History of Clickers at Missouri S&T

Students who attend Missouri University of Science and Technology are, on paper, the best prepared of all the students in the state to pursue Science, Technology, Engineering and Math (STEM) degrees. Historically, they have the highest college entrance exam scores among public higher education institutions in Missouri with ACT scores that average above 27, high school GPA's with averages of 3.5 or better and a high school rank averaging higher than 80%. Yet, 10 years ago, a large percentage of them were doing poorly in an introductory required science class that more than 80 percent of freshman take during their first year at Missouri S&T. Instructors in this science class, Chemistry 1, were concerned that these students were ill prepared for the rigors of the curriculum they would face as they continued their STEM education.

Harvest Collier, former vice provost for Undergraduate Studies, had been teaching chemistry for 25 years at Missouri S&T, but in 2003 his concern about learning and success in Chemistry 1 reached new heights. There seemed to be a disconnection between what students actually knew and what faculty assumed students were learning. Final grades for Chemistry 1 for fall 2003 showed 38% of the students receiving a C, D or F in the class or withdrawing.

Chemistry 1 typically serves about 1,100 students per year in sections of roughly 150 students. Aside from the issues of the impersonal nature of a large lecture class, there were several other problems with the learning environment that Collier could point to: Students were often frustrated in trying to put mental images with the material presented; there was little time for questions due to the amount of material that needed to be covered (Collier, himself, often filled six chalkboards per class with material for students to copy), and, even when there was time for questions, very few students were brave enough to raise their hands to display a lack of understanding in front of so many of their peers.

Although early test performance indicated that many students did not understand the material, the bothersome lack of questions continued. Collier and other Chemistry 1 instructors could not discover if students understood the material until after the first exam, and that was often too late to help them recover and be successful. Many years of data showed that students who scored below 70% on the nomenclature exam, the first test of the course, typically received Cs, Ds or Fs as a final grade.

Collier also believed the problems with learning in Chemistry 1 were representative of a larger problem on campus. There was an urgent need to incorporate more active learning in the classroom, especially in traditional, large lecture courses at a rigorous technological school. These problems were compounded by student overconfidence from their previous K-12 educational experience and a lack of metacognitive awareness, especially not being able to identify when they had learned.

Collier and his teaching assistants began to look to new technologies for possible answers. About this time, the publishers of the chemistry textbook used at the time began discussing the use of personal response systems (colloquially known as “clickers”). Also during this time, the Center for Educational Research and Teaching Innovation (CERTI), a faculty
development center on campus, started up, and Collier and the committee together began looking into the clicker option.

A perfect laboratory for the experiment turned out to be the Minority Engineering Program (MEP), a summer camp of 25 under-represented minority students who were going to be incoming freshman the following fall and who were being readied for the rigors of college work. Collier’s chemistry MEP class had already begun when the clicker experiment got under way, so students were well aware of the six-chalkboard approach to learning and eagerly welcomed the change to mini-lectures, interspersed with clicker questions that involved peer discussion.

The technology hardware involved a loaner set of infrared response cards provided by Turning Technologies, then a start-up company that provided clicker technology to campuses and businesses. The company also provided the detector for the classroom, which was used to collect the signals from the response cards and feed the information to the software on the computer.

Collier discovered that the clickers were not only transformational to student learning but to his teaching as well. “Clickers changed the way I taught,” he said. “The student answers created confirmation of what students were learning” or – just as importantly -- not learning, and so could help direct his future lectures accordingly. Clickers provided a record of what students comprehended, which previously had been available only through exams and quizzes, making this information available almost instantaneously.

There were few outside resources to use as far as ready-made clicker questions, so when Collier could not keep up with developing clicker questions during the summer class and went back to the chalkboard style of teaching, students protested vehemently. They also encouraged him to use clickers when he taught the course in the fall.

The chemistry department agreed and decided to use clickers for all sections of Chemistry 1 in fall 2004, which meant four other instructors in addition to Collier would use the tool, affecting approximately 600 students. Results were quick and astounding. In the first exam of the semester, the scores for the test on nomenclature rose from an average of 65-70% in fall 2003 to 85% in fall 2004.

