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A Study on the Effects of Mobile-based LMS on Flipped Learning: Focused on the Affective Pathway in Pre-service Teacher Education

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Abstract

Flipped learning is a type of blended learning that has recently emerged as an innovative teaching and learning method. In this study, a mobile-based learning management system (LMS) is developed in order to support flipped learning for mobile-friendly learners. The purpose of the study is to investigate the effects of flipped learning focused on a problem-solving approach on the affective pathway. In addition, the study examines the ways in which mobile-based LMS facilitates flipped learning compared to the PC-based Web environment. A series of instructional design of flipped learning for a math class was developed and implemented for undergraduate students at C University in South Korea. The participating students were asked to write self-reflection journals for 6 weeks (12 periods). In-depth interviews were conducted with the students and the contents of the discussion board in the mobile-based LMS were analyzed using Nvivo, in order to track a series of changes of the affective pathway. The results obtained from the qualitative data revealed that students gained high self-esteem, motivation, and interest regarding academic activities, which eventually cultivated a positive local affect. Furthermore, there was convincing evidence of changes from the "flipped classroom" to "flipped learning", where students were able to take advantage of the mobile-based LMS. Compared to the PC-based Web environment, students were able to overcome the limitation of time and space, using the new environment proactively and creatively.

Keywords*: Mobile-based LMS, Flipped Learning, affective pathway, Pre-service Teacher Education*

1. Introduction

Creativity is a major issue in education in South Korea. According to the Revised National Curriculum (RNC) of 2009 and 2015, the main purpose of education in South Korea is to foster creative (fusion) talent [1, 2]. Demonstration of instruction has been included in the teacher qualification examination since 2010 [3], and creativity is emphasized in teaching and learning methods, which are usually taught in curricular and extra-curricular programs. It is problematic that only two courses (4–6 credits) of curricular program is required for graduation and teacher certification. Although contents knowledge education cannot be separated from teaching and learning method education in pre-service teacher education, only limited opportunity is provided for students to practice various teaching styles and strategies.

Although South Korean students' academic achievements are relatively high according to previous studies on international comparative studies (PISA, TIMSS), their performance in the affective domain, such as competence and motivation, remains very low. Mathematics is a very important subject in South Korea in terms of its class hours

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and proportion in the Scholastic Aptitude Test (SAT). However, there are many students who simply give up on math, which has been widely reported by the press [4].

One possible reason for this is the general academic atmosphere in schools, which emphasizes the "drill and practice mode", even though the National Curriculum stresses the thinking ability and creativity in mathematics education. Math tests in school and/or SAT usually set a time limit in order to rank students based on test scores. Moreover, thanks to the fever of SAT in South Korea, school mathematics remains focused on fundamental arithmetic operations from elementary school to high school. Thus, math is regarded as a time-consuming and uninteresting subject rather than a meaningful tool to understand the real world. This unique circumstance in South Korea requires new strategies for teaching and learning mathematics in pre-service teacher education.

Having recently gained attention worldwide, flipped learning is being distributed rapidly in secondary schools and universities in South Korea. Flipped learning reverses the traditional instructional environment by delivering class materials as homework and providing various kinds of student-centered learning opportunities, such as group activities, discussions, and asking questions in the classroom.

With the advent of smart society, it is necessary for instructors to understand learners' characteristics and make the most of smartphone and other information and communication technologies (ICT) [5]. In its early stage, flipped learning stressed providing movie clips as learning materials and the PC-based web environment. On the other hand, smart society prompts flipped learning to transform itself to adjust to the ubiquitous learning environment and to require mobile-based learning management systems (LMS). Students in South Korea are very mobile-friendly because of the high prevalence rate of mobile devices (84%). Therefore, a mobile-based LMS enables students to access learning materials beyond the boundaries of time and place, which is very appropriate considering the fact that a flexible environment is an important aspect of flipped learning [6, 7].

