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Why not both?

Indiana University-Purdue University Indianapolis

The Teaching – Technology Linkage in Mathematics
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Why not both?

In planning a college curriculum, or just a course, we must consider three aspects of the endeavor,

- **Teaching**

- **Subject matter**

- **Learners**

and the interactions between these objects of our thought.

This presentation will explore the effect that technology has had, is having, and should have on each of these aspects of our interest.

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What about your colleague who does not use technology?

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NONSENSE, we all use technology, it's just a matter of what technology we choose to use!

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"COOL" is not the point!

For me, it is about mathematics – not about "COOL"

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Our use of technology in teaching should have the goal of enhancing our students' understanding of the mathematical concepts or facilitating our students' learning!

In reflecting on our use of technology and the effects of technology, this should be our primary concern.

I want to mention just two ideas about use of technology in teaching for your consideration.

First,

I believe student errors deserve more of our thought than we often give them – one obvious reason is that students' errors give us clues as to what they are thinking and how we might change our teaching.

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But, in addition, students' ideas about errors interfere with their learning!

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Students' ideas about errors interfere with their learning!

Let me explain,

and let me explain how I use technology
to help overcome the problem.

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Students bring to our classes ideas about themselves and about us – as to our expertise in mathematics.

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Often, students believe that someone who knows mathematics well (like us) sees how to answer every question immediately and never makes conceptual or strategic errors in solving problems.

In particular, they sometimes infer that they are 'no good' at mathematics because they do *not* see how to answer every question immediately.

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We *know* we do *not* always see the way to the solution of every problem and that we make errors –

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One of the most important things we can help our students learn is to recognize errors in their thinking, and after discovering an error, how to recover from it.

To do this, we need to *model* recovery from errors in our classes.

An Example

In teaching linear algebra, I get students to guide the solution of example problems.

Pre-technology, I would have worked out the example before class…

Now, post-technology, I have a computer linear algebra tool available during the entire class.

I still get students to guide me in the solution of example problems…

With the computer tools available, together, we follow
student proposed solution attempts
either until we have solved the problem,

   or,

until some student has recognized we have made an error.

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until some student has recognized we have made an error.

We can then discuss how we knew there was an error,
  and talk about strategies to recover from the error.

The goal:

to let students know that making errors is normal for all (!) and to help them see that what distinguishes success from failure is the ability to recognize and recover from the inevitable errors!

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Thus, if you believe use of technology is an important tool to help your students learn, then you need to incorporate the technology into your assessments.

To put it a different way, if you want your students to take seriously the technology you are using, you need to include it in your *tests*!

Curriculum

One of my main messages today is that changes in technology

    have changed our curriculum in the past,

     are changing it now,

      and *should* continue to change it in the future.

We will make these changes more effectively

   if we are *conscious* that this is happening

    and if we are *intentional* about making the changes.

The case of logarithms

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This is the *most* obvious change in our curriculum, and one of the fastest, caused by technology, but not the only one, or the last one!

The case of linear algebra

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Books in the '30's on modern algebra began to suggest linear algebra as a separate subject;
e.g. van der Waerden ('30-31), Birkhoff & MacLane ('41)

Dorier: Halmos "Finite Dimensional Vector Spaces" (1942) was first book on linear algebra for undergraduates.

Linear algebra began to be taught as a topic in courses on modern algebra in the 1930's, and as separate courses a few places in the '40's.

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I believe the creation of this course as a separate entity, and its transformation from abstract to computational have been driven by the changing technology!

Other earlier cases

Formulas → Algorithms: 19th century mathematics focused on getting formulas as the solutions to problems of all kinds. Now, it has become clear that algorithms for finding good approximations to the solution are much more likely to be satisfactory than theorems giving formulas for exact solutions…

The Rivest-Shamir-Adelman scheme for cryptography has produced a huge rise in popularity of teaching Euler's Theorem and number theory more generally…both as part of an abstract algebra course and as a free standing course.

A current case

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Many questions arise: how are the biosciences changing? what kinds of mathematics will our students need to help? how will other mathematical sciences be impacted? …

~~A current case~~ A future case

Biotechnology?

BIO 2010 – a report from the US National Research Council …

~~A current case~~ A future case

Biotechnology?

BIO 2010 …

BIO 2010 suggests that we in the academy must reinvent our mathematical science and physical science curricula for bioscience majors…

How can we help our bioscience students become familiar enough with the broad range of mathematical sciences they need to be able to communicate with experts in the mathematical sciences?   How much math do they need? What kind of math and how much time do they need to learn it?