“At the time, it seemed pretty amazing,” said Johnathan Harper, one of the chemistry GTAs involved in the clicker implementation. He credited the clickers with doing several things to assist with learning, including encouraging attendance in class, keeping students engaged with the material, allowing students to recognize what they understood and what they didn’t, and also allowing students to see where they stood in relation to the rest of the class.

The difference in grade distribution from fall 2003 to fall 2004 included 18.7 percent more A’s in the class, 9.5 percent less Cs, and 5.1 percent less Ds and Fs. Fifty-two percent of students surveyed reported heightened engagement and interest in the lecture material. Chemistry faculty reported now having an early warning system to let them know if students were struggling well in advance of the first exam.
After the initial pilot in the chemistry department and interest generated in other departments on campus, the question to be answered was whether to deploy this tool more broadly. The CERTI faculty development committee recognized a number of issues that needed to be addressed:

- Who would be responsible for technology support -- the department or the instructor?
- Would the Information Technology helpdesk support the effort?
- Would departments have to change textbooks?
- Would students need to be charged extra fees? (Students weren’t purchasing their own clickers at this time; chemistry instructors loaned out clickers for their particular classes.)
- What about distance classes?
- Would clickers be outdated soon; should the campus look to purchase laptops for students instead?

Even with several of these questions unanswered, the preliminary results of data in summer and fall 2004 were significant enough to warrant looking at a full campus pilot of the program. Meg Brady, a project manager in the IT department at the time, joined the CERTI team and wrote a proof of concept plan for how to roll out the technology to the campus.

“We wanted this to be something that any faculty could do if they wanted to,” Brady said, which meant a tool equally accessible to about 400 instructors in 21 departments. “We wanted to guarantee success campus-wide.”

“Essentially, there were two projects,” Brady remembered, “clickers and projectors.” Fewer than 20 classrooms on campus had projectors installed, so from late 2005 through summer of 2006, classrooms began being outfitted with projector technology. By the end of 2007, presentation technology was available in all centrally scheduled classrooms.

The proof of concept document included a three-year campus roll-out plan of controlled growth, which Brady felt was key to the program’s success. A few interested, engaged and committed faculty members were invited to participate in the pilot, and that group would not be allowed to grow until all other support entities were in place to ensure success.

Brady’s plan projected that a range of 30% to 70% of students would be using clickers in the future, once the program went campus-wide. Support systems had to be set in place to accommodate that number of students and classes utilizing the technology.

“A lot of things were missing at the time we wanted to put some wheels under the clicker bus,” said Brady. “We certainly didn’t want it to crash.”

The provost cabinet gave approval of the pilot project and provided funding. The faculty pilot group -- consisting of two chemical engineering instructors, four chemistry instructors, one biological sciences instructor and three math instructors -- implemented the technology in their 2005 fall courses and provided metrics and feedback to the CERTI committee.
Training consisted of on-campus sessions about creating slides, running sessions, saving results and running reports, even for faculty who had already used clickers in the past. Turning Technologies supplied a free, all-day training and demo kits to the eight faculty members who attended. Follow-up training once the semester began was offered by CERTI in two sessions with 100 percent participation. Peer mentoring was offered by one instructor who felt particularly comfortable with the technology. A further mid-semester training by CERTI also had total participation.

During this phase, the CERTI group researched the various vendors that were available and settled upon Turning Technologies. Campus IT was able to work directly with developers to provide exactly what faculty needed in the classroom. Typically, vendors work with individual professors, but S&T wanted the vendor to go through its IT department to release updates and new versions to the campus in a controlled manner.

Some of the faculty who were part of the early pilot were similar to Ron Frank, associate professor of biological sciences and an early adopter of the technology. His interest in clickers was based on his own experience in college. He recognized retrospectively that he had not been as active a learner as he could have been because he was reluctant to raise his hand and speak out in class. As a professor, he began to recognize the students in his classes who were similar to him and looked for a way to engage them more. What if he could poll his class the way the TV shows polled their audiences, he wondered? When he found out that was indeed possible through clickers, he volunteered immediately to be part of the project.

