AN INTERACTIVE LEARNER-CENTERED CLASSROOM: SUCCESSFUL USE OF TABLET COMPUTING AND DYKNOW SOFTWARE IN FOUNDATIONAL MATHEMATICS

Technology in Practice Strand

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1. Abstract

Community college students in foundational mathematics programs require innovative instruction using techniques that resonate with individual learning styles. A synchronous workspace is provided using pen-based tablet PCs and DyKnow collaborative software. Students meet teachers and fellow classmates face to face as well as in a web-enabled environment within the classroom. The interactive features of the software allow for group interaction, self-paced learning, immediate feedback, and sharing of the teaching role to stimulate student engagement. In this active-learning space, weaker students develop the confidence to become part of the learning community due to the anonymizing features of the software. This follow-up project with a larger college class size confirms the initial findings of a pilot study exploring the use of this instructional methodology to improve student success. Grade data suggest that students are more successful completing this course. Student comments elicited by survey questions give a greater understanding of why participants feel tablet PCs and DyKnow enhances their learning.

2. Problem Statement and Context

Pen-based computing provides a unique opportunity for students to take electronic notes when learning mathematics. Writing with a stylus gives students the ability to brainstorm solutions and annotate important concepts with the familiar 'pencil on paper' input. However, simply having advanced technology may not be sufficient to engage students in a subject they may be reluctant to learn. A certain level of mathematical skill and confidence is required to successfully complete college technician/technology programs. Those entering first semester foundational mathematics courses have a wide range of backgrounds and experiences. Re-teaching concepts in a traditional way may have little or no effect on students who believe they 'can't do math'. After several years of observing foundational mathematics students in the classroom, I noted they demonstrate certain tendencies: an assumption their answer is incorrect, a reluctance to seek help, and a fear that peers or teacher may discover their lack of understanding. An interactive collaborative teaching approach may help students overcome some of these predispositions.

In 2008, Seneca College received an HP Technology for Teaching Grant which became a catalyst for several projects aimed at evaluating how technology can best be used to increase student learning and engagement. The uniqueness of our project was to go beyond establishing a laptop laboratory which at that time was not uncommon in higher education institutions: we wanted to develop an online learning community within the classroom. The purchase of

DyKnow Vision collaborative software allowed teachers and students to connect in synchronous two way communication. A pilot study using 20 tablet PCs and DyKnow software provided a convincing argument that this interactive, learner-centered environment resulted in a student perception of increased engagement (supported by increased attendance, persistence in the program, and positive survey answers) and greater success/personal achievement (measured through grades and surveys) [1].

The College Mathematics Project (CMP 2007-12) [2] had found that at least one-third of all students taking first semester mathematics courses were at risk of not completing their chosen program. Since 2007, prospective students take a Canadian Achievement Test (CAT3) and those with a lower score enroll in the Foundations for Technical Mathematics (FTM) course. Those required to take the FTM course may have little confidence in their mathematics abilities, weak language comprehension skills, or a combination of both. Consequently, the goal of this course was to strengthen skill level and enhance students' knowledge to improve success in math-reliant technology courses. As the above mentioned pilot study had a positive outcome, the next logical progression was to use this instructive methodology for FTM courses. The focus of the current study was to determine the effectiveness of using tablet PCs/DyKnow software for learning mathematics in a more typical college class size (40) and to establish if previous results were reproducible.

3. Method Employed

The study was carried out over four semesters from September 2010 to December 2011. The FTM course was offered at two campuses located 17 km (11 miles) apart. Students chose their campus based on career path. One campus was designated as the experimental group, with students in applied science (Biochemistry) disciplines. At the other campus, the control group was made up of students in engineering science (electronics, built environment, advanced technology, fire protection, and aviation). Teachers at both campuses used the same subject outcomes and mark allocation. All students in the FTM course wrote a common final exam. Grading in this non-credit course was calculated as either FAIL (<55%) or PASS. Final grade data were reviewed only from students that gave consent. Surveys to determine use of technology were administered during week 12 of the 14 week semester. In the experimental groups only, students answered additional questions pertaining to the use of tablets/DyKnow in the classroom. The data collected were of two types: twelve questions with closed Likert responses of strongly disagree, disagree, agree and strongly agree and eight open-ended questions.

Teachers in the control group taught using a tablet PC/electronic podium or whiteboard. Students took notes on pen and paper in the traditional manner, often bringing textbooks to class as required by the instructor.

