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Active Learning Across Three Dimensions: Integrating Classic Learning Theory with Modern Instructional Technology

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Abstract. Many educational researchers have proposed moving away from the traditional pedagogical model of long lectures with students as passive learners, listening and taking notes. There is over a century of pedagogical and cognition research that strongly suggests learning occurs best when students take an active role in the construction of their own knowledge. The call for change has only been accelerated by the increasing availability of computer-based educational technology and the exponential growth of digitally available information. This paper combines the long history of educational research with the rapid advancements of instructional technologies to build an Active Learning Model with three active dimensions (teachers, students, and technology). This model can help improve authentic learning within multiple disciplines and pedagogies. A Case Study is presented illustrating how the model helps improve student satisfaction as reported using standardized teaching evaluation metrics.

Keywords: Constructivism; pedagogy; active learning; problem based learning; educational technology

Introduction

A century ago John Dewey said, *"Give the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking, or the intentional noting of connections; learning naturally results"* (Dewey, 1916, p. 181). Many educators agree with Dewey that students become more engaged in the learning process when the learning activity is dynamic, significant, and relevant to their lives. Cognitive scientists have an explanation for this, reporting that neural pathways in the brain are rewarded by the release of neurochemicals (such as dopamine) when student learning is active, meaningful, and authentic (Doyle, 2012). In this way, neuroscience is independently confirming the findings of multiple generations of educational researchers in the areas of effective teaching and learning.

Technology is doing more than just confirming classic research. Modern educational technologies are providing new opportunities to support the efforts of improving teaching and learning. This report extends a classical model for engaged active learning by adding a third dimension that represent the increasingly important role of technology.

Classic Educational Research: The Roles of Teacher and Learner

Educational research has a rich history of investigation into instructional designs for improving teaching effectiveness. Reflections on education go back at least to the Greek philosopher Socrates who is often recognized as the first great teacher (Nelson, & Brown, 1949). The **Socratic method** is a form of inquiry and debate based on asking and answering questions to stimulate critical thinking and to illuminate ideas. The Socratic method placed emphasis on the status of the individual to challenge the polity of the state, and the consensus of society. It was a thus a precursor of modern western intellectual individualism (Anthony, 2006). The skills of critical thinking and of challenging assumptions are just as useful today (if not more so) as they were 2500 years ago when Socrates developed his students in these areas.

Another important cognitive theory that impacts education is **constructivism**, based on the idea that learning improves when students construct their own understanding through experiencing things and reflecting on those experiences. According to the theory, when a person encounters something new, it has to be reconciled with the person's previous ideas and experiences. This reconciliation might cause the learner to change what they previously believed, to discard the new information based on previous experience, or to refine their knowledge if the new experience is compatible with prior experience and understanding (Anzai & Simon, 1979). In the classroom, the constructivist view of learning leads to a variety of teaching practices that encourage active techniques for creating new knowledge and reflection to explain how one's understanding is changing. Similar to a Socratic method, the teacher may guide the learner through the activity by asking foundational questions and encouraging the student to then build on them.

One advantage of active learning is that it avoids the problem of **inert knowledge**, which is information the learner possesses but cannot apply. To understand inert knowledge, consider a student who learns Distance/Rate/Time formulas (e.g., D = R * T and T = D / R and R = D / T) during math class through drill-and-practice on a worksheet of word problems, pulling numbers from the paragraph and plugging them in as the (hopefully) appropriate variable in the (hopefully) appropriate formula. But later in the day when learning about Charles Lindbergh and the Spirit of St. Louis in history class, the student is asked to figure out how long it took to complete the first solo non-stop transatlantic flight. When the student says she does not know, the teacher asks "What information would you need to determine how long the flight lasted?" The student does not realize to ask for the distance travelled or the rate of the plane because the Distance/Rate/Time formulas were learned as memorized inert information rather than active knowledge (Whitehead, 1929; Gick & Holyoak, 1980; Bransford, Franks, Vye, & Sherwood, 1989).

