USING TECHNOLOGY TO PAIR COGNITIVE DEMAND OF TASKS TO ITS' APPROPRIATE COMMUNITY IN A MATH CLASSROOM

Technology in Practice Strand

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1. Abstract

How is the mathematics teacher to best utilize the latest accessible advancements in technology to motivate and foster perseverance and tenacity in students? Pedagogically, what approaches will yield the most fruitful dynamic as regards the balance between class time (community) and homework (individual), given that many students benefit more from the struggle within a community of learners when first facing new, incrementally more difficult material, and when the normal amounts of conventional class time allotted are rarely adequate.

To what degree can the integration of technology as such enhance learning? Would a given teacher's individually created multimedia (i.e. videos with pen and tablet technology, screen casting, and reflective questionnaires within Google forms, etc.) effectively create more time such that the students can address higher cognitive tasks more often while in the classroom community?

2. Problem Statement and Context

High-school students entering a given AP calculus course often struggle in applying skills and knowledge to new problems. Generally, calculus students have succeeded in their previous math classes by following the algorithmic processes that were modeled by their teachers (e.g. knowing and memorizing procedures, etc.) But when they begin the study of Calculus, a markedly different set of skills is required of them. Students are expected to analyze, interpret, conjecture, justify, and apply their skills verbally, graphically, and analytically. Such higher-order thinking requires perseverance and tenacity. To teach, model, and give opportunity for the students to develop these higher-order thinking skills the instructor needs to free up classroom time by spending less of it delivering direct instruction on knowledge-based content. Similar to the teaching dynamic often utilized in humanities classes, AP calculus teachers can – and this paper will argue *should* -- assign lessons for students to study outside of class, and then, in the classroom, engage students in tasks and discussions that require interpretation, analysis, and the overall more intensive levels of content creation. Normally in the mathematics discipline, this model would be more difficult to implement because of (1) time limitations, and (2) the need to present and model content; however, innovations in easily accessible technology (like virtual pen and tablet technologies, and others) make it possible for students to access a given teacher's presentations of assigned content outside of class. Pragmatically speaking, the AP calculus instructor thereby *creates* time, or at the least, reaps a far more effective use of the time allotted.

3. Method Employed

In spring of 2011, I awoke to the disheartening reality of being a 20th century educator teaching mathematics in a 21st century world. An ever-increasing deluge of advances in accessible technology had raced so far ahead of me that I was missing opportunities to more fully engage my students. In March of 2011 I attended my first annual conference of Computer-Using Educators (CUE) where I learned the benefits of tools like virtual screen casting, Google documents, and Flip-teaching. In July, I attended a weeklong session at Pepperdine University with the organization Teachers Create where I was introduced to the tools, skills, and opportunities necessary to create curriculum related videos, which would align with my content standards. Continuing this path of professional development during the ensuing academic year I attended monthly meetings with Teachers Create, the annual CUE conference in March 2012, a summer session with Teachers Create, and a subsequent CUE conference in July 2012. These experiences challenged me to rethink my pedagogy as regards designing units of study and using technology as a tool to more effectively develop students who are tenacious problem-solvers.

For example, I have been using pen and tablet technology as a tool to pair the learning activity with the learning community. As presenter and teacher, Ramsey Musallam, suggests, I examine the level of cognitive demand (as aligned to Bloom's taxonomy) of given content tasks in a unit and pair it/them appropriately with either the classroom community or the individual setting. Where a skill or concept can be learned through direct instruction without requiring the classroom community, I will create and upload a student accessible video using pen and tablet technology, assigning the viewing of the video and student reflection as a homework assignment. The next class will include a short discussion analyzing individual student responses to the video followed by a task(s) of higher cognitive demand that requires, and benefits, the classroom community.

While planning a unit on solving optimization word problems in my Calculus class, for example, I examined the content objectives, the assessments, the research on problem solving, and representative problems. I then aligned it to Bloom's taxonomy as diagrammed below.

