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University students' self-regulation, engagement and performance in flipped learning

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Abstract

Purpose – The purpose of this study is to examine the effect of students' self-regulation, co-regulation and behavioral engagement on their performance in flipped learning environments in higher education.

Design/methodology/approach – The subjects were college students taking an education course offered at a 4-year university in South Korea. Structural equation modeling was adopted to analyze 221 student responses.

Findings – The findings indicated that the more students self-regulated, the more likely they were to engage in co-regulation with other students in the class. Students' self-regulation and co-regulation also significantly affected their behavioral engagement. Finally, students' self-regulation positively affected their academic performance, while co-regulation and behavioral engagement did not affect their performance.

Originality/value – Based on these findings, this study provides meaningful implications for scholars and practitioners on how to select and use more appropriate instructional and evaluation strategies to improve students' positive behavior, engagement and performance in a flipped learning environment.

Keywords Self-regulation, Co-regulation, Behavioral engagement, Performance, Flipped learning, Higher education

Paper type Research paper

Introduction

To improve the quality of instruction and learning in higher education, universities and researchers have recently paid considerable attention to flipped learning (Awidi and Paynter, 2019; Murillo-Zamorano *et al.*, 2019). Flipped learning refers to a learner-centered instructional strategy that promotes engagement by providing learning content that students must review, view or learn before class. They then spend class time focusing on diverse, active learning activities instead of simply listening to lectures (Bergmann and Sams, 2012). By adopting flipped learning, instructors have more time to assign various interactive activities (e.g. discussion and collaboration). Assigning pre-learning content before arriving in class saves time in class, as instructors do not need to deliver learning content through in-class lectures.

Some scholars, however, have expressed concern about flipped learning, despite the findings from multiple studies that have found that students' performance in flipped learning courses is higher than in traditional classroom courses (González-Gómez *et al.*, 2016; Nwosisi *et al.*, 2016). The concerns center around the problem that all students have

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different skills, time and motivation for learning; thus, their pre-learning engagement and participation could be different (Akçayır and Akçayır, 2018; Huang *et al.*, 2019). In particular, college students may be resistant to doing pre-learning tasks and could question the need for pre-class learning when they are more familiar with classroom lectures in K-12 education and less familiar with a flipped learning style (Chen *et al.*, 2016). Lee and Choi (2019) indicated that participation in pre-learning activities had a strong impact on performance in a flipped learning environment.

Regardless of how well instructors prepare the pre-learning materials, the effectiveness of flipped learning cannot be guaranteed without students completing the pre-learning assignments before class (Blau and Shamir-Inbal, 2017; Sengel, 2016). Considering that flipped learning is different than traditional lecture-based learning methods, it is important for instructors to examine how students can regulate their learning process in this new learning environment (Jovanović *et al.*, 2017). Several scholars have emphasized that students' self-regulation is the key to successful flipped learning (Sletten, 2017; Sun *et al.*, 2017).

Self-regulation is viewed as a contextual-specific variable because it is demonstrated differently according to the individual environment and context. According to Alexander (1995) and Lai and Hwang (2016), self-regulation in individualized situations and in social environments or relationships with others should be separated. For instance, learners can have self-regulation through conversations with others but have lower self-regulation in individual learning environments (Law *et al.*, 2016). When individual learners collaborate with others, they need co-regulation (supporting self-regulation among team members and recognizing individual roles) and shared regulation of learning (all members controlling the team learning process), as well as self-regulation (Winne *et al.*, 2013).

Specifically, co-regulation should be an important consideration in a flipped learning environment. As flipped learning has a combined format including both individual learning outside of class and collaborative learning in the class, both self- and co-regulation can affect students' learning performance in a flipped learning class. Learners' self-regulation is required for successful pre-learning before class (Sletten, 2017) and then with enough pre-learning, learners can demonstrate co-regulation and active engagement in class (Law *et al.*, 2016).

Previous studies, however, have focused more on self-regulation than co-regulation (Shih *et al.*, 2019; Greene *et al.*, 2012). Although recent studies have emphasized the role of co-regulation in flipped learning (Blau and Shamir-Inbal, 2017), little research has been conducted to empirically examine the effect of both self-regulation and co-regulation in a flipped learning context from an integrated perspective. Beyond studies comparing instructional methods in traditional classes and flipped learning classes, more research is needed to examine which student characteristics can improve performance in a flipped learning environment (Sun *et al.*, 2018). Such studies would help scholars and practitioners incorporate more appropriate instructional strategies for individual students when designing flipped learning courses.

The purpose of this study is to examine the effects of students' self-regulation, co-regulation and behavioral engagement on their performance in a flipped learning environment in higher education. Self-regulation was selected as a variable related to work outside of class and co-regulation and behavioral engagement were included as variables for work in the classroom. The following research question guided this study: What are the relationships among students' self-regulation, co-regulation, behavioral engagement and performance in a flipped learning course at the university level?