Active Learning

The best way to avoid inert knowledge is to acquire knowledge as part of an active learning process. "In the process of learning, the learner's dynamic cooperation is required" (Gragg, 1940). Such cooperation from students does not arise automatically, however. It has to be provided for and continually encouraged. (Duncker, 1945). Active learning goes beyond memorization of facts and builds on the students' preexisting conceptions (Bonwell & Eison, 1991). Active learning activities involve opportunities for students to view information as means to important ends, which in turn helps students learn about the conditions under which knowledge is useful (Simon, 1980). When knowledge is learned actively, it increases the chances of spontaneously using that knowledge to solve new problems that are confronted later on (Bransford et al., 1990). Modern neurological science further supports the idea of active learning: "Fifteen years of neuroscience, biology, and cognitive psychology research finding on how humans learn offer this powerful and singular conclusion: *It is the one who does the work who does the learning*." (Doyle, 2012, p. 7)

One example of active learning is **problem based learning** which often involves a process similar to the four problem solving stages as stated by Polya: (1) understanding the problem, (2) making a plan, (3) executing the plan and (4) reviewing the solution (Polya, 1945). Problem-Based Learning (PBL), as a general model, was refined in medical education in the early 1970's and since that time it has become common practice in most medical schools where PBL is used in the first two years of medical science curricula, replacing the traditional lecture based approach to anatomy, pharmacology, physiology, etc. (Savery and Duffy, 1995). The model has been adopted in an increasing number of other areas including Business Schools (Milter & Stinson, 1995), Schools of Education (Bridges, 1992; Duffy, 1994); Architecture, Law, Engineering, Social Work (Boud & Feletti 1991); and high school (Barrows & Myers, 1993). As Bransford et al. state, "Problem-oriented acquisition helps students appreciate the value of information" (Branford et al, 1990, p.121).

Great Teachers in 1966

The educational concepts of active learning and problem based learning are old ideas that have been successfully applied in a wide variety of classrooms over the last century. On May 6, 1966, Time Magazine did a cover story on 10 highly effective college professors from ten different universities and who taught in ten different academic disciplines (Figure 1). These professors may not have been aware of the active learning insights of James (1899), Thorndike (1913), and Dewey (1916), and they certainly were unaware of the future insights from neuroscience regarding active learning from the likes of Goswami (2006), Willis (2010) and Sigman et al. (2014). Nonetheless, these Time magazine professors were successful as teachers because they knew the critical importance of engaging their students with the material.

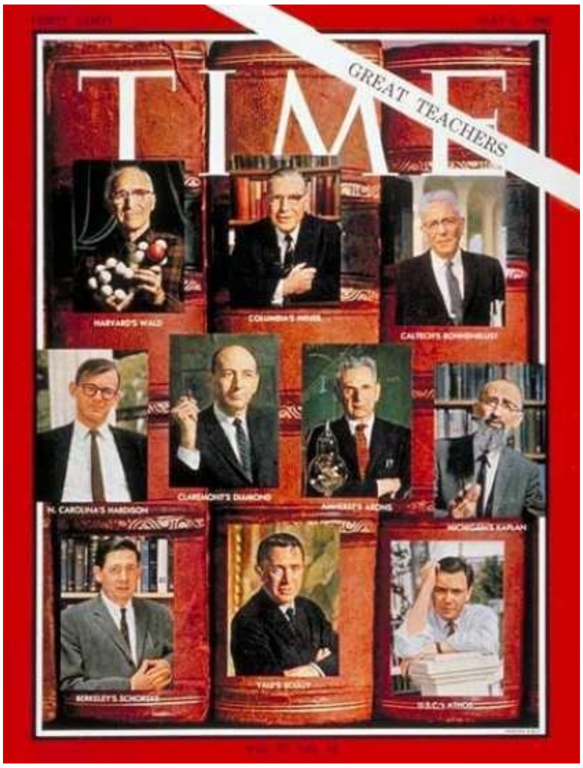

Figure 1. Time Magazine's "Great Teachers" Cover, 1966

These "Best Teachers" of 1966 were each unique in their situations, teaching different subject disciplines to different student populations at different universities. What they had in common was intentional efforts to create a space where students would be engaged in highly interactive and authentic learning. This space can be captured visually in two dimensions where one axis represents the activity level of the teacher and the second axis represents the activity level of the learner (see Figure 2). In this model, the lower-left quadrant represents the Traditional Classroom where the student is a passive learning (listening and taking notes) and the teacher is also a passive participant (non-stop lecturing). This is not meant to be viewed as an indictment of lectures or the traditional classroom model. Rather it is a visual summary of the opportunities to make students more active in their education process, and also to make the instructor more active as well.

