

# COMPARATIVE CASE STUDY ON DESIGNING AND APPLYING FLIPPED CLASSROOM AT UNIVERSITIES

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## ABSTRACT

There have been many reports on cases where flipped classroom was applied which put greater emphasis on conducting various learning activities during class. However, there is a limitation in redesigning existing university lectures as flipped classrooms merely based on reports that describe the learning activities of and their effects on individual subjects. Therefore, for this study, flipped classroom was applied to and managed two different courses and a comparison was made on different application types and learners' responses depending on the different instructors, learners, subjects and teaching methods of the class before the redesign. The result showed that the types and numbers of learning activities redesigned into flipped classrooms turned out to be different depending on the characteristics of the learners, the teaching methods of the previous class, and the types of activities that instructors thought were significant but insufficient. Moreover, surveys and interviews were conducted on positive and negative aspects of online video, learning activities, homework, and the overall flipped classrooms. We suggest different opinions according to characteristics of learners and composition of learning activities as a result. This study has its significance in demonstrating that various kinds of flipped classrooms can be designed and managed in accordance with various compositions of different courses while providing an overall guideline on how to design the course based on the different factors of each course.

## KEYWORDS

Flipped Classroom, Instructional Design, Case Study

## 1. INTRODUCTION

Lecture-centered education is one of the most commonly used methods as it can deliver a great amount of knowledge within a short period of time. However, it has also been heavily criticized for being unable to nurture higher-level thinking such as critical, problem-solving, and creative thinking. Moreover, it is also ill-suited to developing the social knowledge capacity that is one of the important goals of education and facilitated through interaction between instructors and co-learners.

To improve higher-level thinking and social knowledge capacity through communication and interaction, various learner-centered education methods such as Problem-Based Learning, Situated Learning, and Goal-Based Scenarios have been suggested as an alternative to one-sided knowledge delivery. Based on such changes in the education paradigm, flipped classrooms have recently gained particular interest among experts. In flipped classrooms, learners listen to the lecture in advance through online video before class; and for the parts they have failed to fully understand through the online video, they actively engage in problem-solving activities either through discussions with co-learners or through the help of teaching assistants and instructors during the class (Bates & Galloway, 2012). Emphasizing the concept of 'flipped (inverted),' Bergman and Sams (2012) defined flipped learning as 'the type of learning in which activities traditionally conducted in classrooms are done at home and conversely, activities usually done at home are conducted in classrooms.'

Examples of university courses where inverted learning was applied are the Software Engineering course at Miami University (Gannod, Berge, & Helmick, 2008), the Basic Information Engineering course at Bentley University (Frydenberg, 2013), the Genetics and General Biology course at University of Missouri (Stone, 2012), and the Calculus course at University of Michigan (Berrett, 2012). In Korea, KAIST and UNIST have been running flipped classrooms since 2012. In particular, KAIST started to run three courses implementing flipped classroom in the spring semester of 2012 and expanded it into 10 courses during the

fall semester of 2012; throughout the spring and fall semesters of 2013, a total of 62 courses in KAIST were run in flipped classrooms and the number is expected to further increase (Lee, 2012).

Case studies of these universities where inverted classrooms were applied provide data on management formats, composition factors and effects of the flipped classrooms. In most cases, flipped classrooms were applied to subjects in the field of science and engineering and were generally composed of online video lecture before class, quizzes, discussion, problem-solving and feedback during class, and wrap-up and review after class. There have been significantly meaningful effects in terms of learners' achievement, satisfaction, and participation in flipped classrooms (Bates & Galloway, 2012; Frydenberg, 2012; Gannod, Burge, & Helmick, 2008; Johnson & Renner, 2012). However, there are limitations in effectively redesigning existing university lectures into flipped classrooms based solely on description of individual subject's learning activities and their effects. Even though the classes deal with the same learning content, they need to be designed and applied to different types of flipped classrooms in accordance with the characteristics of subjects, learners, and instructors as well as the teaching method of the previous class.

This study applied and ran inverted learning in two different courses; and based on the results, it examined different application types and learners' responses to inverted learning depending on instructors, learners, subjects and the teaching method of the previous class and learners' responses to them.

## 2. METHODS

For this study, the Calculus 2 and Nonlinear System Theory courses opened at Seoul National University in Korea were redesigned into flipped classrooms during the 2013 fall semester. For each course, one person with a doctoral degree in educational technology and one graduate student supported the instructional design and management; and instructors and teaching assistants were closely consulted for course application. During every class, observation was made through either manned or unmanned filming and surveys were conducted of every student during mid-term and final examinations. After the end of the semester, five learners were closely interviewed.

The survey conducted during the mid-term exam aimed to gauge the general response of the class and get feedback from the students for future classes; survey conducted during the final exam aimed to find out the effects of the class methods applied to each course and the learners' responses. This study made use of some parts of the mid-term survey items, which enable comparison of the two courses. Following is a table on the different characteristics of the two courses based on the syllabi, instructor interviews and learner surveys.

