

# Teach So That They Learn: How Technology Use Can Benefit from the Principles of “How People Learn”

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## Introduction

Throughout the history of instructional media, numerous educational technologies have taken center stage and then quickly faded into obscurity. Well-known examples are radio in the 1930s and instructional television in the 1950s (Reiser, 2001). The failure of so many new technologies of the day to live up to their educational promises can be attributed to a techno-centric view of technology integration that focuses on the glamour of the technology rather than how to use it to serve identified pedagogical needs and enhance student learning (Draper, 1998). The myriad media comparison studies still growing in the education literature stand as a reminder of how little we have learned from our past failures and how urgently our research focus needs to shift from studying the “*if*” to investigating the “*how*”. To remedy the situation, we propose that technology integration should be guided by research-based principles of how people learn, placing student learning on the center stage while using technologies as supporting pillars.

## Four Principles of How People Learn

One set of such principles are elaborated in *How People Learn* (Bransford, et al., 1999), a synthesis of research on learning and instruction resulting from two years’ study by the Committee on Developments in the Science of Learning. These principles state that an effective learning environment should be learner-centered, knowledge-centered, assessment-centered and community-centered. Simply put, a learner-centered learning environment focuses on the knowledge, skills, goals and cultural beliefs that each learner brings; a knowledge-centered learning environment has as goals deep and integrated understanding of a knowledge domain; an assessment-centered learning environment stresses the importance of formative assessment as an integral part of the learning process as well as the alignment of summative assessment with learning goals; a community-centered learning environment features class norms that are reflective of a good match between teacher and student expectations and a good balance between collaboration and competition. When we bring new technologies into the classroom, it is easy to be dazzled by what the technology can do and lose sight of how it can be used to enhance student learning. The principles mentioned above can help guide technology adoption towards supporting the building of an effective learning environment.

## Background

In the current study, we examine a professor’s integration of Student Response Systems (clickers) into her Introduction to Business Statistics course at a major Canadian university over six consecutive semesters through the lens of the above four principles from *How People Learn*. We hope that our analysis and reflection will contribute to better understanding of what constitutes best practice in technology integration, especially clicker use, in undergraduate introductory courses.

The clicker technology is basically a polling tool, allowing students to vote with a handheld input device and the instructor to display the aggregated results as a histogram on a projection screen. During the activity, the instructor displays a multiple-choice question and asks students to respond with their remotes. The question usually targets concepts students normally find difficult and will, as a result, yield uneven distribution of responses. After seeing such results, the instructor calls on small group discussions followed by a second vote. Then a whole class discussion may ensue to make sure misconceptions are completely dispelled. The pedagogy used in this activity is called Peer Instruction (Crouch & Mazur, 2001). In the course taught by the professor involved in this study, three to five Peer Instruction activities were employed in a typical class of 75 minutes.

Prior to the adoption of clickers, the professor had taught the course once and identified many challenges in the learning environment. The course was mandatory for all business students and taught in large classes of 118 students. The professor had no experience teaching Millennium generation students who were new to university learning. The class size prohibited the professor from getting to know the students, which in turn made it hard for students to adapt to their new learning environment. The mandatory nature of the course made it unappealing to students who had negative preconceptions about courses featuring “math-related” subjects. Since it was also a coordinated course, the

content and exams were standard across the sections making it challenging for professors to introduce creative improvements. The assessment was mostly summative with a small percentage of the grade allocated to multiple assignments through the semesters. No effort was placed on creating a learning community for the course. In this first semester of teaching the course, the professor focused on teaching the content.

The introduction of clickers and Peer Instruction gradually ameliorated the situation over the past six semesters. The next four sections will be devoted to an examination of the professor's clicker-related teaching practice from the four research-based perspectives presented earlier.

### **The Learner-centered Perspective**

In terms of teaching practice, the learner-centered principle speaks to “diagnostic teaching” where the instructor assesses students’ prior knowledge, skills, attitudes and beliefs through techniques such as observation, questioning, discourse and reflection as well as activities or tasks that elicit student misconceptions and create cognitive dissonance essential for knowledge construction (Bransford et al., 2004). The clicker technology is a powerful tool that can help implement some of those techniques and activities, such as designing clicker questions targeting misconceptions and deep understanding, and facilitating small group discussion that allow students to explain their reasoning and wrestle with conflicting ideas from peers.

After the dismal first experience with teaching the course, the professor adopted clickers to direct students’ attention to difficult concepts and make them somewhat realize the importance of conceptual understanding versus mere memorization and problem-solving. However, the usefulness of using clickers and peer instruction was not initially communicated well to the students, many of whom showed negative perceptions of this activity in the course evaluation. Over the next few semesters, lack of appreciation of the clicker questions and peer instruction was remedied by addressing its benefits in the course outline and during the first class, and by improving the use of this technology and pedagogy. In spite of the resulting improvement in student engagement and perceptions of the course, the persistence in students’ lack of appreciation for the value of clickers and peer instruction made the professor realize the need for more support for students to make the significant shift from a traditional lecture hall learning to a more active, constructive way of learning. Subsequently, the professor employed four strategies to make sure students engage in and benefit from clicker activities and the course in general: 1) PowerPoint of study strategies was developed to help students improve their study skills to achieve deep learning; 2) When only a small number of students answered a clicker question correctly, the professor gave hints during peer discussion to guide their discussion and help them understand; 3) Weekly reminders about reviewing study strategies were mentioned in class; 4) Course outline included how clickers would be used. In the final semester, the professor further refined her strategies and practice by 1) targeting the PowerPoint strategy instruction to managing student expectations; 2) adjusting subsequent instruction based on feedback from clicker questions (more agile teaching); 3) expanding the introduction of clicker use to half of the class time in the first class, explaining the benefits through citing evidence from the literature as well as from the previous semester; 4) providing more detailed instruction on what students are expected to do before, during and after class in the course outline; 5) stressing the relevance of topics to their majors throughout the course. As a result of constant revision of the course based on action research (plan, act, observe, and reflect), these two semesters yielded much higher performance and greatly improved student perceptions.