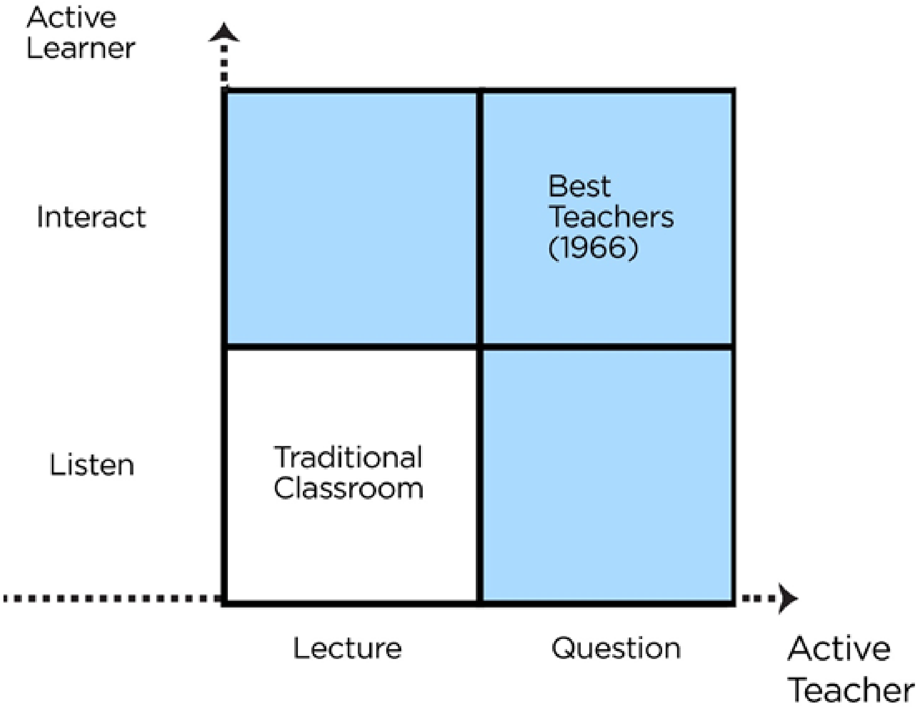

Figure 2: Active Learning Model for "Great Teachers" (circa 1966)

It is important to note that Figure 2 does not suggest any specific approach to active or authentic learning. Indeed, there is no "one size fits all" recommendation because effective learning depends on many factors, including the content being learned, the knowledge level of the learners, the class size, and the learning objective just to name a few. Specific techniques might work better in some situations than others. The good news is that there are many techniques designed to help participants (students and teachers alike) become more active in the learning process. If a teacher were to plot a specific instance of a course onto the Figure 2 chart, the location of that class would not be static, but would make many small moves over time based on the dozens of choices made in the design and refinement of the course, each decision moving the class slightly toward the upper-right quadrant or slightly toward the lower-left quadrant, or somewhere in-between.

Computing Technology in Education

Research efforts to explore and understand the impact of computing technology in education has a longer history than one might think. Before a man walked on the moon, Atkinson and Wilson edited a book of research efforts in the area of computer-assisted instruction (Atkinson & Wilson, 1969). Over a decade before the introduction of the IBM personal computer, Seymour Papert and others were developing tools to allow children to develop hands-on computer programming skills at a time when computers were the size of refrigerators and cost tens of thousands of dollars (Papert & Solomon, 1971). In the early 1980s, Lepper analyzed four sets of research issues raised by the rapid intrusion of microcomputers into the lives of children, including the use computers as a vehicle for intrinsic motivation, the study of the instructional effectiveness in educational software, contrasting philosophies of instruction in different designs of computer-based educational programs, and the effects of the computer on the goals of formal education (Lepper, 1985). These and similar investigations at the time are particularly impressive as they occurred before it was clear that computing technology was certain to play some type of role in education, and well before the World Wide Web came into existence in 1991 and the resulting exponential growth of information in the two-plus decades that have followed.