<table>
<tr><td>Create</td><td rowspan="6">Optimization project – create a product with given conditions
Given a new optimization problem, students are able to apply knowledge of derivatives, solve, and interpret their answer.
Model given information with a function
Apply the problem-solving process
Understand that extrema occur at critical points
Find the derivative of a function
Learn the problem-solving process of Question, Clarify, Strategize & Solve, and Check.</td></tr>
<tr><td>Evaluate</td></tr>
<tr><td>Analyze</td></tr>
<tr><td>Apply</td></tr>
<tr><td>Understand</td></tr>
<tr><td>Know</td></tr>
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For the knowledge-based skills (i.e. finding the derivative and using critical points to find the extremas of a function) I used a SMART board to record several lessons for the students, which gave examples with solutions already worked out. In the past I have also used a Wacom Tablet or iPad to record my lessons. I subsequently upload these videos to our class website for student access. After viewing the videos, the students are then responsible for submitting responses to a Google form that I created, which is embedded on the class's website. The questions in the Google form require students to reflect on their understanding of derivatives and critical points and to solve problems similar to those presented in the video. Their responses provide an excellent starting point for class discussion on the following day. As a class, the students will engage in error analysis as I display their responses to the Google form on the SMART board, and I can address any misconceptions in their understanding prior to applying the skills that day.

I also used pen and tablet technology to create instructional videos introducing a problem solving protocol and modeling the implementation of this protocol in solving optimization word problems. In my research on teaching problem solving, one of the consistent elements of student success is that students are taught a protocol based on reading-comprehension and given ample opportunity to use this protocol in problem solving. By creating these videos, the students then come to class the next day with a foundational understanding of the problem-solving protocol and how to solve optimization word problems. Classroom time is then freed up so that students can spend this time solving new problems in a collaborative environment.

I also use pen and tablet technologies to hold virtual conferences for review sessions at the end of a chapter. Typically, I will plan on using one class session to review content prior to a chapter test, however, during this time, there is always conflict between the students and myself as to how to spend the time. I want to facilitate student groups collaborating on cumulative problems as they review the learned skills of the unit. The students typically want to spend the time asking individual questions to assigned review problems. As a result, the review sessions end up stretching to two class sessions instead of one class session. In order to maximize the effectiveness of class time, I have started using an online application, Canvas by Instructure, as a tool to host review sessions at the end of a chapter. This is a free resource for teachers. I create a class, invite my students to join the class, and then set a date and time for a virtual conference. In the sessions, students can log in and can ask questions. I upload a blank page to the site and use a Wacom tablet to answer the mathematical questions of my students. As a result, I can meet the needs and desires of both the students and myself by spending one class session working on cumulative problems and one virtual session answering the individual student questions.

I have repeated this cycle of unit planning for several units this semester. For my presentation, I will include samples of videos that I have created using pen and tablet technology, student questionnaires linked to these videos, and a review of our class website.

4. Results and Evaluation

While the anecdotal evidence constituted by students' thank you notes and their affirming reports to fellow teachers and parents indicates how helpful the videos have been, it is difficult to directly, or conclusively, link or quantify perceived gains (academic and otherwise) to the technologically enhanced approach to teaching discussed herein – at least it is for me at this time.

However, my chapter tests rose about 5% this year over last, and my most recent AP Calculus AB results are historically high for our school, but these results could, of course, also be effected by other variables.

As of this writing, in the second quarter of my current classes, I still have students complaining about "how hard AP calculus is," and how they know the rules but have a difficult time answering the questions.

After the first month of originally implementing this technologically enhanced approach to teaching, I had observed that it was necessary for students to not only do problem-solving in the collaborative community of the classroom but also independently (outside of class). My initial mistake in this regard was having the students do most of the problem solving in class and very little at home. The students thereby gained confidence while working with their classmate – which was fantastic -- but when given individual assessments, their individual scores did not align with their level of competency demonstrated in the classroom. So I did, of course, adjust the pacing and homework assignments to include more individual practice of problems similar to those that I observed being solved in class.

5. Future Work

Given the wide accessibility of the technologies discussed herein I envision a multifaceted expansion of technologically integrated methods and memes, including students' use of technology (and whatever follows in its wake) to create their own collections of instructional videos. For instance, prior to an Advanced-Placement exam, I would like to assign free response questions to pairs or groups of students where they create a video, which presents their solution(s). Such groups would also benefit by creating an accompanying questionnaire to each video. Subsequently one might even have students provide feedback evaluating their classmates' videos probably based upon a teacher-created rubric.

6. References

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