INTEGRATING THE TI-NSPIRE™ HANDHELD IN UNDERGRADUATE CALCULUS CLASSES: CHALLENGES AND IMPACT

Jane M. Wilburne
Ilya Shvartsman
Ron Walker
Penn State Harrisburg
777 W. Harrisburg Pike
W331 Olmsted Building
Middletown, PA 17057
jmw41@psu.edu

Calculus is traditionally a course that emphasizes symbolic manipulations to perform techniques such as differentiation and integration. Nowadays, the implementation of computer algebra systems (CAS) into these courses helps eliminate time spent on the "drudgery" of these manipulations and allows students to focus on the solutions and graphical representations of the concepts (e.g., Davis, Porta, & Uhl, 1994b; Heid, 1988; Palmiter; 1991; Tall et. al., 2008). The use of CAS in the classroom can promote rich learning environments where students focus on deep conceptual learning as defined by the National Research Council (NRC) in *How People Learn* (Bransford, Brown, & Cocking, 1999).

The increasing developments of technologies with computer algebra system capability impacts decisions regarding the curricula and pedagogy in calculus classrooms. New technologies typically require some training and practice in order for professors or teachers to feel comfortable in incorporating them into their lessons. The newest technology, Texas Instruments' TI-Nspire™ and TI-Nspire™ CAS handheld units, is no exception. The TI-Nspire™ handheld allows for multiple representations of concepts that are dynamically linked to allow for robust explorations and inquiries to help promote conceptual understanding.

The purpose of this study was to identify professors' and students' successes, challenges and impact when adapting new technologies into the teaching of calculus, specifically, the TI-Nspire™. The study analyzed the experiences and reactions of both the professors and undergraduate students learning calculus concepts with a dynamically interfaced handheld technology. Two mathematics professors (Professor A & B) each taught a traditional style calculus during a semester with four student-centered labs designed for use with the TI-Nspire™ included in the course. Forty students (19 in Professor A's class, 21 in Professor B's class) participated in the classes. Neither professor had taught calculus with a CAS system prior to this study, although one professor was familiar with *Maple*. Both professors teach the undergraduate Calculus I course in a fairly traditional

manner with a focus on students learning procedural knowledge (Hiebert & Lefevre, 1986) related to finding limits, derivatives, and integrals.

The professors' experiences and implementation of the TI-Nspire™ aligned with the four-stage process of growth in using technology proposed by Zbiek and Hollebrands (2008). The professors acquainted themselves with the capabilities and procedures to learn how to use the TI-Nspire (CAS) at a full day workshop run by Texas Instruments. The workshop focused on mechanics and capabilities of the handheld units.

Next, the mathematics professors met with the mathematics education professor to practice representing the various calculus concepts with the dynamic tools and split screen options available with the TI-Nspire™. They explored lessons and activities that are available on the Texas Instrument website (http://education.ti.com/educationportal/activityexchange/activity_list.do?cid=us) and tested their applicability to the calculus classes. The TI-Nspire™ CAS activities were used to supplement the traditional calculus curriculum in this study. The two professors collectively decided which topics would be taught with the technology. The professors also discussed the sequence of steps in the activities and the potential questions they would include to engage students in inquiry-based explorations. The activities downloaded were slightly adapted from the website for use in the calculus classes. They were selected primarily because of the dynamic nature of the activities and the visual representations incorporated into the lessons. The activities were integrated in several class sessions designed as labs. The conceptually-based lessons designed around the TI-Nspire™ were presented prior to the procedural knowledge skills that accompanied the concepts. For example, the students engaged in the slope of the tangent line activity with the TI-Nspire™ prior to the lecture on finding derivatives. Both professors used the carefully planned guided-discovery lessons and student worksheets that included questions to scaffold students' exploration and allow the students to work collaboratively. This enabled the professor to take on the role of facilitator posing questions to help students focus on the calculus concepts they were exploring. At the close of the class period, the professors posed questions to the whole group to help students reflect on the activity and make the necessary learning connections between the procedural knowledge of the lectures and the conceptual knowledge embedded within the TI-Nspire™ activities.