Based on the characteristics of the learners in South Korea and the educational environment of the country, we designed a flipped learning model to exert a positive impact on students' emotions in math classes. The present study employs a longitudinal approach in order to develop an affective pathway during flipped learning experiments. To do this, self-reflective journals, in-depth interviews with students, messages, and responses in the discussion boards at LMS were analyzed with Nvivo, a computer-aided qualitative data analysis system (CAQDAS). The research investigated the following issues:

(1) Does the mobile-based LMS facilitate flipped learning compared to the PC-based Web environment?

(2) Does the flipped learning model focused on problem solving have an effect on developing a positively affective pathway?

(3) Can the instructional design of this study help to overcome negative local affects?

Figure 1 illustrates the process of the study.

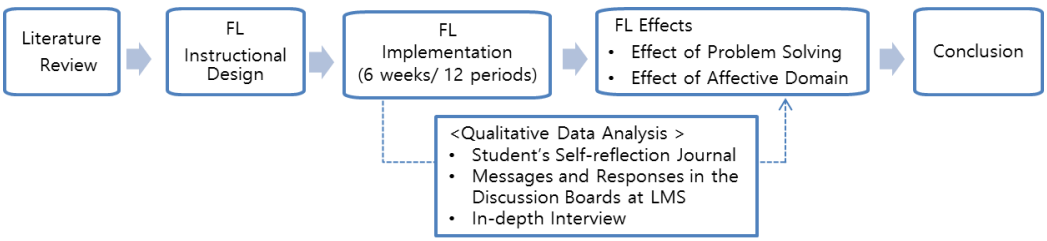


Figure 1. Overview of the Research Process

2. Literature Review

2.1. Mobile-based LMS and its Application to Flipped Learning

LMS refers to a system for managing and supporting the learning of students in the e-learning environment and a Web-based platform in order to manage various activities associated with teaching and learning [8, 9]. Early LMS has been developed to mainly support academic contents on platforms such as the blackboard, VOD, and simple HTML [10]. However, changes in the learning environment and diversification of learning contents led to the functional changes of the LMS in order to provide more powerful management and support systems. The general functions of the LMS include connection management, learning content, interaction tool, and group management [9, 11]. It is common to provide customizing options in addition to a basic solution [10]. Accommodating the new paradigm of education and ubiquitous society, U-learning is characterized by permanency, accessibility, immediacy, interactivity, and situating of instructional activities [12]. In order to support the U-learning environment, C University has launched a new mobile-based LMS, which is equipped with lecture authoring tool from an existing PC-based LMS. The present study was conducted to take advantage of the new features of an improved mobile based-LMS.

Table 1. Comparison between Previous Studies and Proposed Model for Flipped Learning

	Previous studies on FL	Proposed model for FL
Society	Information-oriented society	Smart society
Environment	PC-based Web environment	Mobile-based LMS environment
Learning Media	VCR, CD, YouTube, PC	Smartphone, tablet, PC
Emphasis	Video preparation, video watching	Communication (discussion board, resource room, bulletin board, feedback, etc.)
LMS usage	Δ	O
Paradigm	Flipped “classroom”	Flipped “learning”

2.2. Integrating WSPQ Method with Flipped Learning

Flipped learning has recently emerged as an innovative and blended teaching and learning method. There is a paradigm shift from “flipped classroom” to “flipped learning.” The former places a stronger emphasis on video preparation and video watching, while the latter on real learning in all aspects of classroom activities. So far, studies on flipped learning have mostly been related to the cognitive domain, such as comparison of academic achievements [13, 14, 15]. A handful of studies have examined affective domains, such as self-efficacy, attitudes, and satisfaction, by measuring improvements in students’ learning before and after flipped learning [16, 17, 18, 19]. However, a simple parallel comparison between pre-test and post-test phases in the affective domain is pointless because students often go through various kinds of emotional stages during class activities and problem solving.

