The Internet and Higher Education 36 (2018) 41–53

Contents lists available at ScienceDirect

The Internet and Higher Education

journal homepage: www.elsevier.com/locate/iheduc

The role of self-regulated learning in students' success in flipped undergraduate math courses

Zhiru Sun[a,*], Kui Xie[b,c], Lynley H. Anderman[b]

[a] Department of Business and Economics, University of Southern Denmark, Campusvej 55, Odense M, 5230, Denmark
[b] Department of Education Studies, The Ohio State University, 29 West Woodruff Avenue, Columbus, OH, 43210, USA
[c] School of Educational Information Technology, Central China Normal University, Luoyu Road 152, Hongshan District, Wuhan, Hubei 430079, China

ARTICLE INFO

Keywords:
Flipped classroom
Self-regulated learning
Self-efficacy
Learning Strategies
Structural equation modeling

ABSTRACT

Based upon the self-regulated learning theory, this study examined the relationships between academic achievement and three key self-regulatory constructs - prior domain knowledge, self-efficacy, and the use of learning strategies - in two flipped undergraduate math courses. Structural equation modeling was employed as the primary method to analyze the relationships in both the pre-class and in-class learning environments of the flipped courses. The results of the study showed that students' self-efficacy in learning math and the use of help seeking strategies were all significantly positively related with academic achievement in both pre- and in-class learning environments. In addition, students' self-efficacy in collaborative learning had a positive impact on their use of help seeking strategies during in-class learning. The theoretical and instructional implications are discussed.

1. Introduction

The flipped classroom model of instruction has received a great deal of recent attention (Bergmann & Sams, 2012). Although some have argued that the concept of a flipped classroom has been practiced in education for decades (e.g., Tucker, 2012), the development of the Internet infrastructure and multimedia production, and increased accessibility to personal technologies have brought this instructional model to the forefront. In a typical flipped class, students learn content material prior to class through online instructional videos and text readings at their own pace and schedule. Then, they work in-person with the course instructor to apply their newly acquired knowledge through problem-based and group-based learning activities (Yarbro, Arfstrom, McKnight, & McKnight, 2014). In essence, the flipped classroom model consists of two major components: pre-class Internet-based individual learning and in-class interactive group learning (Bishop & Verleger, 2013). This model aims to maximize the face-to-face in-class time for instructors to interact with students and provide personalized feedback on students' learning (Bergmann & Sams, 2012; Herreid & Schiller, 2013). It also allows students to engage with each other in group learning activities, to potentially achieve at a level that they would under an individual tutoring condition (Guskey, 2007).

With growing interests in the flipped classroom model, a number of empirical studies have examined its effectiveness compared to traditional face-to-face instructions. These studies have yielded mixed findings. On one hand, some studies supported the effectiveness of the flipped classroom model. For example, Mason, Shuman, and Cook (2013) found that students in a flipped classroom demonstrated equal or better academic performance and showed greater satisfaction with the learning model than did those in traditional classes. Similarly, Schullery, Reck, and Schullery (2011) suggested that the flipped classroom design successfully engaged more students in active learning and improved the connections both among students and between students and the college (Baepler, Walker, & Driessen, 2014; Fulton, 2012). In contrast, some studies did not found the flipped classroom model more effective than the traditional classroom model. For example, Davies, Dean, and Ball (2013) found no significant differences between flipped and traditional classes in students' evaluation of instruction, perceived learning, or their final achievement. Strayer (2012) found that students in a flipped class were actually less satisfied with how the classroom structure oriented them to learning tasks. This dissatisfaction was based on students' feeling less settled in the flipped class because of the variety of learning activities in the class.

These mixed findings may be due to several reasons. There is a considerable variability in the design and implementation of flipped classrooms, although researchers use this common terminology – “flipped classroom”. First, the design of flipped classroom often is guided by various conceptual frameworks, such as Bloom's Taxonomy

* Corresponding author.
E-mail addresses: zhiru@sam.sdu.dk (Z. Sun), xie.359@osu.edu (K. Xie), anderman.2@osu.edu (L.H. Anderman).

http://dx.doi.org/10.1016/j.iheduc.2017.09.003
Received 10 May 2016; Received in revised form 4 June 2017; Accepted 21 September 2017
Available online 27 September 2017
1096-7516/

(e.g., Bergmann & Sams, 2012) and the Four Pillars of FLIP framework (e.g., Muir & Geiger, 2016), reflecting different assumptions about student learning and, therefore, effective instruction. Secondly, there is a wide range of content areas and larger programmatic contexts within which flipped classes operate. Third, students in flipped classrooms are not homogeneous. Some students may be successful in the flipped classroom, with more engagement and higher achievement, while others may not. In order to meaningfully interpret the results of previous studies, the conceptual frameworks, the theoretical and pedagogical underpinnings of the design, the contexts of study, and importantly students' characteristics need to be considered. Therefore, research needs to move beyond the comparison between flipped and traditional classes, and specifically examine how students learn in the context of flipped classrooms, in order to uncover the nature of flipped classrooms and describe students' learning in these contexts. The present study particularly focuses on individual characteristic variables that may explain differences in student success in flipped classrooms.