The labs included in the courses focused on the topics: slope of tangent line, calculating derivative of a function graphically, Riemann sum definition of definite integral, and optimization. The labs provided an interactive and relaxed social environment where students had the opportunity to discuss with one another about the calculus explorations and concepts. All students were provided with a handheld unit and copies of the calculus

lab activities. Students completed the labs in small groups with the professors assisting when needed. Class assessments did not allow students to use the TI-Nspire™.

Findings

Both professors viewed themselves from different roles throughout the study. Professor A saw his role as both a facilitator (Heid et al., 990) and explainer (Farrell, 1996) and Professor B saw his role more as a technical assistant (Heid et al., 1990).

Professor A:

> *I generally tried to let the students investigate themselves using the lab worksheet as a guide. (This allowed students to each work at their own pace.) At select points in time I would bring the class back together to discuss answers and key concepts from the lab.*
>
> *In assisting with the technology, I generally helped answer questions one-on-one as they arose. If certain questions commonly arose, I would give an answer addressed to the class as a whole. (The emulation software helped with this. However the lack of emulation software my first lab hindered this a bit.)*

Professor B:

> *I found it easier to be a facilitator when the activity was well planned and posed well written questions throughout the activity. More often, students did not pay attention to the commands and found themselves lost in the technology. Thus, I needed to play the role of technical assistant.*

Overall mean scores on the class exams for both professors were consistent with previous semesters where the calculus was taught with no technology. Common open-ended questions found on the exams showed students in the TI-Nspire™ sections referred to the visual representations they created with the TI-Nspire™ in their description of the meanings behind the Riemann Sums, graphs of derivative functions, and slope of tangent line. However, the mean score on the correct conceptual understanding of these questions remained the same.

Students commented that the TI-Nspire™ class activities promoted their learning in a different context than the lecture format alternatively used throughout the course. Working in small groups provided opportunities for them to discuss and share ideas and discoveries explored with the TI-Nspire™ CAS. This interaction enabled them to verbalize their thinking and help them make sense of the dynamic representations to visualize the concepts. They found the technology helped them understand the definition

of a limit better with a visual diagram as opposed to just a description of the concept that was provided in the textbook.

The undergraduate student's responded to several survey questions at the end of the course. Samples of their responses are provided below:

How did the use of the TI Nspire™ CAS enhance your understanding of calculus?

- *The graphical capabilities of it and the ability to adjust things on the spot for instant results helped display the concept.*
- *With the pre-programmed calculus lessons, it helped me to visualize the concept better.*
- *I could visually see the graph.*
- *Helped me to understand graphs.*
- *It didn't. It was too confusing to use and understand.*
- *I don't know how to use Ti-Nspire™, it didn't help me to understand the calculus.*
- *The TI-Nspire™ did not enhance my understanding of calculus.*

What was the greatest drawback to using the TI-Nspire™ CAS in the calculus class?

- *Well, if you didn't know how to use it, then that would be a very big drawback*
- *Too complex*
- *Hard to use not very user - friendly*
- *There was so much information on the device, it was hard to understand.*
- *Sometimes can't answer all the questions*
- *Relatively confusing.*
- *Too many buttons*
- *Many complicated buttons made it confusing.*

Implications

The use of the dynamic technology offered undergraduate students opportunities to discuss in small groups and manipulate various conditions associated with the context of the given calculus problems. The use of these informal explorations in a course can lead students to a deeper understanding of more formal definitions or procedures emphasized in traditional lecture-style classes.

Including the technology into a calculus course requires planning time to have students explore concepts with the TI-Nspire™. Professors may need to provide more technical instruction prior to using the handheld units for exploration activities. Students appreciate and understand the results better when professors discuss the lab activities prior to their small group explorations.

While the handheld unit lab activities created opportunities for the undergraduate students to make connections between the procedural approaches and concepts, there were limited opportunities for such explorations within the study. Ideally, the calculus curricula, pedagogy, and assessments should be revised to incorporate the technology effectively. There needs to be ample time for students to explore, explain, and reflect on their learning to help them make sense of the concepts and to integrate the technology effectively.

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