

Chapter 16

Innovative Instruction in STEM Education: The Role of Student Feedback in the Development of a Flipped Classroom

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ABSTRACT

Research from the learning sciences provides evidence that students engaged in collaborative learning in authentic activities are better able to retain and transfer knowledge to alternate contexts leading educators to reexamine the role of the lecture as a dominant instructional method. The use of alternate classroom structures to create student-centered learning environments is appropriate in STEM education. This chapter presents the development of a flipped classroom in a higher education STEM course, and describes the iterative process and subsequent structure of the course over several years. Considerations when implementing a flipped model of instruction are: the degree of self-regulation required of students, methods of assessment and the relationship between online information and authentic activities that students participate in during class. Recommendations for future research directions are discussed.

INTRODUCTION

As Americans moved from farms to urban industrial areas in the early 20th century, they joined the manufacturing ranks, working side by side with a more experienced coworker, learning on

the job. Often employees spent their entire career working for the same company. Toward the end of the 20th century, new technologies and an increasingly global economy changed manufacturing in America. The American economy experienced a shift, companies moved away from jobs that

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demanding physical skills, and toward jobs that involve technologies previously unheard of. Many innovative technologies require a skill set specialized to deal with sterile dust-free environments or scale too small to be seen with the naked eye. Often, workers collaborate with each other, with responsibility for only a small part of the product. With these shifts come an increase in need for an educated work force adept at problem solving, able to collaborate with partners globally, synchronously and asynchronously (Stephens, 2013; Wulf, 1998). Technology makes collaboration possible, requires that individuals be flexible, think independently, and find solutions while negotiating changing conditions (Keengwe, Onchwari, & Onchwari, 2009; Salomon, 2002; Stephens, 2013; Wulf, 1998).

In order to address the skills gap that exists between the number of technical jobs available and the number of graduates to fill them, it is imperative that we improve science, technology, engineering and mathematics (STEM) education at all levels (Committee on Prospering in the Global Economy of the 21st Century, 2007; U.S. Congress Joint Economic Committee, 2012, 2013, 2014; PCAST, 2010, 2012). To remain competitive in a global economy, American colleges and universities have been pressured to improve preparation program for students entering STEM career fields (Committee on Prospering in the Global Economy of the 21st Century, 2007; Felder, Brent & Prince, 2011; Stephens, 2013; Wulf, 1998). In an effort to insure that we meet these and other challenges, engineering programs are moving away from traditional models of teacher-centered learning supported by a lecture format, to a student-centric model infused with active engagement, authentic activities and practical problem-solving experience (Granger et al., 2012; Spencer & Mehler, 2013; National Science Foundation, 1995). By leveraging research from the learning sciences, and the needs of industry, STEM educators are now creating collaborative learning spaces that improve student outcomes and provide opportu-

nities for students to develop soft-skills desired by employers (Ambrose, 2013; Stephens, 2013).

For generations, the typical college classroom was portrayed as students bent over a notebook, furiously scribbling while the instructor lectured, reiterated theory, and provided insight into highly specialized fields or techniques that may or may not have been related to the learning objectives of the course. This mode of instruction, the “sage on the stage,” placed an expert at the front of a room, and students, arranged facing the instructor, were expected to absorb wisdom as it was issued. In the early 20th century, Dewey (1923) recognized that lecture was not always conducive to student learning and retention of material, recognized that learning could also be dependent on social interaction. As the nature of learning became better understood, social interaction and participation in authentic experience were endorsed as critical to the learning process; it was determined that providing students control over their learning contributed to their agency, and through that, self-regulation and adaptation (Bandura, 2001; Johri & Olds, 2011; Kolb & Kolb, 2005; Vygotsky, 1978; Wenger, 1998). As a result of this knowledge, STEM teaching and classroom practices have shifted to better support the constructivist models of learning; educators now serve as the “guide on the side,” facilitating students in their learning by providing increased opportunities for engagement and authentic experiences that benefit retention and transfer (Catalano & Catalano, 1999; Fisher & Frey, 2008; Kolb & Kolb, 2005; Newman & Gullie, 2009).

Experiential learning, including collaboration with peers, is proving to be successful in all domains of knowledge building, but none more than within the STEM fields (Granger et al., 2012; Spencer & Mehler, 2013; U.S. Congress Joint Economic Committee, 2012). STEM courses that are experiential and inquiry based provide best experiences in learning by offering through trial and error, experimentation and collaboration rather than lecture. As a result, STEM

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