Chapter 2

Ideation to Execution: Flipping an Undergraduate Pre-Calculus Course to Create Significant Learning Experiences

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ABSTRACT

In this chapter, a flipped model is implemented in an undergraduate mathematics course. There is a need to enhance learning experiences in STEM disciplines and college mathematics courses. The authors seek to redefine the traditional relationship of instructor as the active conveyor of knowledge and the student as the passive receiver of knowledge. They discuss their efforts to plan and prepare for the course and their experiences with its implementation. The authors started with what they wanted their students to learn in the course. Prior to coming to class, students watched video lectures and completed pre-work assignments. In class, the authors incorporated group-work through peer-instruction and lab activities, and the use of a classroom response system. They present the results of their data collection, feedback from student response surveys. Among other results, the students realized the value of preparation and took an active role in the formation of their own learning experiences.

INTRODUCTION

In recent years, the teaching and learning of science, technology, engineering, and mathematics (STEM) disciplines have become a top priority at every level of the educational system—from K-12 schools all the way to undergraduate institutions (NSF, 2014). The need to prepare a competitive workforce that is qualified for highly technical jobs has become a major economic concern. According to a recent economic indicator, knowledge and technology intensive industries make up a growing
sector of science and technology fields worldwide. In 2011, of the 26 million U.S. jobs, approximately 20% of all jobs require a high level of knowledge within any one of the STEM related fields (Rothwell, 2013). Moreover, the United States relies on skilled workers within STEM related fields more than any other country in the world, making up about 40% of its gross domestic product (NSF, 2014). Although STEM competencies are greatly needed, it is not clear that the current or even the future workforce will possess the skills necessary to fill those jobs. Findings from the Department of Commerce (2011) suggest that, between 2001 and 2011, the overall growth in STEM jobs was three times faster than that of non-STEM jobs. Furthermore, by the year 2018, the United States will have approximately 1.2 million unfilled jobs because the workforce will either be uninterested in taking on STEM jobs or simply lack the skills to do so (Bertram, 2014).

STEM fields present inherent challenges to learning due to the specialization and technical nature of these fields. However, mathematics, unlike science, technology, and engineering fields, serves as a gatekeeper (Stinson, 2004) to other disciplines. Historically, mathematics has been a critical filter for many students. With mathematics as a gatekeeper, students have academic access to advanced courses within the discipline, access to other related disciplines, and better opportunities in the job market. Recent findings from the National Assessment Educational Progress (NAEP) report indicate that mathematics continues to be a challenge to students at all grade levels. Specifically for 12th graders, there were no changes in the performance on the national assessments in comparison to assessment performance reported in 2009 (NAEP, 2013). This suggests that many students may continue to struggle when they begin to study mathematics at the undergraduate level.

For some educators the solution is clear. If students are expected to overcome barriers in mathematics, they must develop a different kind of skill when they are learning the subject. As Bertram (2014) states, “[We must] help students develop the interest and the collaboration, critical thinking, and problem-solving skills necessary to succeed in the global economy. [We] must [s] tart by implementing interesting, relevant, rigorous, and hands-on STEM curriculum in schools” (Bertram, 2014). While it is essential to train students well at every level of their mathematics educational experience, it becomes even more critical at the undergraduate level. For many students, the undergraduate level may represent the last opportunity to take math courses before they leave the educational system and move into the job market. By 2018, STEM jobs will only make up about 5% of the U.S. economy (Carnvale, Smith, & Melton, 2011). At the undergraduate level, it is imperative that mathematics courses, serving as gateways to STEM fields, help students develop competencies, find agency in their learning, and make connections to other disciplines helping to make the content more meaningful.

This chapter draws from a two-year course redesign and implementation project at a four-year mid-sized open access undergraduate institution in the southeast. This chapter examines the ways in which an undergraduate Pre-Calculus mathematics course was first restructured using an innovative model of instruction called the Flipped Classroom Model (FCM). The FCM created a possibility for instructors and students to create a robust classroom experience and to help create more relevant mathematics content for students to learn. The Pre-Calculus course re-design was a result of our attempt at reforming (1) the assertive role that is taken on by instructors as the conveyers of knowledge and (2) the passive role of the student as the receiver of knowledge. The goal was to create, for instructors and students, a climate of possibility where these two roles are shifted in such a way that significant learning could occur (Fink, 2003). We relied on the notion that these possibilities would exist at the intersection