The major lesson learned from the past six semesters is that effective teaching is highly dependent on the extent to which the learners and their need are put at the forefront.

### **The Knowledge-centered Perspective**

Overlapping with the learner-centered principle, the knowledge-centered principle emphasizes designing instruction with learners’ entry state and their developmental stage in mind. Also at the core of this principle are educational goals of fostering understanding and transfer, disciplinary thinking, and an integrated knowledge structure. The clicker technology can be used to assess students’ state of understanding, promote deep learning of key concepts, and raise students’ metacognitive awareness of their own learning progress.

In her first semester of the course, the professor found it just as challenging to make her class knowledge-centered as making it learner-centered. Students did not see the importance of learning statistics and exam questions only exacerbate the situation by testing memory of solution patterns rather than deep learning. By introducing clickers and Peer Instruction into the classroom, the professor was hoping to make what is not obvious or intuitive easy to understand and revert students’ tendency to memorize as opposed to understand by using conceptual questions on

exams. However, this expectation was not met within one semester. As mentioned in the previous section, many strategies were used over the next few semesters to promote deep learning, such as study strategy instruction and detailed guidelines on class preparation. In the past two semesters, the professor also used a “storyline” of statistics topics, providing a non-mathematical explanation of each topic, the reason for covering it and how it is related to the topics covered to date. This was appreciated by the students and the course has made considerable progress towards being knowledge-centered.

### **The Assessment-centered Perspective**

The assessment-centered principle intersects with the learner-centered and the knowledge-centered perspective in that assessment should be used to diagnose what the learner brings to the learning environment as well as provide information on how the learner is progressing towards the learning goals. By making students’ thinking visible clickers are especially valuable for conducting formative assessment, providing feedback and opportunities for revision and correction of problematic understanding. Through their robust feedback mechanism, clickers and clicker-enhanced Peer Instruction also allows the practice of agile teaching, which is instruction based on real-time assessment of learning needs. Nonetheless, clicker implementation often faces the challenge of summative assessment, which often tests students’ ability to reproduce memorized facts and problem-solving procedures rather than conceptual understanding. In a coordinated course that involves multiple sections and professors, it is hard to achieve the alignment of summative assessment with learning objectives and instructional activities designed by individual professors.

Before the introduction of clickers, there was no formative assessment and summative assessment was not congruent with the deep learning goal. While there are improvements on this issue over the semesters, it remains a serious obstacle to deep learning today. Use of clickers and Peer Instruction brought about in-class formative assessment. To maximize the effects of clicker use, out-of-class formative assessment such as pre-class and post-class learning reflections and online self-quizzes were also gradually introduced. The Peer Instruction method was refined over the semesters as well, evolving from simply “discuss and vote” to “vote, discuss and re-vote”, making better use of the technology-enhanced feedback to benefit both instruction and learning. The course is becoming increasingly assessment-centered with constant retuning of assessment practice.

### **The Community-centered Perspective**

Encompassing all the above principles, the community-centered perspective recognizes the social nature of learning and the importance of a cohesive community in building an effective learning environment. What is particularly interesting is the distinction made between “talent selection” and “talent development”, underlying a competitive and a collaborative class norm respectively. Clickers are useful for building a good sense of community in the classroom through making visible the entire spectrum of class performance on a particular question, giving voice to the silent majority and making those struggling feel less alone and frustrated. The feeling that “we are all in this together” and “we’ll figure this out together” may help create a democratic learning environment where the majority of students have an opportunity to develop their talent rather than just the few “selected” top students.

Prior to the adoption of clickers and Peer Instruction, the 118-student class was far from being a learning community. Peer Instruction was an important step towards forming a learning community; however, it did not work well initially due to students’ poor preparation for the discussions. Moodle discussion forum was set up later but attracted very little participation at the beginning. As the professor encouraged more preparation for class and refined Peer Instruction, the clicker-based activity became increasingly effective in building a learning community, as evidenced by many students’ voluntary formation of study groups outside of the class. The online discussion forum also flourished and together with in-class clicker participation formed a virtuous cycle for building and strengthening a learning community.

### **Conclusion**

Using the four perspectives from the learning science, we analyzed and reflected on seven semesters’ teaching experience with an introductory business statistics course, focusing on issues related to the use of the clicker technology and the Peer Instruction pedagogy. We observed a parallel between the extent to which the four principles were applied and the degree of effectiveness with clicker use and the success of the course as measured by both exam performance and course evaluation. It is safe to conclude that the use of educational technology can benefit from following the principles of how people learn and best practice for clicker use should be based on

research evidence from the learning science. One caveat, though, is that significant improvement only comes with ongoing refining and revision of practice based on reflection – it will not be a case of the magic bullet.

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