Today's computing technology is becoming ubiquitous, and as such we cannot leave it out of our discussion about Active Learning and Great Teachers. An interesting thing happens when technology is added as a third dimension in the Active Learning model (see Figure 3). As with the teacher and student dimensions, emphasizing interaction with technology moves the class away from the passive traditional classroom and toward a more authentic and personalized learning experience.

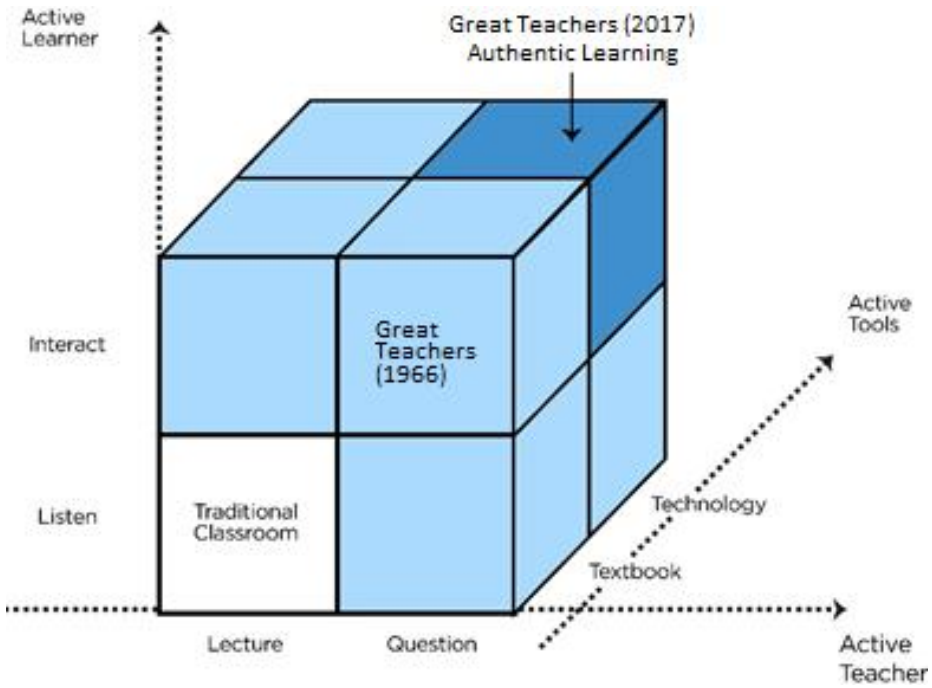

Figure 3. The 3D Active Learning Model in Three Dimensions

This model has implications for a variety of high profile educational technology issues. For example, enrollments in online classes have grown significantly (Clark & Mayer, 2007) and many traditional institutions are expanding their capacity for online courses (Allen & Seaman, 2013). Likewise, hybrid courses that blend face-to-face and online instruction are one the rise (Bonk & Graham, 2006; Keengwe, Onchawari, & Oigara, 2014). Too often faculty are not provided sufficient guidance on how to integrate technology into these new online or hybrid courses.

It is possible to replace face-to-face lecture with recorded lecture, but that does not move the learning experience out of the lower-left quadrant of the Active Learning Model. Using technology to replicate the traditional classroom might be cost effective, but it does not improve learning. When technology is introduced with the goal of increasing the interactivity of the learning experience, educational technology begins to fulfill its promise. This is consistent with a study by Crews and Butterfield where students identified interaction through class discussions and other types of active learning activities as the single greatest predictor of success for a face-to-face course (Crews, Butterfield 2014).