Our study makes substantial contributions to the field. First, we investigated how students' self-regulation can affect their collaborative learning process, behavioral engagement and performance in flipped learning. This study viewed self-regulation as a critical antecedent of students' behavior and outcomes in emerging new learning environments that demand strong responsibility and control in learning. Second, we provided a conceptual framework to support the relationships among self-regulation, co-regulation, behavioral engagement and performance. This study will provide researchers with a deeper understanding of their relationships and seek more advanced models to explore different dynamics in flipped learning contexts. Third, we examined how students perceived their learning process and behavior in a collaborative learning context in the Korean university context. Our findings could encourage scholars and practitioners to focus more on how to promote the effect of self-regulation on students' collaborative process, engagement and performance in Korea.

Theoretical foundation and literature review

Flipped learning

Flipped learning can be defined as a continuous learning experience between the school and home, including doing school work at home and doing homework at school (Yarbro *et al.*, 2014). Lectures from instructors are assigned as outside-of-class videos and in-person classes focus on discussion, problem-solving and collaborative learning that require active participation, often among team members. By rearranging the traditional education format, flipped learning provides multiple, diverse formats and activities to promote student learning (DeLozier and Rhodes, 2017). In general, flipped learning consists of two types of activities:

(1) students view short video lectures online at home before class; and

(2) then students attend class and actively participate with peers (Abeysekera and Dawson, 2015).

The key feature of flipped learning is to emphasize a student-centered learning process and environment. Ng (2014) suggested that the theoretical foundation of flipped learning is based on cognitive and social constructivism. By adopting flipped learning, instructors can provide a supportive design that encourages students to create their own meaning in the class (Sohrabi and Iraj, 2016). To successfully implement flipped learning, students need to engage in:

- active learning to recognize what they learn first at the individual level and then.
- engage in social interaction with peers to construct meaning (Bishop and Verleger, 2013).

Flipped learning also has a student-centered approach to pre-learning (Abeysekera and Dawson, 2015). Compared to a traditional setting where students may not have time to fully absorb new topics in class, flipped learning promotes students' learning initiative to learn at their own pace and helps them effectively acquire new knowledge as they view video lectures before class. Wang and Eccles (2013) explained that students demonstrate different achievement levels in traditional school settings because they have the same learning time regardless of their different competency levels. In higher education, particularly where students must learn in-depth knowledge in a specific major but often have to take classes outside their majors, students have different levels of understanding. However, the traditional higher education system focuses more on efficiency (e.g. 5 days a week, 6 h per day) than on effectiveness (e.g. the students' mastery of content) (Huitt *et al.*, 2009). In this

context, flipped learning can help students master learning by providing opportunities to review content and check their understanding before class (Bergmann and Sams, 2012). This strategy frees them up to engage in interactive activities in the classroom.

Scholars have investigated the diverse aspects of flipped learning in different higher education contexts (Brewer and Movahedazarhouligh, 2018; O'Flaherty and Phillips, 2015; Shi *et al.*, 2020; Wilson, 2020). Their main research focus is related to how to design flipped learning environments, how flipped learning can be effective in improving students' learning outcomes and teaching practices and what factors contribute to enhancing the strengths of flipped learning. Although some scholars have expressed concerns about flipped learning (e.g. as only a partial solution to replace a whole class, devaluing teachers and context-dependent results) (Kim *et al.*, 2014), researchers have indicated that flipped learning supports students' higher cognitive and affective outcome through positive learning experiences (Cho *et al.*, 2019; Shi *et al.*, 2020).

Although flipped learning provides a flexible learning environment to meet students' individual learning pace, not all students experience the benefits of flipped learning (Flipped learning network, 2014). In a flipped learning environment, students need to take responsibility for learning by preparing for and controlling their own learning. Flipped learning cannot provide meaningful learning outcomes when students are unfamiliar with the learning process or they are not self-regulated to learn the pre-class content. Because of these individual characteristics of learners, some studies have found that there are no differences between traditional and flipped learning strategies for college students (Davies *et al.*, 2013; Findlay-Thompson and Mombourquette, 2014).

Related theories: self-regulation theory and social learning theory

Self-regulation theory and social learning theory explain the important role of individual motivation and collaboration in a flipped learning environment. Self-regulation theory describes an individual's process to establish goals, monitor progress toward those goals and regulate individual actions and behavior to accomplish the goals (Carver and Scheier, 1981; Latham and Locke, 1991). To describe this process, self-regulation theory emphasizes four components: standards (to clarify ideals and goals), monitoring (to track self-regulation), willpower (to promote self-regulatory strengths and resources) and motivation (to meet the standard and to achieve the goals) (Baumeister and Vohs, 2007). In particular, motivation plays a critical role in self-regulation by helping individuals focus on their goals and controlling and affecting their behavior (Baumeister and Vohs, 2007). In flipped learning settings, self-regulation theory explains how students lead and manage their learning processes and pace based on their goals, monitoring, resources and motivation.