Thus, the fundamental transition from flipped classroom to flipped learning is attributed to students’ self-directed learning. In other words, it is no longer a matter of delivering instructional contents in the form of video clips, but a question of students’

actual learning process. In order to facilitate students' self-directed learning, we applied the watch-summarize-pose problems -question (WSPQ) method, which is developed by applying Kirch's watch-summarize-question (WSQ) method ([20, 21]) to mathematics education. As a before-class activity, students were asked to follow the four steps of W-S-P-Q. The primary focus of this activity is posing and solving problems, which is "not only a goal of learning mathematics but also a major means of doing so" [22].

2.3. Affective Domain in Mathematics Education

International comparative studies such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) conducted in 2003 and 2007 showed that students' academic achievement in mathematics is relatively high, while performance in the affective domain is very low [23, 24, 25].

Emotions are closely intertwined with the cognitive domain, and it is particularly true in the process of solving mathematics problems [25, 26, 27]. Both positive and negative emotions can be generated during the process of problem solving [28, 29]. Goldin referred to this as the "local affect." Depending on the context, the sequence of repetitive changes of local affects is called an "affective pathway," which forms a "global affect" from the long-term perspective. Designing an affective pathway and developing a "'meta-affect" mean that positive local affects as well as negative local affects, such as bewilderment, puzzlement, anxiety, frustration, and resignation might be controlled to foster a positive global affect eventually.

3. Research Methods and Procedures

3.1. Instructional Design of Flipped Learning

Researchers recommend that flipped learning be developed and implemented with a series of thoughtful instructional design considerations, including effective ways to plan for blended learning. Figure 2 shows the instructional design of flipped learning for a math class following a pre-, in-, and post-class frameworks.

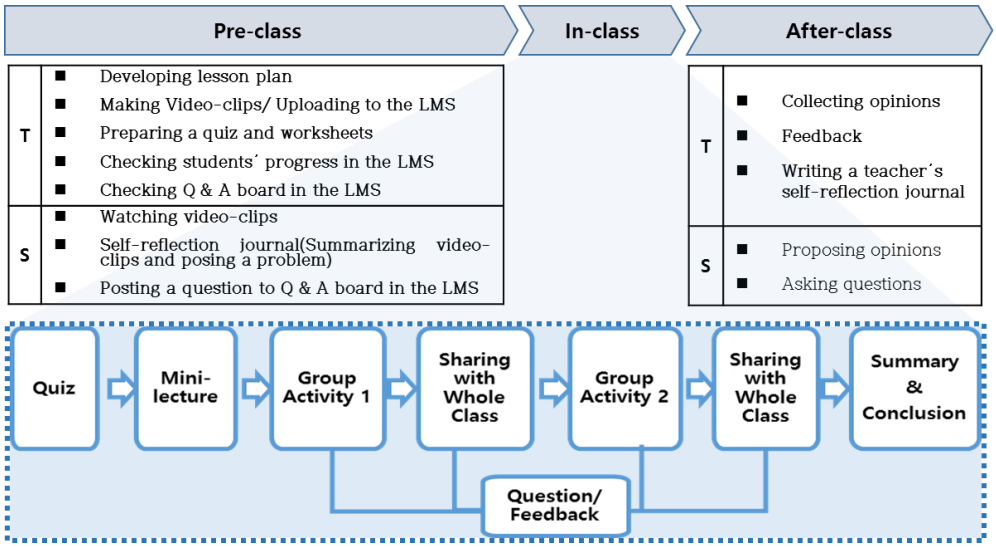


Figure 2. Instructional Design of Flipped Learning

Note: T (teacher), S (student), LMS (Learning Management System)

3.2. Development of Mobile-based LMS for Flipped Learning

In this study, a mobile-based LMS was developed in order to support flipped learning for mobile-friendly learners. The process of the mobile-based LMS for flipped learning is illustrated in Figure 3.