CASE STUDY: Applying the 3D Active Learning Model to a Computer Literacy Course

The 3D Active Learning Model has been implemented and revised over multiple semesters in a college of business service course on computer literacy. The class covers traditional literacy content on computer hardware, computer software, and computer networks. The course also requires students to complete numerous hands-on projects with Microsoft Word, Microsoft PowerPoint and Microsoft Excel. This is significant amount of material for a single class, with some schools having required textbooks that total over 700 pages of reading material. Furthermore, students enter the class with diverse backgrounds regarding computer knowledge and skills, which makes it even more challenging to teach in a way that the majority of the students are challenged and engaged.

For this case study, technology has been incorporated into this course according to the 3D Active Learning model with the goal of moving the course toward the highly interactive and authentic learning space. The first active technology introduced in this course was **SAM Projects**, an expert system for grading student projects in Microsoft Word, PowerPoint and Excel (Cengage, 2016). This technology is a type of expert system that allows students to get detailed feedback on their hands-on Microsoft Office projects. SAM Project grades the students work and provides detailed feedback almost immediately regardless of the time of day. When using SAM, a student may submit an assignment at 2:00 am, and the student will receive immediate detailed expert feedback while the project is still fresh in the student's mind. Furthermore, students are able to use the feedback to resubmit their work multiple times (as determined by the faculty member) and to improve their work based on the expert feedback.

A second technology element used in this revised course is **recorded lectures**, which are increasingly common in a variety of online and flipped classrooms (Thompson, 2011). Recorded lectures themselves are not more interactive than a classroom lecture, but they lecture delivery to occur outside of class, which allows face-to-face classroom time to be repurposed to support more active learning activities. Using technology outside of the classroom to increase the human interaction within the classroom is consistent with the book "Teaching Naked: How Moving Technology out of your College Classroom Will Improve Student Learning" (Bowen, 2012) that won 2013 Best Book on Higher Education from the American Association of Colleges and Universities.

A third technology element incorporated in this Case Study was to increase interactivity through **online practice quizzes**. After each assigned chapter reading, an online practice quiz was made available to the students containing a pool of questions first drafted by the publishers and edited and pruned by the faculty member. These questions are made available for a period of time (e.g., 1 week) and the students could take the practice quiz multiple times during that week.

Strategic technology adoptions are only part of this case study. Lectures became shorter and more interactive, emphasizing the major challenges and opportunities that students will be facing. Student participation was increased. Small group projects, discussions, debates, class-wide problem solving activities, and in-class demonstrations were all considered based on the main learning objectives for that material and the technique that seemed most intuitive to the faculty member.

The 3D Active Learning model is not a one-size-fits-all solution. It involves treating each learning objective uniquely with the goal of increasing interactivity by the student, the faculty member and the available technology. It involves a series of small steps that cumulatively help move the course toward the desired furthest quadrant where active learning is at its highest.

Results

The course revisions over three semesters based on the 3D Active Learning Model have had a demonstrably positive effect. Students showed an increase in attendance, alertness, participation, and attitude. Class meetings were more engaged and pleasant.

In addition, students reported higher satisfaction with various elements of the course as captured by the university's standardized Student Instructor Teaching Evaluation (SITE) scores. Students rated the professor of the 3D Active Learning course above college and departmental averages across all questions in the SITE evaluation over each of the past three semesters.

Furthermore, student evaluations show a positive increase over the past three semesters while college and departmental averages remain relatively flat (with spring 2015 included as a baseline). By increasing engagement, students felt the learning was more authentic and in line with the course objectives (Figure 4), feedback (Figure 5), teacher effectiveness (Figure 6), and student learning (Figure 7).