Social learning theory emphasizes that social interactions affect individual cognition and behavior, as well as their learning process (Bandura, 1986). From a social learning perspective, individuals tend to show higher motivation and performance when other people are involved in the learning process (Morrison *et al.*, 2019). In group work, students can enhance their learning experience in both the online and in-class environment through collaboration and interactions (Hill *et al.*, 2009). By working together with other members who have different abilities and views, individuals can observe other members' attitudes, understand the topics better, solve problems and teach each other how to work more efficiently in a group (Lin and Huang, 2020). Social learning theory can elucidate how individuals, based on the previous self-learning, collaborate with their colleagues to achieve the goals of the group in flipped learning environments.

Self-regulation and co-regulation

Scholars have described learning outside the classroom in the flipped learning process as self-regulated learning (Sletten, 2017; Sun *et al.*, 2018). Self-regulation in the learning process includes using appropriate cognitive strategies (e.g. organization and demonstration) to efficiently understand learning content and using diverse behavioral strategies at one's understanding and meta-cognitive thinking levels (Zimmerman, 1989). Highly self-regulated students tend to establish their own learning objectives, evaluate their learning outcomes, seek help for better learning and understanding and manage their time in learning (Williamson, 2015).

Students' self-regulation affects their learning outcomes in both traditional classrooms and online learning environments (Dabbagh and Kitsantas, 2005; Greene *et al.*, 2012; Zheng *et al.*, 2020). In the flipped learning process, self-regulation is critical because it requires online pre-learning outside of class and offline learning in class. According to Zheng *et al.* (2020), students who lack self-regulation strategies may fail to comprehend or connect ideas in their pre-class learning, which could lead to ineffective learning outcomes during in-class activities. Students' meaningful learning experience in flipped learning depends on how well prepared they are for learning before class (Sun *et al.*, 2016). Self-regulation plays an important role in the whole learning process from online learning outside the classroom to face-to-face learning in class because students need to monitor their learning and check for understanding themselves in the pre-learning stage so they can be prepared for active participation in the classroom (Estes *et al.*, 2014).

In addition to self-regulation, co-regulation is also significant in that most classroom activities focus on collaboration in a flipped learning environment (Yarbro *et al.*, 2014). To solve problems and complete assignments, students not only need to use their own learning strategies but also recognize the contexts and situations of the assignments and then accept other strategies their classmates suggest (Hadwin *et al.*, 2005). Co-regulation is based on the assumption that individuals' self-regulation is enhanced or newly acquired through interaction with others (Rogat and Linnebrink-Garcia, 2011).

Scholars have defined co-regulation from different perspectives because subjects and objects of self- and co-regulation can be different in a collaborative context (DiDonato, 2013; Hadwin and Oshige, 2011; Hayes *et al.*, 2015; Zheng and Yu, 2016). For instance, Hadwin and Oshige (2011) viewed co-regulation as the conversion of individual self-regulation strategies to adjust to collaborative learning contexts. DiDonato (2013) regarded co-regulation as the process of acquiring self-regulation through collaboration and interaction with peers. While both Hadwin and Oshige (2011) and DiDonato (2013) emphasized that the development of self-regulation is influenced by others, Hayes *et al.* (2015) described co-regulation as providing scaffolding from team members sharing more knowledge and skills with others.

In this study, we adopted the definition of co-regulation suggested by Hadwin and Oshige (2011) because flipped learning provides a link between pre-learning in an online setting and learning in the classroom setting. In the pre-learning stage, students can practice their self-regulation skills. As students engage in collaborative activities in the classroom, their self-regulation can be converted to co-regulation to meet the requirements of the in-class collaborative context. For instance, students who can self-regulate by managing their learning time and methods in the pre-learning stage outside of class can also make similar efforts in the team activities and collaboration in class.

Numerous researchers have investigated the relationship between self-regulation and co-regulation (Blau and Shamir-Inbal, 2017; Panadero *et al.*, 2015). In research on students in a teacher education program in a Finnish university, Panadero *et al.* (2015) indicated that individual self-regulation could affect co-regulation because self-regulated students were

capable of demonstrating diverse learning strategies that could also apply to collaborative learning situations. Blau and Shamir-Inbal (2017) also found that students who self-regulated their learning pace and pre-class learning time also self-regulated the team activities in class. These students recognized that individual learning was a prerequisite for successful team activities:

H1. Students' self-regulation level will be positively related to their co-regulation level in a flipped learning setting at the university.