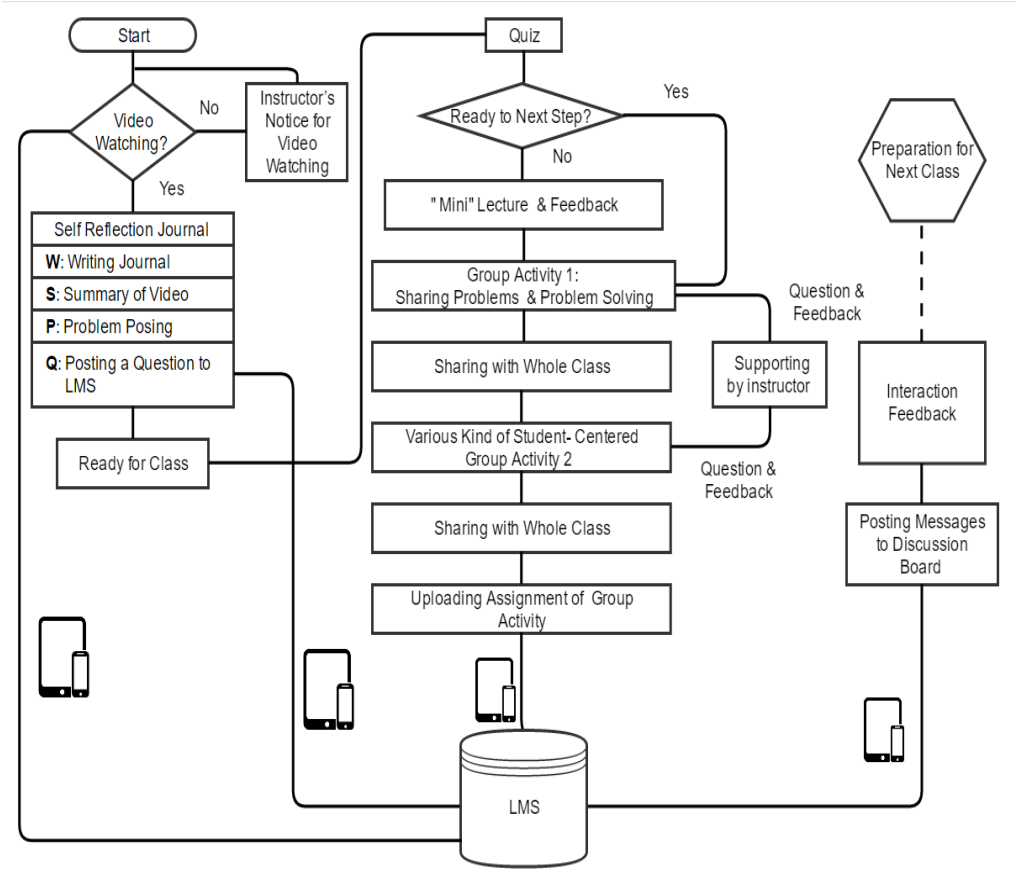
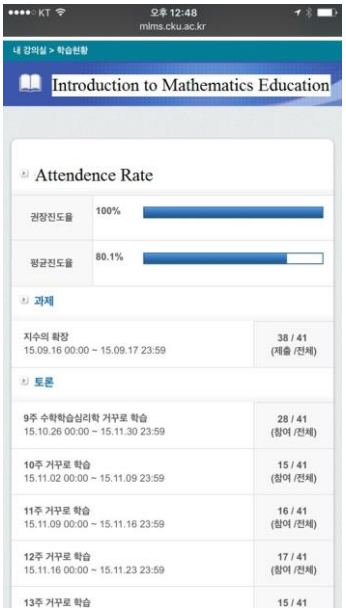


Figure 3. Process of Flipped Learning Supported by Mobile-based LMS

This system aims to provide learners with a flexible environment for watching videos regardless of location (classroom, home, or elsewhere). In addition, the lecturer can send a prior notice to students who would not be ready for the lesson. In the class, the lecturer and students can engage in face-to-face communication and share the results of group activities via the mobile-based LMS. Furthermore, each member of the class can post messages, questions, and resources, and respond to the on-line discussion board in the mobile-based LMS, which is able to create cooperative relations between each content element and the database of blended learning [30]. Figure 4 shows several screenshots of the mobile-based LMS.