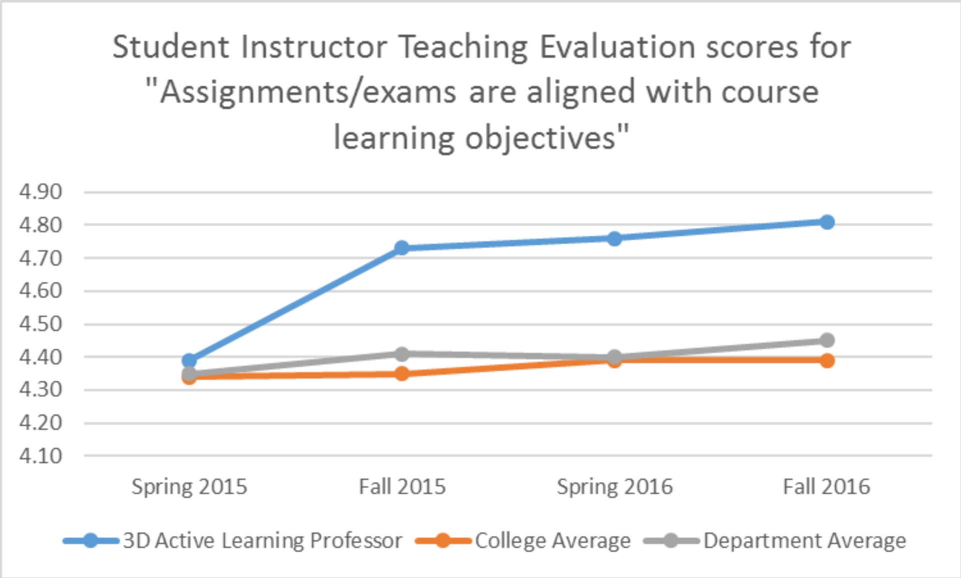

Figure 4. Improved SITE evaluations regarding learning objectives

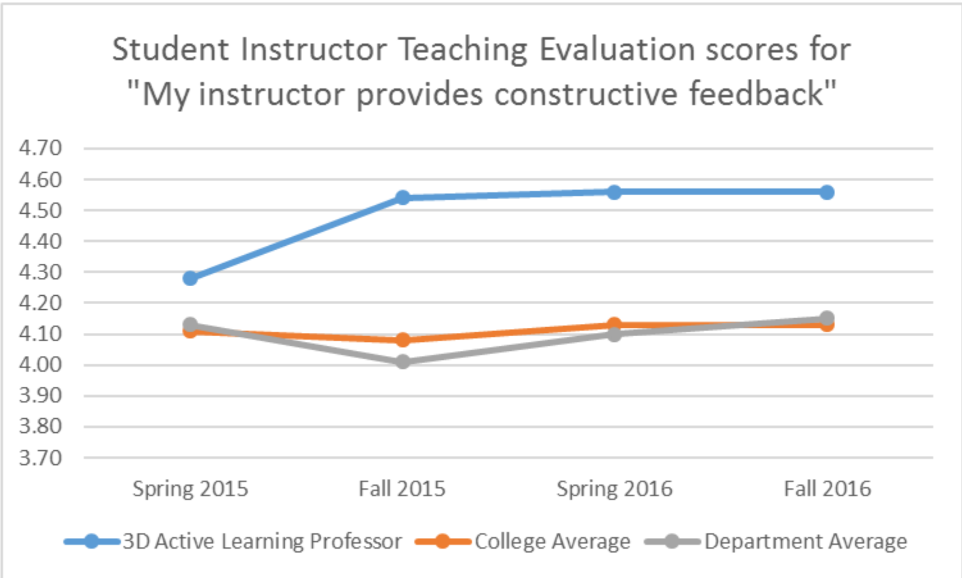

Figure 5. Improved SITE evaluations regarding feedback

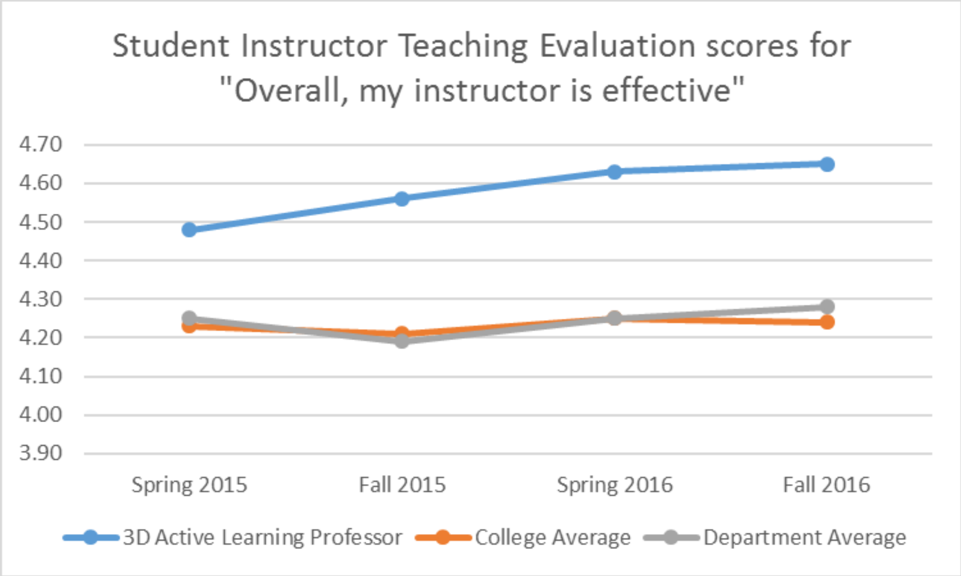

Figure 6. Improved SITE evaluations regarding teacher effectiveness

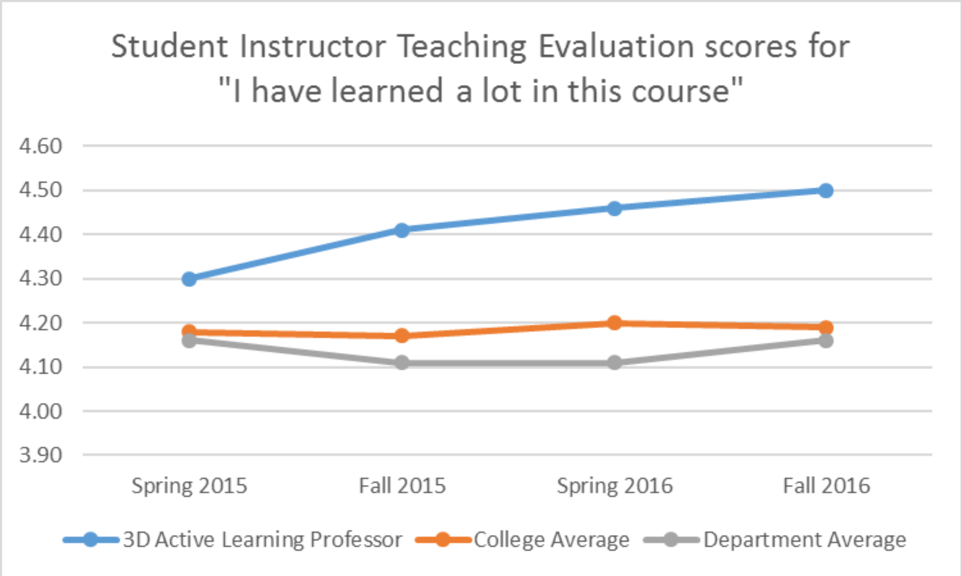

Figure 7. Improved SITE evaluations regarding student learning

Conclusion

There is a long and rich history of educational research showing improved student learning through increased interaction and engagement. Each teacher, each student, each topic, and each setting is unique. But with each of these unique challenges, there are multiple opportunities to make small changes in course design and implementation with the goal of moving students toward the most authentic and interactive learning space possible.

The 3D Active Learning Model provides a visualization for faculty looking to increase the level of active learning in their course. The model is especially helpful for faculty incorporating technology in the form of online or flipped classes. The 3D Active Learning Model does not recommend any specific activity or event or technology. Rather it is a model that encourages incremental change away from a traditional classroom toward an environment of more authentic learning involving increased interaction across three dimensions: teacher, learning, and technology. It is a journey over time that requires a series of pedagogical decisions where each choice is guided by the goal of increasing active learning. Collectively these small changes have the effect of creating a learning space that is well suited for better teaching and more authentic learning.

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