Behavioral engagement

Student engagement is a critical part of a flipped learning environment. While individual learning activities outside the classroom are designed to provide foundational knowledge of the content, learning activities in the classroom involve the engagement process of constructing meaningful knowledge for students. Engagement needs considerable effort to achieve individual learning objectives above and beyond the typical level of participation and mere physical presence in the classroom (Hu and Kuht, 2002). In this regard, engagement is an important factor to examine if the traditional and instructor-led class is converted to a student-centered class (Teng *et al.*, 2012).

Scholars have discussed engagement in terms of cognitive, emotional, behavioral aspects (Christenson *et al.*, 2012; Handelsman *et al.*, 2005). Cognitive engagement is related to efforts to acquire new knowledge and skills through learning by emphasizing the relationship between learning motivation and cognitive engagement (Yazzie-Mintz and McCormick, 2012). Emotional engagement focuses on students' emotions and feelings (e.g. interest and boredom) in school and in the classroom environment (Wang and Holcombe, 2010). Behavioral engagement emphasizes the concrete behavior of students' efforts for learning such as actively interacting with group members and seeking help from the instructor for assigned tasks and learning activities (Handelsman *et al.*, 2005).

Specifically, behavioral engagement is activated when students have authentic and meaningful assignments (Wang and Eccels, 2013). In a flipped learning setting, the instructor promotes students' behavioral engagement by providing diverse learning activities, a flexible environment and a learner-centered culture (Chen *et al.*, 2014). In several studies examining a flipped learning context that provided multiple activities (such as preparation, questions, problem-solving with peers, questions and answers), students showed a high level of behavioral engagement in pre-class, in-class and post-class activities (Elmaadaway, 2019; Huang *et al.*, 2019). Student engagement also affected learning satisfaction and achievement in flipped learning settings (Chen *et al.*, 2014; Huang *et al.*, 2019).

Self-regulation, co-regulation and behavioral engagement

Several studies have supported a positive relationship between self-regulation and behavioral engagement (Park and Yun, 2018; Sun and Rueda, 2012). Sun and Rueda (2012) indicated that self-regulation was a significant predictor of cognitive, emotional and behavioral engagement in online learning environments in the USA. Park and Yun (2018) also reported that the level of behavioral engagement improved when both graduate and undergraduate students used diverse motivational regulation strategies.

Multiple scholars have indicated that behavioral engagement is also positively related to co-regulation (Nguyen *et al.*, 2018). When students' behavioral engagement was categorized into not engaged, passive engagement and active engagement, students with active

engagement demonstrated higher levels of interaction between peers and instructors (Nguyen *et al.*, 2018). Highly engaged students are more likely to have effective co-regulation and interaction skills by seeking help from peers and checking each other's understanding of the content:

H2. Students' self-regulation and co-regulation levels will be positively related to their behavioral engagement in a flipped learning setting at the university level.

Self-regulation, co-regulation, behavioral engagement and performance

Scholars have frequently discussed self-regulation, co-regulation and behavioral engagement as antecedents of student performance (Huang *et al.*, 2019; Huang *et al.*, 2019; Lai and Hwang, 2016; Sun *et al.*, 2018; Wang, 2017; Zheng and Huang, 2016). In a flipped learning environment, highly self-regulated students had higher academic performance levels than those who had lower self-regulation levels in both elementary schools and the university (Hyppönen *et al.*, 2019; Lai and Hwang, 2016; Sun *et al.*, 2018). The more university students regularly engage with the pre-class assignments and activities throughout the flipped course, the higher their performance in the final exam is likely to be (Jovanović *et al.*, 2019).

Co-regulation strategies can also lead to higher performance in various online collaborative learning environments (Järvelä *et al.*, 2013). In a master's program for learning and educational technology, the quality of students' outcomes was high when students used co-regulation in both face-to-face and online collaboration (Järvelä *et al.*, 2013). Co-regulation also helped undergraduate students achieve high performance in computer-supported collaborative learning environments (Zheng and Huang, 2016). When students were highly and behaviorally engaged in flipped learning activities, their performance was better in both pre-class and post-class activities in terms of timing and quality (Huang *et al.*, 2019). Students also demonstrated higher achievement when they behaviorally engaged in problem-solving than when they only engaged in self-reflection and learning content (Wang, 2017):

H3. Students' self-regulation, co-regulation and behavioral engagement levels will be positively related to their performance in a flipped learning setting at the university level.

Based on the literature review, we established three hypotheses and a research model as shown in Figure 1.

Methods

Participants and research context

Subjects for this study were undergraduate students enrolled in a "foundations of education" course in the College of Education at a university in South Korea. This course was required for preservice teachers and aimed to provide comprehensive knowledge related to education (e.g. educational psychology, educational philosophy and educational methods). It also gave students the opportunity to apply their knowledge in practice. This course used a flipped learning format to facilitate an effective learning process and provide a flipped learning experience for future teachers.

Participants included 221 students enrolled in the Fall 2017 or Spring 2018 semester. The same instructor taught both semesters using the same syllabus. The course included 10 flipped learning sessions over 15 weeks (Table 1).