(a) Main home screen

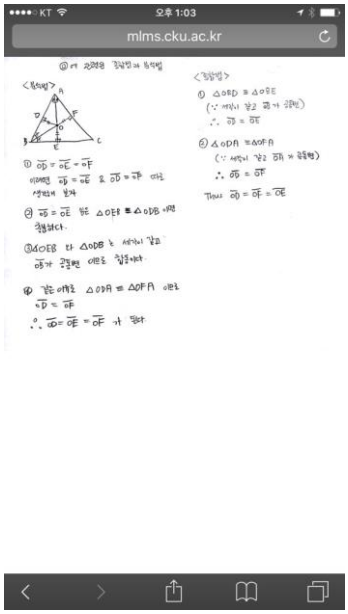


(b) Attendance rate

(c) Movie clip

(d) Discussion board

(e) Threads on discussion board



(f) Results of group activity

Figure 4. Screenshots of Flipped Learning Supported by Mobile-based LMS

3.3. Research Methods

In order to examine the combined effects of flipped learning and problem solving in the math class, we introduced this format to 37 students (26 male, 11 female) in the Introduction to Mathematics Education class, which is offered to sophomore students at C University in the South Korea. Students who participated in this study had no prior experience of flipped learning. Students were not familiar with group activities since most classes in the department of mathematics education were not student-oriented and based on lectures. In order to track a series of changes that occurred in the affective pathway, self-reflective journals written by the students, in-depth interviews, and the postings on the discussion board in the mobile-based LMS were analyzed for 12 periods (6 weeks) using Nvivo.

4. Results and Discussion

By coding self-reflective journals written by 37 students, 68 nodes emerged from 867 references. A number of consistent themes were reflected by 34 among 68 nodes. Results fell into two distinct groups: the first 3 weeks and the second 3 weeks. The former showed 21 nodes regarding the relatively new classroom experience, such as flipped learning and classroom activities of problem solving. On the other hand, the latter showed 13 nodes regarding the contents of learning itself. In other words, the first half was related to the effect of flipped learning and problem solving, and the second half was related to the combined effects of both, which apparently exerted a strong influence on students' affective pathway. Upon further review, we were able to identify three themes as follows.

4.1. Effects of Mobile-based LMS for Flipped Learning

The main obstacle of flipped learning with a PC-based LMS is that it is difficult to manage a class when some students have not watched the video clips at home and are not ready for the lesson, since it is only possible for the lecturer to realize the fact only after the class begins. Thus, in this study, we have an observant eye for attendance rate by using a mobile–based LMS. The lecturer can send a text message to the students who have not watch the video. The analytics of the LMS showed that the attendance rate of the class was as high as 95–98%.

On the other hand, the mobile-based LMS enables students to access learning materials regardless of time and location. The average audience rating of each video clip was 2.0, which means that the students watched the video repeatedly during their commute or spare time.

Still, there were several students who had not watched video before the class. Those students were able to prepare for the class using a mobile device and headset/earphones while other students took the quiz. At the beginning of the semester, there were 4–5 students who had not watch the video. However, after 2–3 class sessions, the percentage of students who were not ready for class dropped sharply.

Students who were familiar with mobile devices became accustomed to the new mobile-based LMS quickly. An interview below indicates an opinion of the mobile-friendly generation.

> *"I used my smartphone to capture and store importance scenes while I watched videos. It was a piece of cake. Using a mobile device, it is very easy to produce and/or reproduce learning materials and share them with others. It's fun." (Interview with Kim after the end of the course).*

According to the interviews and the analytical results, it is evident that the students took advantage of the mobile-based LMS. Compared to the PC-based Web environment, students were able to overcome the limitations of time and space and used the new environment proactively and creatively.

4.2. Effects of Flipped the Learning Approach

Students claimed that preparing for a lesson by watching video clips had positive learning effects, which improved their concentration and participation in the class. We also observed positive affective responses in their self-reflective journals. They were motivated to study and recognized the value of mathematics. It reveals that they are very much interested in the new class style. The following are examples of how students prepared for classes for positive learning effects.

