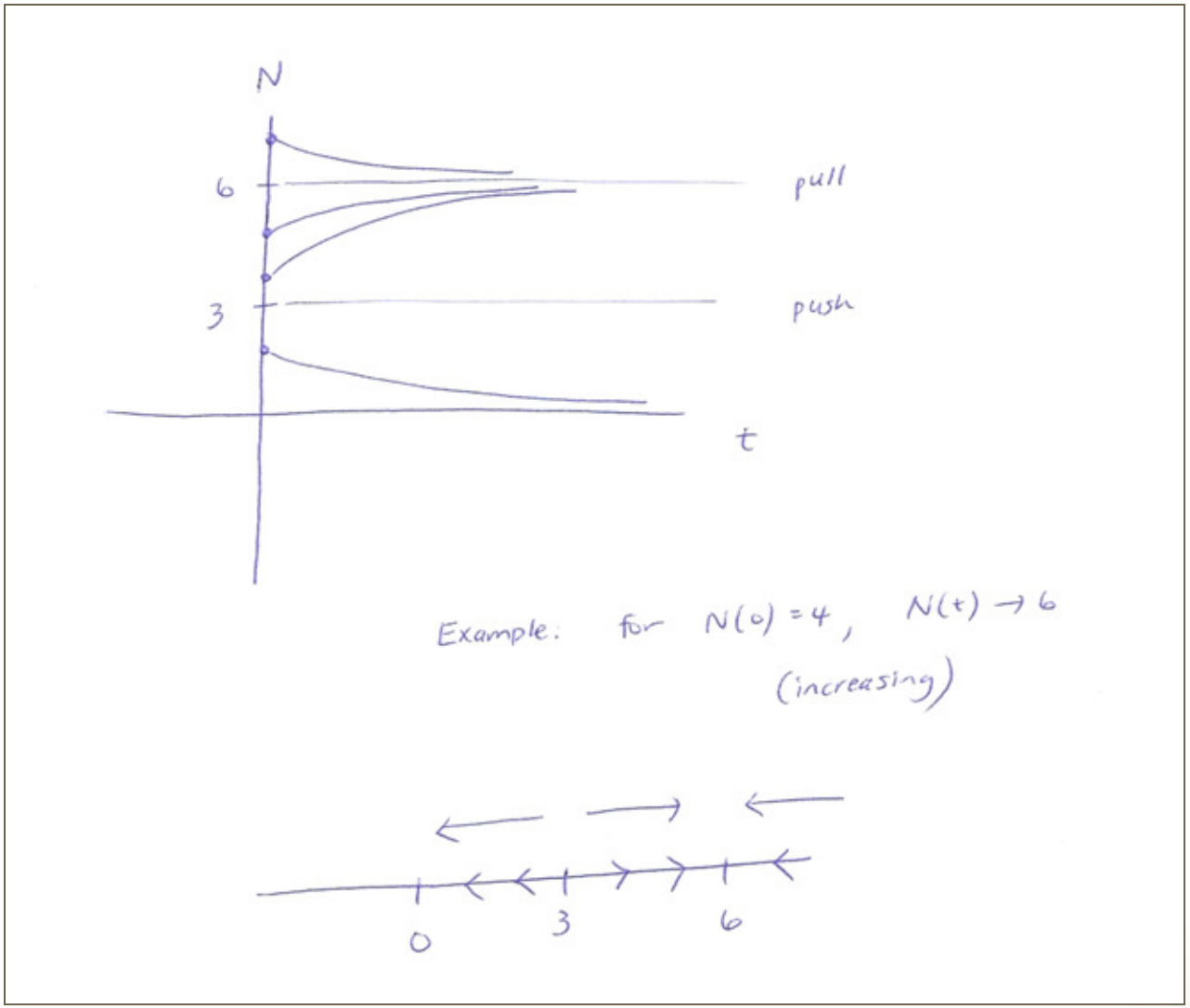


Graph of dN/dt vs. N

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



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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