For the flipped learning lessons outside of class, the instructor assigned a 10-min or shorter video each week before class was posted on the learning management system. Reviewing the video before class was required for all students to gain 10 points toward the

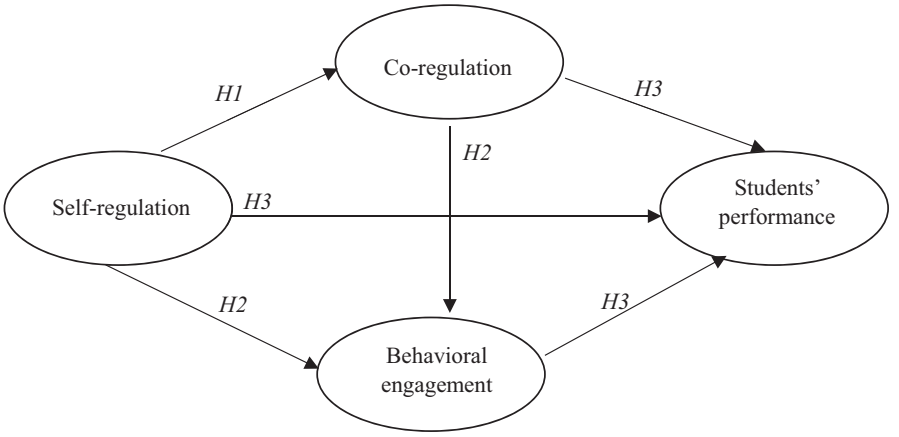

Figure 1.
Hypothesized research model

Week	Topic	Flipped	Week	Topic	Flipped	Week	Topic	Flipped
1	Introduction	N	6	Educational sociology	Y	11	Educational issues 2	N
2	Concept of education	Y	7	Educational issues 1	N	12	Educational technology	Y
3	Educational history	Y	8	Mid-term	N	13	Educational counseling	Y
4	Educational philosophy	Y	9	Educational curriculum	Y	14	Lifelong education	Y
5	Educational psychology	Y	10	Instruction and learning	Y	15	Final exam	N

Note: Flipped sessions (Y) and no flipped sessions (N)

Table 1.
Class schedule

total grade. Additionally, students were given a quiz with three questions to check their knowledge of the material presented in the video. In the subsequent 100-min class, the instructor gave a mini-lecture and then assigned team activities. In the in-class mini-lecture, the instructor summarized the content of the video and provided answers for the questions on the quiz. For team activities, each 4-member team had a discussion and answered questions (e.g. What are learner-centered instructional strategies?), summarized and submitted their outcomes by filling in a worksheet and shared their answers with the class through the learning management system.

The 221 participants included 97 (43.4%) female and 124 (56.1%) male students. In terms of majors, 112 (50.7%) were in humanities/social science, 59 (26.7%) were in science/engineering and 50 (22.6%) were in arts/physical education. Most of the participants were sophomores, with 188 sophomores (85.1%), 18 juniors (8.1%) and 15 seniors (6.8%).

Instruments

The instruments were prepared for use in Korean using appropriate translation procedures. The questionnaire implemented a five-point Likert-type scale ranging from 1 (strongly

disagree) to 5 (strongly agree). This instrument included 24 items, excluding demographics and exams.

Self-regulation. Pintrich *et al.*'s (1991) Motivated Strategies for Learning Questionnaire (MSLQ) was used to measure self-regulation. The MSLQ has been commonly used to measure learning motivation and strategies (Duncan and McKeachie, 2005); 12 items were adopted in this study. A sample item is, "when I study for this class, I set goals for myself to direct my activities in each study period." The Cronbach's alpha from Pintrich *et al.*'s (1991) study was 0.97, while the present study was 0.81.

Co-regulation. To measure collaborative regulation, six items were selected from the instrument developed by DiDonato (2013). These items ask how an individual (as a group member) is committed to collaboration and group activities in the flipped learning context. A sample item is, "I double-checked my work to make sure I was doing it right." The Cronbach's alpha value was 0.83 for both DiDonato's (2013) and our study.

Behavioral engagement. Handelsman *et al.*'s (2005) Student Course Engagement Questionnaire (SCEQ) was adopted to measure learners' active participation in class. The SCEQ categorized engagement into skills engagement (e.g. note-taking and listening), emotional engagement (e.g. motivation and interest), participation engagement (e.g. interaction and active behavior) and performance engagement (e.g. recognizing achievement after class). In this study, six items were selected from participation engagement. A sample item is, "I ask questions when I don't understand the instructor." The Cronbach's alpha values of Handelsman *et al.*'s (2005) and this study were 0.79 and 0.84, respectively.