Students in the experimental group had classroom access to the tablet laboratory and instructors taught at least 90% of class time using DyKnow in ways similar to the pilot study. Several features of the software promote active learning, which helps students develop their self-confidence. The anonymous poll feature focuses students on the subject matter and initiates discussion. Teachers receive individualized and immediate feedback from students by asking

them to send their ‘status’, ‘submit panels’, or to ‘chat’ directly. The status icon lets them send a red (‘don’t’), yellow (‘a little’), green (‘well’) stoplight to indicate their level of understanding. In practice, it is best to begin by requiring students to respond using the ‘request status’ feature. Eventually, students will automatically send feedback (e.g. ‘red’); they may want additional problems solved without alerting the rest of the class. Teachers ask students to ‘submit panels’, giving the opportunity of collecting class work electronically. The retrieved panels are added to the class notes, or saved to be returned at a later time. When added to class notes, student solutions are discussed and annotated in real time, providing multiple examples. By viewing other responses, weaker students realize they may not be alone in their misunderstanding. Many use the panel submission without being prompted – they like the immediate feedback without the necessity of identification. Finally, the ‘chat’ feature gives students the ability to connect with classmates or ask questions directly of the teacher.

For students in the FTM course, this anonymity may enhance their willingness to participate in class. They can be placed in online groups so answers that are difficult to achieve independently are shared and supported by group understanding. The teacher can ‘share control’ of the classroom screen by designating a willing student to ‘ink in’ their solution. While sitting at their own tablet, one or several students can demonstrate their approach, providing an answer that may closely resonate with other learners’ styles. In this way, students become the ‘temporary teacher’, which places greater emphasis on being responsible for one’s own work. In addition, students determine the pace of their learning. The teacher can make the entire session of panels available and students can scroll back or forward at their will. This is useful in a subject like mathematics where repetition is required to develop competence, but can be ‘time wasting’ or even ‘boring’ while all students achieve their understanding. This dynamic classroom complements the learning style of our students by using the collaborative/interactive features of the software. Students save this consolidation of notes that accurately reflect the classroom experience to a server, which they access from any web-enabled computer. Further, once notes are saved, they can activate the ‘replay’ icon and watch each panel be completed in a stroke-by-stroke fashion. As step-wise problem solutions aid in understanding, this feature is beneficial. It was assumed the anonymity of response is one of the most desired features of the software – students can participate without feeling centered out until confidence in their abilities is restored or fortified. In this setting, experienced teachers guide students to interact with appropriate digital media and learning activities. This affords students a variety of approaches to become skilled with challenging mathematical concepts and provides opportunities for teachers to identify common errors as well as exemplary approaches.

4. Results and Evaluation

4.1 Student Success

Data were collected from 9 sections of experimental groups and 20 sections of control groups. Out of approximately 900 students, 59% gave consent to use their grade data. As indicated in Table 1, an analysis of grades showed that, by comparison, students in the experimental group were more likely to be successful achieving a passing grade (SAT).

Grade	Experimental	Control
PASS	79%	74%
FAIL (<55%)	21%	26%
Total Studied (consent)	180	335
Total Enrolled	291	583

Table 1: Grade Data

4.2 Survey Excerpts

Students in both groups were given the same technology survey and 63% of all students responded (57% of the control group and 76% of the experimental). Those in the experimental group were asked additional questions regarding the specific use of this instructive methodology. Student response of strongly disagree, disagree, agree and strongly agree were aggregated into agree/disagree responses, as illustrated in Table 2. At least 60% of students agreed that having the ability to interact with fellow classmates and getting immediate teacher feedback helped them pay more attention, participate in class discussion, increase their understanding, which in their opinion, helped them to improve their performance and grades.

QUESTION: The pen based tablet PC and Dyknow software ….

Answer Options	Agree	Disagree
was an effective tool for classroom presentation and note taking	74%	26%
helped me to be better organized in coursework	58%	42%
helped me to pay more attention during classes	65%	35%
helped me to participate in class discussion	72%	28%
improved my interaction in class by having the ability to "share control" to display my work	71%	29%
changed the way I approach learning	65%	35%
helped to improve my understanding by being able to submit panels and get instructor feedback	74%	26%
helped me to improve my performance/grades in this class	61%	39%

Table 2: Likert Scored Answer – Survey Question 20

Students in the experimental groups were given the opportunity to express their opinion in response to the following open-ended questions:

1) *Please let us know some of the ways that using tablet PCs and DyKnow software helped or made learning more difficult with respect to: notetaking and organizational skills, attention/motivation, participation in class, learning experience, attendance in class and persistence to complete the course.*
2) *Finally, in what ways did the tablet PC/DyKnow change your class experience?*

Analysis of student comments is continuing, however, trends in response can be used in context to gain insight as to how the tablet PC/DyKnow methodology may be effective. Many instructors teach mathematics in the way they were taught - today's students want more flexibility in their learning environment. *"Using the pen on screen was more interesting than making notes with pen and paper."* and *"I started enjoying math lecture just because of such software…"* indicated that they feel they benefited from the use of this technology. Students in the tablet/DyKnow classroom felt that *"Dyknow is the best notebook I can have…"*, *"It's easy to take notes…" , "made me more organized"* and "*Theres more time to understand the lecture because i don't have to worry about writing the questions."*