2. Theoretical framework

2.1. Self-regulated learning theory

The flipped classroom model offers opportunities to students to take control of their learning pace and be responsible for their learning process (Fulton, 2012); at the same time, however, it demands more from students (Flipped Learning Network, 2014). In a flipped class, students are expected to be self-directed and complete pre-class tasks in order to be well-prepared for in-class activities (Talbert, 2014). To actively engage in in-class activities, students need to set personal learning goals, deploy appropriate learning strategies, and be capable of monitoring their behaviors (Estes, Ingram, & Liu, 2014). In this situation, knowing how to regulate time, resources, and strategies to achieve learning goals is important (Connor, Newman, & Deyoe, 2014). Research shows that students with higher levels of self-regulation tend to learn effectively and achieve better in a flipped classroom than those with lower levels of self-regulation (Lai & Hwang, 2016). In the present study, we used self-regulated learning theory as the underlying theoretical framework in guiding the investigation of students' learning processes in the flipped classroom model.

Self-regulated learning is an integrated learning process guided by a set of motivational beliefs, behaviors, and metacognitive activities that are planned and adapted to support the pursuit of personal goals (Schunk & Zimmerman, 2012). We adopt the framework developed by Winne and Hadwin (1998, 2008) because their model specifically addresses self-regulated learning in technology-enhanced contexts (Azevedo et al., 2011; Azevedo, Moos, Greene, Winters, & Cromley, 2008), which are aligned well with the characteristics of flipped classes. Winne and Hadwin's self-regulated learning model consists of four stages: *task definition, goal setting and planning, enactment, and adaption*, with each stage occurring within a micro-cognitive system that includes fives processes: *conditions, operations, products, evaluation, and standards*. The self-regulated learning process is such that, when a student is given a task, he would first define the task (e.g., as an easy or a hard task) based on both task and his individual cognitive factors (*conditions*), and then create a profile of standards for satisfactory task performance (*standards*). After setting the standards, he would enact learning strategies (*operations*) to produce learning outcomes (*products*), and then compare those outcomes with the standards to obtain internal feedback regarding his behaviors and performances (*evaluations*). At the same time, he may also be provided with external feedback (*evaluations*) from peers and teachers.

Winne and Hadwin's self-regulated learning model emphasizes the *conditions* and *operations* processes. The *conditions* play a foundational role in self-regulated learning and have a direct impact on the processes that follow (Greene & Azevedo, 2007), and *operations* connect *standards* and *products*, during which learners manipulate information obtained in previous processes, enact certain learning strategies, and produce learning outcomes to match with set standards (Winne, 2001). In the *conditions* process, how to define a task is highly dependent on students' prior task-domain knowledge and self-efficacy (Winne & Hadwin, 2008); while the selection of appropriate strategies and putting them to work are essential in the *operations* process (Winne, 2001). Consistent with the emphasis of Winne and Hadwin's work, researchers have identified the significant impact of these key constructs – *prior domain knowledge, self-efficacy*, and *the use of learning strategies* on students' self-regulated learning (e.g. Diseth, 2011; Murphy & Alexander, 2002; Pintrich, Smith, García, & McKeachie, 1993).

Prior domain knowledge – a construct in the *conditions* process – refers to "… the knowledge, skills or ability that students bring to the learning process" (Jonassen & Grabowski, 2012, p.417). Research has revealed a significant relationship between prior knowledge and self-efficacy (Ferla, Valcke, & Cai, 2009), the use of learning strategies (Murphy & Alexander, 2002; Taub, Azevedo, Bouchet, & Khosravifar, 2014), and academic achievement (Song, 2010; Thompson & Zamboanga, 2004). Pajares and Miller (1994) reported that students' prior math experience had direct effects on math performance and math self-efficacy, and they emphasized that prior knowledge affected performance largely through its influence on math self-efficacy. Murphy and Alexander (2002) found that students with limited domain knowledge tended to use more surface text-processing strategies, such as rereading or omitting unfamiliar words, for the initial understanding of a written text, while those with more developed domain knowledge tended to use more deep and advanced text-processing strategies, such as relating the text to prior knowledge or building a mental image.

Self-efficacy – another construct in the *conditions* process – is defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Extensive research has demonstrated its association with academic achievement (Caprara, Vecchione, Alessandri, Gerbino, & Barbaranelli, 2011; Phan, 2012; Pintrich & Zusho, 2007), as well as students' use of learning strategies (Diseth, 2011; Liem, Lau, & Nie, 2008). Bandura (1986) argued that people are more influenced by how they interpret their experience rather than by their actual attainment per se. For this reason, self-efficacy usually predicts future behavior and achievement better than other psychological and study skill factors. This hypothesis has been supported in multiple empirical studies, as demonstrated in the meta-analysis conducted by Robbins et al. (2004). Self-efficacy is also positively related to the use of cognitive and metacognitive learning strategies. Students who believe in their capabilities are more likely to self-regulate their behaviors by using cognitive strategies and reflecting on their performance during learning (Pintrich & De Groot, 1990). To increase the accuracy of the measurement of self-efficacy, Pajares (1996) has emphasized the importance of defining efficacy at the domain-specific level, for instance, math self-efficacy—students' perceived confidence in their abilities to learn math and complete math tasks (Pajares & Miller, 1995), Internet self-efficacy—students' perceived ability of using the Internet as a problem solving tool (Kim, Glassman, Bartholomew, & Hur, 2013), and collaborative learning self-efficacy—students' perceived confidence in their abilities to work with peers and as a group in collaborative learning activities (Johnson & Johnson, 1999).

Learning strategies – a construct in the *operations* process – denote "behaviors and thoughts in which a learner engages and which are intended to influence the learner's encoding process" (Weinstein & Mayer, 1983, p.3). The effective use of learning strategies is believed to be the hallmark of sophisticated self-regulated learning (Winne, 2001). Three main areas of learning strategies include cognitive strategies, metacognitive strategies, and resource management strategies (Pintrich et al., 1993). Specifically, cognitive strategies involve students' use of basic strategies to process information from texts and lectures such as repeating words, paraphrasing, summarizing,