Performance. A mid-term exam (30%), final exam (30%), team activities (20%) and class attendance (20%) were used to measure student performance. The mid-term and final exams were paper-and-pencil tests in Weeks 7 and 15, respectively. Team activities were evaluated by reviewing team worksheets for 10 weeks, including a final peer evaluation (5%). Class attendance was divided into watching the pre-class videos for flipped learning (10%) and class participation (10%).

Data collection and analysis

The survey was distributed to participants in class before they took the final exam in Week 14. The collected data were analyzed using the following procedures. First, exploratory factor analysis (EFA) was conducted to confirm the validity and reliability of the instruments. After conducting EFA on each variable in this study, self-regulation, co-regulation and behavioral engagement were determined to be unidimensional factors. We used item parceling for the three variables to minimize any possible overweight and the estimation error on a particular variable in the hypothesized model (Kishton and Widaman, 1994; Sass and Smith, 2006). Self-regulation, co-regulation and behavioral engagement were extracted randomly to generate two-item parcels, which were used for the measurement model and the structural model. The performance was included as a measurement variable in the structural model.

Second, descriptive statistics (mean and standard deviation) were conducted using SPSS. Multivariate normality was checked by examining the values of skewness and kurtosis. Additionally, correlation analyzes were performed to observe any significant correlations between the variables examined in this study. Third, confirmatory factor analysis (CFA) was performed to evaluate the model fit of the measurement model prior to testing the hypotheses (Kline, 2015). The CFA results indicated that a correlation coefficient between the latent variable and the observed variable was higher than 0.50, confirming convergent validity (Hair *et al.*, 2009).

Finally, the structural model and hypotheses testing were conducted to examine the relationships between the variables. Maximum likelihood estimation was selected as an appropriate statistical estimation method. The goodness of fit indices used for this study

included chi-square (CMIN, $\chi 2$), comparative fit index (CFI), the root-mean-square error of approximation (RMSEA) and Tucker-Lewis index (TLI) (Kline, 2015).

Results

Descriptive analysis including means, standard deviations, skewness and kurtosis was performed to confirm the multivariate normal distribution. As the results of exploratory factor analysis showed that self-regulation, co-regulation and behavioral engagement were one-dimensional factors, item parceling was used (i.e. self-regulation 1 and 2, co-regulation 1 and 2 and behavioral engagement 1 and 2) to reduce measurement errors by combining individual items and using these combined items (Kishton and Widaman, 1994). Considering the skewness and kurtosis values in Table 2, our data met the assumption of a multivariate normal distribution, in that the values of skewness were lower than 3 and the kurtosis values were lower than 10 (Kline, 2015). All correlations among the variables were statistically significant ($p < 0.05$).

Measurement and structural models

The measurement model was evaluated before examining the structural model. All fitness indices of the measurement model seemed desirable ($\chi 2 = 4.10$; df = 6; $\chi 2/\text{df} = 0.68$; TLI = 0.99; CFI = 0.99; RMSEA = 0.00) (Table 3). All factor-loading values of the items in the confirmatory factor analysis were acceptable, ranging from 0.74 to 0.94. The results indicated adequate validity of all factors in the measurement model.

As the fitness index of the measurement model satisfied the fitness index criteria and the estimated possibility of the structural model was theoretically confirmed, the fitness of the initial research model was estimated using a maximum likelihood estimation method. The initial structural model provided a good fit to the data ($\chi 2 = 6.94$; df = 9; $\chi 2/\text{df} = 0.77$; TLI = 0.99; CFI = 0.99; RMSEA = 0.00) (Table 3).

		1	2	3	4	5	6	7
1	Self-regulation 1	–						
2	Self-regulation 2	0.62*	–					
3	Co-regulation 1	0.42*	0.35*	–				
4	Co-regulation 2	0.39*	0.34*	0.75*	–			
5	Behavior engagement 1	0.48*	0.43*	0.38*	0.41*	–		
6	Behavior engagement 2	0.54*	0.49*	0.43*	0.49*	0.78*	–	
7	Performance	0.36*	0.29*	0.21*	0.19*	0.24*	0.33*	–
Mean		3.38	3.42	3.70	3.71	3.26	3.37	68.81
Standard deviation		0.55	0.57	0.70	0.58	0.71	0.73	13.69
Skewness		−0.10	−0.12	−0.22	−0.02	−0.21	−0.43	−0.17
Kurtosis		0.06	−0.10	0.17	0.26	0.23	0.07	0.01

Note: *$p < 0.05$

Table 2. Descriptive statistics and correlations

	χ^2	p	df	$\chi 2/\text{df}$	TLI	CFI	RMSEA (90% confidence interval)
Measurement model	4.10	0.66	6	0.68	0.99	0.99	0.00 (0.00∼0.07)
Structural model	6.94	0.64	9	0.77	0.99	0.99	0.00 (0.00∼0.06)
Fit criteria		>0.05			>0.90	>0.90	<0.08