After watching the video clips, we discussed about the topic as a group. I think preparing for the class and reviewing the materials thoroughly helped me a lot. I was able to get a better understanding about the concept of function and its importance after the class (Lee's reflection journal, week #3).

From time to time, I would pause a video clip and look up textbooks and other resources for things that I could not understand. From today's lesson, I realized that I needed to watch the videos more carefully (Lee's reflection journal, week #8).

Figure 5 illustrates the theme of the effects of the flipped learning approach.

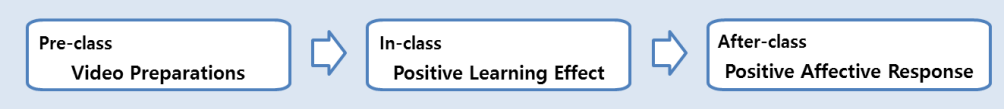


Figure 5. Effects of the Flipped Learning Approach

4.3. Effects of the Problem-Solving Approach

Students were asked to pose questions and solve problems from the previous teacher employment exam as group and/or class activities. This provided an opportunity for the students to share opinions and communicate with other students. They appreciated different ideas and the importance of convergent and divergent thinking skills. Several quotes from students' journals show the process and the effects of the problem solving approach.

It was a great opportunity to share different ideas and pose a variety of questions. Also, there was plenty of time for us to talk to each other and actively engage in problem-solving tasks in the classroom because we had already watched the videos at home. (Yun's reflection journal, week #1)

Today, I learned the meaning of epistemological obstacles and thought about various kinds of difficulties, which was a little bit vague at first. However, after posing a problem and discussing how to solve the problem with group members, I got a clear understanding about the concepts. (Kweon's reflection journal, week #5)

Figure 6 illustrates the theme of the effects of the problem solving approach.

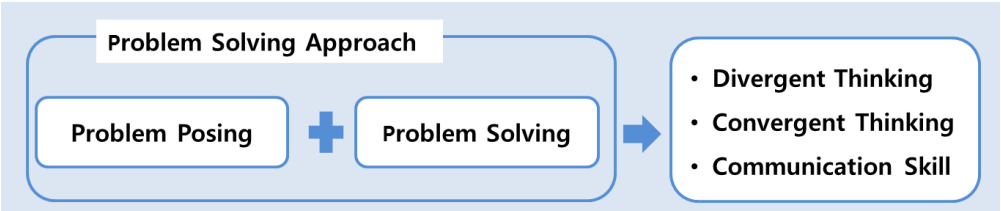


Figure 6. Effects of the Problem Solving Approach

4.4. Combined Effects on the Affective Pathway

Students' responses for the second 3 weeks can be characterized by the cognitive, affective, and psycho-motor domains of the learning process. In particular, we discovered how students were able to overcome the negative local affect and foster the positive local affect (*i.e.*, increased interest and motivation) while they encountered obstacles, frustration, and anxiety in the problem solving process.

> *On one hand, flipped learning is difficult because I have to spend time and efforts to prepare for classes. On the other hand, I'm pretty proud of myself since I accomplished a task of solving a quite challenging problem from the previous teacher employment exam. (Park's reflection journal, week #12)*

> *For me, it was hard to understand the difference between the 2009 RNC and the 2015 RNC. Also, the purpose of these revised national curriculums were confusing and I became frustrated. (Kweon's reflection journal, week #6)*

> *Still, it seems too difficult to grasp the meaning of the class materials. However, after explaining it to peers, asking each other, and struggling to find good examples, I was able to finally understand the difference between analysis and synthesis in the reasoning & proof process. (Kweon's reflection journal, week #8)*

> *Today, we learned about the parallel postulate of non-Euclidean geometry. Frankly speaking, it was intellectually challenging but very interesting, too. (Kweon's reflection journal, week #9)*

Figure 7 illustrates the theme of the combined effects on the affective pathway.

