

Chapter 8

Flipping the Classroom in STEM Education

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ABSTRACT

STEM (science, technology, engineering, and mathematics) holds a special position in higher education, and data indicated that online teaching may increase the rate of dropout in STEM courses. Meanwhile, much higher percentage of STEM courses require hands-on experience that cannot be satisfied by online teaching and the virtual reality (VR) techniques. Flipping classroom provides a unique approach to utilize the components of online teaching and the advantage of traditional face-to-face classroom teaching. This chapter summarizes the development of flipping classroom and practical examples to explain the general principles to improve the design and conduction of flipping classroom, especially in STEM education.

INTRODUCTION

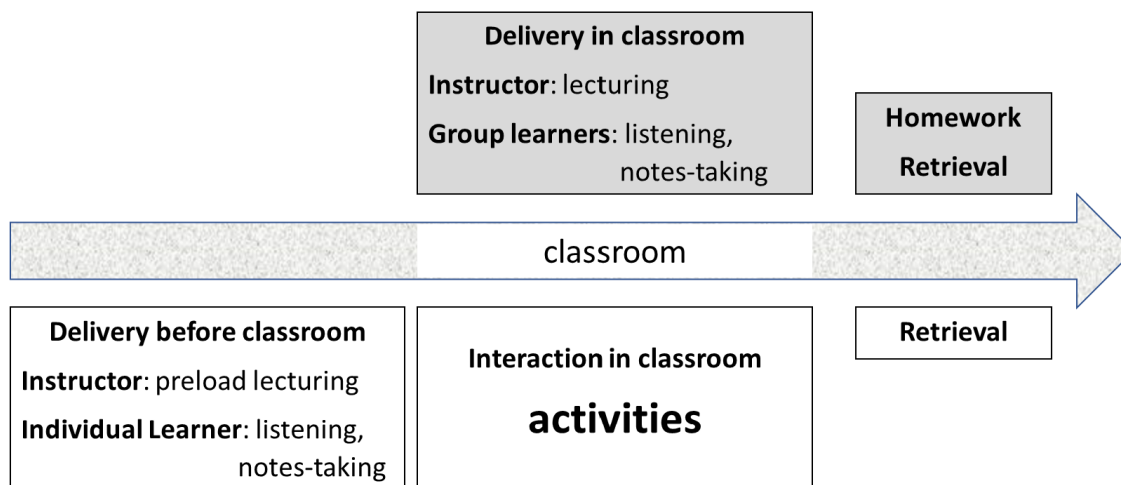
“FLIP” was first coined by Barbi Honeycutt as “Focus on your Learners by Involving them in the Process” to improve the teaching outcomes with universal design for learning (Tobin & Honeycutt, 2017). However, the pedagogical practice can be traced back much earlier, such as a “prelecture assignment is intended to motivate students to preview the relevant text material before attending lecture” (Kristine, 1985), but the complete renovation was described by Alison King in her publication “From Sage on the Stage to Guide on the Side” in the effort to convert the learner from passive mode to active mode (King, 1993). Meanwhile, another group of educators reported their practice to “invert” the learning from “inside the classroom” to “outside classroom”, emphasizing the application of multimedia (Lage, et al., 2000). In another direction, the educators also indicated that flipping classroom is not only about the shift of timing and location of teaching, but also the individualization of teaching (Bergmann & Sams, 2012). Basically, the group-delivery of knowledge (lecturing) was replaced by individual-delivery (self-study of

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lecture materials), followed by interactive group learning. Robert Talbert tried to define the purpose of “flipping” as promoting self-learning for confident “problem-solvers” of a new generation (Talbert 2014), which emphasized the important role of the learners. The traditional education is designed to convey the information all together in a unified mode that ignored the individual background and capacity, and the different learning preference with limited interaction between the instructor and the learners due to the limitation of class time. Traditionally, learning mostly takes place along with and after the teaching. While in the flipping mode, learning takes place before teaching, and continue along with teaching in the classroom. In fact, the flipping model moves learning ahead of teaching, transforms passive learning to active learning. In addition, flipping mode of teaching separates the delivery and digestion of course information, turn learning into a learner-dependent process.

Education in science, technology, engineering and mathematics (STEM) has been globally intensified to deal with multiple challenges such as the climate change, shortage of energy and water, and food security in the future. Unfortunately, the enrollment of students in STEM fields is declining significantly. Self-motivation was reported as the primary cause for STEM decline in the US (Bahar & Adiguzel, 2016), so improving the teaching strategy would be critical to attract more students in STEM fields. Flipping classroom as the emerging strategy has been applied in multiple disciplines including STEM. Problem-solving skills is one of the core educational goals especially in STEM education. Reports indicated that flipping classroom could effectively guide the students to construct new knowledge by improved participation, communication, and cooperation (Ash, 2012; Wang et al., 2018). Along with the improvement of computer science, online teaching (distance learning) became popular especially in higher education. Many educators vacillate to utilize online teaching in STEM due to the requirement of hands-on practice in STEM subjects and flipping model may provide an excellent tool in taking the advantage of both online and face-to-face (F2F) approaches. Nevertheless, flipping classroom may provide unique opportunities to reform the STEM education in certain degrees and in varied directions, to meet the call for reformation of STEM education (NAE 2005; Jamieson & Lohmann, 2009).

Figure 1. The concept of flipping classroom. The arrow indicates the timing of teaching, above the arrow shows the traditional classroom and below the arrow shows the flipping classroom.



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