The feedback from his students was overwhelmingly positive and continues to be so today, he says, including increased attendance, and more security and less anxiety among students as they see where they stand compared to their peers in understanding class content. He adds that it also helps him as an instructor discover what areas to focus on in class.

Martin Bohner, professor of mathematics and statistics, was the first instructor in the math department to use clickers in the pilot project in fall 2005. Adding the clicker technology was part of a strategy to reduce the rates of students withdrawing or getting Ds or Fs in Calculus 2 (Math 15), which is the Calculus class for engineers and serves about 700 students annually.

With upwards of 100 students in the sections, the clickers were helpful with student engagement. Along with a variety of efforts that were instituted in addition to clickers, such as the promotion of Learning Enhancement Across Disciplines sessions (optional learning centers for students to attend), the DWF rate fell from slightly more than 30% to far less than 10% within two years. “It took extra time and work, but we saw tremendous success,” Bohner said.

After the fall 2005 pilot, instructors were surveyed about their level of satisfaction with the project and how they perceived clickers’ usefulness for learning:

- Seventy-five percent found it easy to teach themselves how to use the clicker software
- 100 percent found it easy to teach the students how to use the clickers
50 percent found they had to increase the amount of time required to prepare for lecture
100 percent said it required a substantial change in their teaching methodology
100 percent chose to use the technology the following semester as well as recommend the technology to their colleagues
100 percent felt that the benefits of the technology outweighed any problems they had

Students in two sections of chemistry and two sections of calculus (n=417) also were surveyed and across all sections “significantly more students agreed that the clickers made the class more engaging, facilitated collaboration, enhanced student and instructor awareness, and motivated them to attend class. They even reported that they were more likely to enroll in courses that used these devices in the future” (Maib, Hall, Collier & Thomas, 2006).

In retrospect, Brady saw many ripple effects on campus as a result of the clicker project. IT was just beginning to formalize how projects were rolled out to campus, so the clicker and projector projects served as a prototype of how to do subsequent technology roll-outs. There was a shift in IT as it began supporting technology for teaching, learning and research, rather than simply installing software and hardware or handling the administrative aspects of new technology. This resulted in the formation of a much-needed educational technology office in 2008.

In fall 2006, once the project had been opened to the campus, 10 instructors joined the ranks of clicker users, and the number of instructors utilizing the tool has continued to increase since then. Recent data (fall 2012) shows that approximately 49 percent of students on the S&T campus now carry a clicker that they can use for multiple classes, and the technology has been utilized by up to 14 departments and 37 instructors at a time in a semester. More than 80 unique instructors have utilized clickers as a classroom tool since 2003. (Note that on-campus enrollment during the time that clickers have been used has risen from 5,102 in 2005 to 6,760 in 2012, a 24.5% increase. See appendix for more data on student and instructor clicker use).

As project manager of the clicker technology roll-out, Brady points to five keys for successful implementation of the clicker project:

1. Get buy-in to use only one product on campus. “(The technology) has got to be the same in whatever classroom faculty to use,” said Brady. “A unified solution is necessary for success.”
2. Use the controlled growth approach with at least one full year of a pilot. Start with the most eager faculty in an interdisciplinary approach, with at least two faculty from each department to support one another.
3. Build peer community among clicker instructors during the pilot phase.
4. Prepare faculty ahead of time to think through issues and provide troubleshooting.
5. Do whatever is needed to ensure the success of the pilot. Stay close to faculty on the ground to ensure that they are successful.
Appendix

Total Clicker Students: Fall Semesters 2005-2011

Total Clicker Students: Spring Semesters 2006-2011
Number of Clicker Courses and Instructors: Fall 2005-2011

<table>
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<tr>
<th>Semester</th>
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<th># Student Seats</th>
<th># Instructors</th>
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# students = unique students using clickers, possibly in more than one class
# student seats = the number of total clicker users, including duplicates

*Graphs and data courtesy of Dan Cernusca, instructional designer, Missouri S&T Global Learning, and Missouri S&T Educational Technology staff*