Table 3. Results of fitness examination of the measurement and structural models

Hypotheses testing

To test the hypotheses, the statistical significance of the path coefficient between the variables was examined. First, the direct effects of self-regulation on co-regulation was statistically significant ($\beta = 0.54$, $t = 6.15$, $p < 0.05$). Second, self-regulation ($\beta = 0.53$, $t = 6.07$, $p < 0.05$) and co-regulation ($\beta = 0.27$, $t = 3.49$, $p < 0.05$) had significant effects on behavioral engagement. Self-regulation also indirectly affected behavioral engagement through co-regulation ($\beta = 0.15$, $p < 0.05$). Finally, the effect of self-regulation on performance was significant ($\beta = 0.36$, t =3.05, $p > 0.05$). However, co-regulation (β = –0.04, $t = 0.43$, $p < 0.05$) and behavioral engagement ($\beta = 0.12$, $t = 1.12$, $p < 0.05$) did not have significant effects on performance. The findings showed that *H1* and *H2* were both supported and *H3* was partially supported (Table 4).

Discussion and implications

This study examined how students' self-regulation, co-regulation and behavioral engagement affected their performance in the flipped learning environment. The data revealed several important findings. First, students' self-regulation positively affected their co-regulation. In other words, students' co-regulation was more likely to improve when they had a higher level of self-regulation. This finding confirms the findings of previous studies (DiDonato, 2013; Hadwin and Oshige, 2011; Volet *et al.*, 2009). In a flipped learning environment, students are often concerned about peer students in their groups who do not prepare for class in advance (He *et al.*, 2016; Strayer, 2012). In practice, collaboration is not easy when one or more of the four-team members are "free riders" in flipped courses (Hao, 2016). Thus, it is important for flipped learning teachers to understand and emphasize that individual students need to have self-regulation.

Second, students' self-regulation and co-regulation positively affected behavioral engagement. Similar to previous studies (Sun and Rueda, 2012), our findings supported a significant effect of self-regulation on behavioral engagement. The findings also indicated that students with a high level of co-regulation were more likely to demonstrate higher behavioral engagement. Students' ability to self-regulate is strongly related to social interaction (Travers and Sheckley, 2000). Highly self-regulated students often share what they understand with peers and ask the teacher for help if needed. Self-regulated students can also elaborate on their understanding by explaining key points to peer students who do not understand the learning content. When a team has problems doing the assigned tasks, self-regulated students ask the instructor to help or will actively search for external resources. In addition, the positive relationship between students' self-regulation and their co-regulation suggests that self-regulation can both, directly and indirectly, affect behavioral engagement.

Table 4.
Hypothesis testing: path coefficient estimates

	Paths	Direct	Indirect
H1	Self-regulation → Co-regulation	0.54*	–
H2	Self-regulation → Behavioral engagement	0.53*	0.15*
	Co-regulation → Behavioral engagement	0.27*	–
H3	Self-regulation → Performance	0.36*	0.06
	Co-regulation → Performance	–0.04	0.03
	Behavioral engagement → Performance	0.12	–

Note: *$p < 0.05$

Third, self-regulation affected students' performance, while behavioral engagement and co-regulation did not significantly affect their performance, which is not consistent with the findings from previous studies (Hinnant-Crawford *et al.*, 2016; Wang, 2019). These inconsistent findings could be related to performance evaluation. In this study, the evaluation included a collaborative task, attendance, watching pre-class videos and paper-and-pencil tests for the mid-term and final exams. The paper-and-pencil tests focused more on understanding knowledge than the knowledge acquisition process. The nature of these tests could be why the total score was lower because students did not have enough opportunities to demonstrate how they acquired meaningful knowledge and to describe their experiences in collaborative activities. Another reason could be related to different factors influencing student performance. Instructor-related factors (e.g. instructors' abilities and skills and activities in class) could affect performance in this study. Future research could further examine how the types and components of the evaluation and instructional factors affect students' behavioral engagement and performance in a flipped learning environment.

Based on the findings, this study has significant implications for higher education. First, diverse activities should be prepared and various learning strategies should be implemented to improve students' self-regulation. Researchers and practitioners have paid attention to self-regulation because it can significantly affect students' academic performance based on their ability to control the learning process, the amount of work and the activities they are asked to complete. Our findings showed that self-regulation affected students' performance in the flipped learning course. Thus, the role of self-regulation should be critically considered before universities adopt flipped learning approaches. Providing short quizzes and videos about content before each class and offering learning guides through the learning management system are examples of strategies to improve students' self-regulation (Hao, 2016; Talbert, 2015). However, the effectiveness of these strategies depends on students' self-regulation levels. If students have lower self-regulation, they may face challenges in monitoring their understanding of the content and in co-regulation. Thus, it is important for instructors to provide appropriate strategies to help improve students' self-regulation by identifying their self-regulation level, adjusting strategies and their ability and maximizing the benefits students can gain from the strategies. Extrinsic rewards (e.g. giving additional hints for the next quiz to students who completed the review videos within the timeline) could be provided to improve self-regulation.