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~~A current case~~ A future case

Biotechnology?

BIO 2010 …

Does BIO 2010 have implications for other of our students?

Do our math majors need to have some different courses because of these changes? Do our physical science students need different math courses because of these changes?

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Biotechnology?

BIO 2010 …

Does BIO 2010 have implications for other of our students?

Do our math majors need to have some different courses because of these changes? Do our physical science students need different math courses because of these changes?

For the most part, our institutions don't have a good way to begin these conversations!

Other future cases

Databases?   What kind of mathematics will become important because of the rise in importance of large databases? for whom should we prepare this material?

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Information security? What kind of mathematics will become important because of the rise in importance of information security? for whom should we prepare this material?

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There are many hard questions that will arise!

It is clear (?) that there will be many more questions addressed in non-deterministic ways in the future than now…

How should our curriculum change to better prepare our students to address these problems?

Generally, how should we be thinking about our curriculum so that we recognize changes in technology that might affect the curriculum

and then,
  how do we find effective responses to these important changes in technology?

Students

My final message today is that students now are much different than we were!

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for them Ronald Reagan is just another dead US President!

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My final message today is that students now are much different than we were!

They are so young! We have experienced so much that they are ignorant of…

 for them Ronald Reagan is just another dead US President!

BUT – much more important,

   THEY have experienced so much that WE are (might be?) ignorant of…

Students

because of technology,

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… that is, different *as learners* than we might expect!

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➢ Email example

That is, rather than
  "They are so young, they don't know who Reagan is!"
the *important* point is

  "I am so old, I don't even use IM"

An often repeated, but important truth is

"We must teach the students we have, not the students we *wish* we had!"

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But our students were *born* with technology spoons in

their mouths!

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An often repeated, but important truth is

"We must teach the students we have, not the students we *wish* we had!"

Because of changes in technology, our students are "digital natives" – they've grown up with computers; they're comfortable with calculators,
with PowerPoint,
with the Web,
with IM,
with iPods,
with Wiki, with Blogs,
with YouTube, with Second Life,
with Facebook, with multi-tasking, …

… and they expect their learning environment to be comfortable with those things, too!

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Recently attended an on-line workshop (not specific to any discipline) entitled

  "Syndicating the Learning Process:
    Pods, Blogs, Wikis, and Writely"

intended to inform educators about the potential of teaching with these electronic tools.

At future professional conferences, there will be talks on how to use these tools for teaching mathematics.

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How can we take advantage of the fact that our students are "digital natives" –

can we use computers and calculators,
  can we use the Web,
    can we use iPods,
      can we use Wiki technology,
        can we use YouTube,
          can we use Second Life,…

to engage the students and help them learn mathematics?

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Our students will be comfortable with using these tools, so we have the potential to increase our effectiveness by incorporating them in our courses.

But, today, I want to concentrate on how their comfort with these technologies has changed their expectations and changed them as learners.

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Important changes I sense:
        impatience
        a "just in time" approach

The web makes everything available "instantly" and our students use the web to get music, new acquaintances, and information on many subjects every day…

I think this has led to a "just in time" attitude – when I need it, I'll get it (and not before then!)…

Our curriculum, our classes??

We must ask ourselves questions about our curriculum, our courses, and our expectations.

Is it really true that we must learn Algebra I as 8th graders so that we can learn Calculus as 12th graders?

How can we keep students' interest up with so much delayed gratification? Can we convince them the wait is necessary and worth it?

Students from U Illinois in a technology based calculus course asked their professors, Jerry Uhl and Debra Woods: "How much of this do you want in our heads as opposed to in our computers?"

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Can we design courses that build in substantial foundational pieces to be added "just in time" and still accomplish the real work of the course?   Is it fair to make the foundational stuff the responsibility of the student?

Will changes that we might want (need?) to make involve a loss of traditional learning and subject matter competence?
    If so, can that be justified by new achievements?

Is multi-tasking the same as a lack of ability to concentrate?
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Is multi-tasking really more efficient?

I don't have answers to these questions!

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How can we use the new strengths of our students to improve our success in helping them learn mathematics,

and how can we compensate for the new weaknesses of our students so that they can learn in spite of these hurdles?

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- **Availability of technology changes the learning environment, including the learner, and we should be conscious of these changes as we develop strategies for our teaching**

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Conclusions: Teaching, Technology *are* linked

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- **Appropriate technology is a good teaching tool when used to enhance student understanding**

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- **Availability of technology changes the learning environment and we should be conscious of these changes as we develop strategies for our teaching**

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Presentation will be available on my webpage:

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