Many commented about the learning experience *"It change my perspective because before I don't wanna go coz its math but now that we don't write lectures it eagers me to go to class".* They were able to set their own pace for learning as *"If I was ever unclear on an item I can easily go back a few slides and take a glance at it…"* and *"because I had my personal screen I looked at things for as long as I wanted".* This learner-centered environment resulted in student perception of enhanced engagement as *"it grabs my attention", "kept us using and paying attention all along. It made math fun"* and *"I pay attention to class more because of how the lessons are displayed"*. One student wrote: *"IT MAKES US CONCENTRATE IN ALL ACTIVITIES!"*

Performance increased measurably and comments such as: *"…I was able to get my individual need met",* "*made my self-esteem go high"* and *"participating in class made my mark go up"* indicated this active learning environment encouraged critical thinking skills and improved comprehension. Comments like *"Its makes everyone understand …and learn from each other"* illustrated the benefits of a personal learning community and its positive impact on confidence. Using the software, the ability to receive immediate feedback helped to build student understanding by having their work regularly reviewed: *"I liked that we can submit work to the instructor to chec*k" and that it *"helped to include everyone … instead of a few people doing some examples in front of the class".* Hesitant students had the opportunity to become contributing members of the class community as they: "*can answer questions without anyone finding out", "it was easy to participate when no one knew who yu were…", "…No one is judging", "…many times students are shy askin or showin their work…using this technology minimises such stress…",* "*It allows me to participate without being embarrassed giving the wrong answer."*

Finally, comments revealed why student success rate may be higher: *"you dont have to study as much since youre participating so much in class", "made me get higher grade…"* and *"…Dykow make my mind clear what I need to do…"*. This collaborative practice made class time more interesting: *"class is more fun than the traditional math class room, math is usually very boring, students interact more often, there is more teamwork and student involvement in the lesson".* Of note, several students observed this was active learning, as the technology: *"helped to learn better because we had to do it while we learn", "made it more hands on",* and *"It enabled me to have a wealth of information at my fingertips…"*. Many students made reference to the fact that "*you can see the lecture close up"* as it was "*right in front of me*". This comment had not been seen previously in the pilot study, indicating students felt they learned better if the lecture was within their personal space.

Some negative student comments related to poor connectivity issues: *"The constant problems we encountered throughout the semester with connection, saving and other issues dampened the experience".* At issue was the requirement for 40 simultaneous wireless log-ins maintained for approximately two hours at a time. This issue has been addressed as the wireless infrastructure was updated earlier this year at our college. Some mentioned the need to block social media sites *"…because it is a distraction to individual learning".* Interesting to note that students wanted it blocked from themselves, because *"…the internet is addictive".* Personally, I do not believe this to be a solution. We prepare students for careers and they will need to learn how to control their

personal use of the internet. A final comment: *"I was skeptical about DyKnow at first, I hated[it] to be honest. Over time i learned that it is a great tool to use in the classroom environment. I still refuse to save my notes as i prefer to take down all notes by hand."* Some students enjoyed the interactive workspace, yet still preferred to have their pencil and paper notes.

With this leading technology experience, students are exposed to a learning/teaching environment that encourages the development of the mathematical skills necessary to be successful. Classroom observation demonstrates students are actively involved in problem solving using pens on tablet screen. Due to the anonymity the medium provides, students take risks, engage in discussion with peers, and feel encouraged to participate. As the class works together to take up student solutions, disagreements in process or answer result in lively conversation and sometimes a face-off of differing opinion to find the correct result. Note taking is a collaboration of teacher-provided framework, individual student solution and annotation, and class collaboration to determine correct explanations.

5. Future work

Data analysis from this study continues. This instructional methodology is being tested in other areas of the college, including other subject disciplines. Teaching in some sections of FTM is evolving into hybrid (mixed) mode delivery, based on feedback and lessons learned from this project. Further explorations using pen-based computing include the development of a screencasting library with videos produced by students and teachers. Through multiple external presentations of this work, Seneca is taking the lead to establish a collaborative group between our college and several others in southern Ontario to explore pen and touch technologies.

6. Additional resources

WIPTE contest video http://www.youtube.com/watch?v=il-k65CFqpE
DyKnow contest video http://www.youtube.com/watch?v=Hd7BsEF1x6g

7. Acknowledgements

This work is supported by the Faculty of Applied Science and Engineering Technology, Information Technology Services (ITS), and a grant from the Centre for Academic Excellence at Seneca College.

8. References

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