In addition, motivational, behavioral and cognitive aspects of self-regulation should be considered. In a flipped learning environment, students need to invest additional time outside of class beyond the time in the classroom. In this process, students could experience stress and could lose interest and motivation, especially when they are required courses for college graduation as in this study. If instructors provide similar lectures in class that review all of the material on the videos that the students should have watched before class, it will devalue the need for and motivation to watch the video. As a result, students are not likely to pay attention to the pre-class activities. By making class lectures and pre-class videos both relevant and distinct, instructors can meet the expectations of students and encourage students to use motivational and behavioral aspects of their self-regulation in a flipped learning setting.

Co-regulation can also be examined further to enhance students' active engagement. Considering the role of co-regulation in behavioral engagement, further investigation is needed to determine how to improve co-regulation and to better understand how co-regulation can contribute to student performance through behavioral engagement. In a flipped learning environment, co-regulation can be understood better by recognizing how collaboration works in student teams. When students need to meet new outcomes each week

by regularly working together with the same team members, the task-oriented aspects of co-regulation are important because they need to share knowledge and solve problems in a limited time (i.e. in one class period). When students can focus on the final outcomes over a longer timeframe (i.e. several class periods or throughout the semester), helping students with management functions of co-regulation would be useful, including role allocation, conflict management and time management.

Finally, teams should be created based on students' self-regulation and co-regulation levels for successful flipped learning. When teams have students with different self-regulation and co-regulation levels, complementary learning activities are likely to be more animated including interactions, discussion, acceptance of different perspectives and peer instruction (Johnson and Johnson, 1999). In the collaboration process, instructors need to group teams so highly self-regulated students can help or motivate lower self-regulated students to learn how to improve their self-regulation and co-regulation skills. After creating teams, instructors also need to design team activities to promote students' self-regulation and co-regulation, which will ultimately enhance behavioral engagement and academic performance.

There are several limitations to this study. First, the findings from this study cannot be generalized because participants were selected from one Korean university based on convenience sampling. For instance, one finding (students' self-regulation as a critical antecedent of their academic performance) could be generalized based on previous and current studies. However, the relationships between co-regulation and performance, and between behavioral engagement and performance could be explored further in different settings and contexts. In addition, self-regulation and engagement were regarded as one-dimensional factors so other dimensions or types of self-regulation and engagement were not included. This study also collected self-report data, which runs the risk of common method bias (Podsakoff *et al.*, 2003). Although this study focused on three behavioral factors, other factors that could affect students' academic performance in a flipped learning environment were not considered.

In future studies, college students in other countries who have experienced a flipped learning environment could be recruited to compare the results with the current findings in Korea. By comparing students in different cultural contexts, future studies could explore how cultural differences affect students' performance and learning experiences in a flipped learning environment. Subsequent studies should include various aspects of self-regulation (e.g. cognitive and motivational strategies for self-regulation) and engagement (e.g. cognitive and affective engagement) to capture students' behavior and attitudes in a flipped learning setting. Additionally, diverse factors influencing student performance could be examined. Students' experiences related to collaboration, motivation to learn content and teachers' knowledge and experience with flipped learning can be examined to reveal different aspects and results in flipped learning courses.

Conclusion

To reflect the critical role of flipped learning in engagement and performance for college students, it is worthwhile to perform a more in-depth study of flipped learning that can be optimally applied to higher education. This study explores if students' self-regulation, co-regulation and behavioral engagement have an effect on their performance in a flipped learning environment in a Korean higher education context. The findings indicated that students' self-regulation was a significant antecedent to improve their co-regulation, behavioral engagement and academic performance and students' co-regulation contributed to fostering behavioral engagement. These findings support similar findings in recent

studies (Huang *et al.*, 2019; Hyppönen *et al.*, 2019; Zheng *et al.*, 2020). Interestingly, another finding shows that students' behavioral engagement and co-regulation did not affect their performance, which is not consistent with previous findings (Jovanović *et al.*, 2019; Wang, 2019).

From these findings, this study emphasizes the importance of designing flipped learning courses and implementing appropriate learning strategies based on students' learning processes and self-regulation levels. When designing flipped learning courses, multiple options to guide learning and relevant activities should be provided to improve students' self-regulation. Providing quizzes and videos, sharing diverse resources and information and offering developmental feedback and diverse exercises can be considered based on students' needs and self-regulation levels. For evaluation, pre-class, during class and post-class activities should be aligned with the course objectives. In particular, to observe how students' behavioral engagement and co-regulation impact their performance, evaluations should provide multiple opportunities to demonstrate how students acquired meaningful and new knowledge through social interaction, how they contribute to group work and how they improve learning experiences in collaborative activities.

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