Figure 7. Combined Effects on the Affective Pathway

Important themes that emerged from the data are shown in Figure 8. The diagram was drawn with Nvivo's model builder, which is a powerful tool for visualizing codes, code families, and themes.

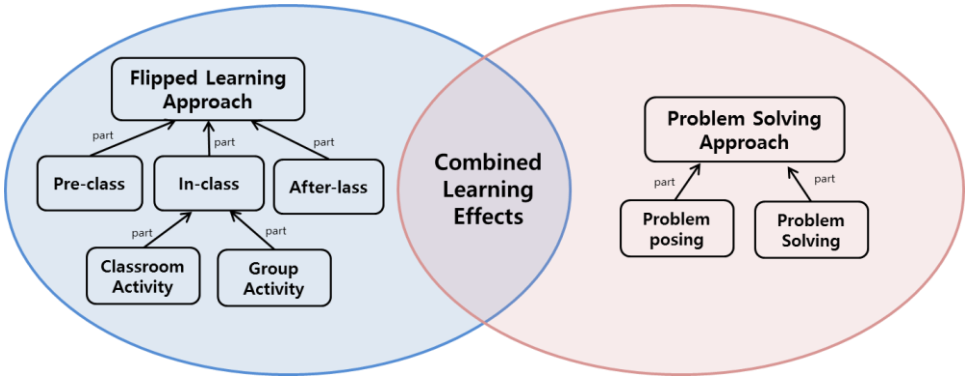


Figure 8. Combined Learning Effects

5. Conclusion

The purpose of the study was to investigate the effects of flipped learning focused on the problem solving approach of the affective pathway. A series of instructional designs of flipped learning for math class was developed and implemented in an undergraduate math classroom at C University in South Korea. Thirty-seven students who participated in the study were asked to write self-reflective journals for 6 weeks (12 periods). The WSPQ method was developed to highlight the processes of solving problems and keeping journals. The qualitative data coded with Nvivo revealed significant changes in students' learning experience throughout the 6 weeks. The first 3 weeks can be characterized as realizing the "wow effect" of flipped classroom, such as the new instructional style, video-watching, preparation for class, motivation, and desire for further study. Results from coding the journals of the second 3 weeks can be characterized by their attention to the progress they made in the learning process. There is convincing evidence of changes from the "flipped classroom" to "flipped learning."

Findings of this study confirm previous studies claiming that flipped learning has a positive influence on academic motivation and students' level of concentration by allowing them to prepare for classes beforehand, which creates a positive cycle. In addition, this study found that students often experience negative local affects when they confront frustration and anxiety during the process of problem solving, which could usually cause a negative cycle. However, the student who participated in this study were able to overcome the difficulties by taking part in various kinds of teaching and learning activities, such as answering questions, presenting one's ideas, conducting psychomotor practices as a group, and posing problems. Ultimately, students were able to foster convergent and divergent thinking, communication, and presentation skills, which had been difficult to achieve in traditional lecture-style classes.

With the advent of smart society, learners have become accustomed to the mobile-friendly environment. Their learning styles have become optimized for mobile devices and flipped learning. Moreover, they are eager to go beyond simply watching video clips. They have a very strong demand for active communication and feedback with the lecturer and other students. That is, there is a Copernican revolution in flipped learning, where the lecturer's role is not only teaching but also facilitating the learning process.

Throughout the process of flipped learning and problem solving in the math class, students gained high self-esteem, motivation, and academic interest, which eventually cultivated a positive local affect. It was a rare opportunity for South Korean students to break out of the negative cycle of math anxiety and low academic achievement. Thus, the study contributes to this affective pathway, and more specifically, to positive and negative local affects. The results also will shed some light on the affective domain, which lacks research.

This study also suggests that instructors need to continuously improve their teaching methods in flipped learning based on the understanding of students' characteristics and needs. Student-oriented collaborative learning can prove its worth when the instructor interacts with students via face-to-face communication as well as online feedback and discussion board of the LMS.

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