Table 1. Characteristics of courses where flipped classroom was applied

		<b>Calculus 2</b>	<b>Nonlinear System Theory</b>
<b>Subject</b>	Categories	Compulsory basic liberal arts course	Elective course within the major
	Level	Mid-Low	High
	Prerequisite subjects	Calculus 1	Linear system theory
	Language	Korean	English
	Video materials	-	Class for 2011 academic year
<b>Learner</b>	Grade/Number	Freshmen among undergraduates/18	Master's and doctorate course at graduate school/12
	Composition of departments	Mathematics Education	Four departments, apart from Dept. of Electrical and Computer Engineering
	Prerequisite subjects	Completed by all learners	Completed by nine out of twelve learners
<b>Instructor</b>	Experience with running the course	Ran for the first time in a decade (ran by professors of the Department in rotation)	Have run for the last decade
	Previous teaching method	lecture + problem-solving through team discussions	Lecture focusing on concepts by using PPT
	Motivation for applying flipped classroom	Improving understanding on conceptual equations and formulas through various visual materials	Enhancing understanding of subject matters through English online video lecture before class + class in Korean

		Igniting learners' motivation by implementing more diverse and larger learning activities	Identifying and correcting learners' misunderstanding through problem-solving Inducing questions from learners
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Aside from the fact that the two classes included content related to mathematics and were small-size classes with less than 20 learners, the two courses had totally different characteristics, as suggested by the table above.

### 3. RESULTS

#### 3.1 Composition of Classes Designed for Flipped Classroom

As the two courses were originally different in terms of subjects, learners, and instructors, they were naturally redesigned and managed as different types of flipped classrooms. Following is a table which provides comparisons on the learning activities between the previous class and the flipped classroom.

Table 2. Comparison of the composition of learning activities between the previous class and the flipped classroom

		Calculus 2	Nonlinear System Theory					
		Before applying flipped classroom	After applying flipped classroom	Before applying flipped classroom	After applying flipped classroom			
<b>Before Class (Online)</b>	Video learning	-	<b>O</b>	$\Delta$	O			
	Questions-Answers*	-	-	-	$\Delta$			
<b>In Class (Online)</b>	Quiz	-	<b>15%</b>	-	-			
	Lecture	70%	15%	80%	20%			
	Problem solving	Team discussion-presentation		30%	70%	-	-	<b>40%</b>
		Questions-Answers*		$\Delta$	$\Delta$	$\Delta$	20%	
		Instructor-led problem-solving		-	-	20%	60%	20%
<b>After Class (Online)</b>	Assignment	Reflection Journal	1 per class	1 per class	-	-		
		RSR	-	<b>4 times</b>	-	-		
		Reports	-	<b>1 time</b>	-	-		
	Questions-Answers*	-	-	-	$\Delta$			

In the Calculus 2 course, online video learning which was not included in the previous class and quizzes to check whether learners had done their learning or not were added; Resource Search & Review (RSR) and reports were added as part of homework while the proportion of problem-solving activities through learner-centered discussion and presentations was increased. Compared to the previous class, the proportion of learning activities learners in the flipped classroom had to do before and after class rose. In the Nonlinear System Theory course, at the beginning of the semester, only voluntary Q&A was added before and after class to lead the class mostly through questions and answers. However, after the mid-term, team discussions and presentations were added to encourage class interaction. It can be said that instructor-led problem-solving was the major activity before the mid-term exam while new activities such as team discussions and presentations emerged as the major activities after the mid-term exam.

## 3.2 Composition of Classes Designed for Flipped Classroom

Following are the learners' responses to the inverse learning based on the survey of positive and negative aspects of prior online video learning, learning activities during class, after-class homework, and the overall inverse learning, which can be found in both the Calculus 2 and Nonlinear System Theory courses.

### 3.2.1 Learners' Responses to the Prior Online Video Learning

Learners in both courses responded positively that repetitive learning was possible through online videos. Such positive responses prevailed among learners as they could use them before class and for preparing for exams. It was followed by the response that they felt burdened under an obligation to engage in mandatory study separately from the official class. Some also gave a negative response that online video lecture were not that efficient compared to classroom lectures. Other responses included that learners were able to adjust the learning time and place for their convenience (Calculus 2) and it was challenging to learn through online video lectures delivered in English (Nonlinear System Theory). Following is the table that shows learners' responses to the online video learning before class.

Table 3. Learners' responses to online video learning before class

Learners' response (Multiple Response)		Calculus 2	Nonlinear System Theory
Pros/Cons	Response		
+	It is helpful because I can repeatedly listen to the parts that I do not fully understand.	7	9
-	It is burdensome as I am under an obligation to study in addition to the class.	2	5
-	Online video lectures are less efficient than lectures delivered during class.	2	3
+	It was good to be able to adjust learning time and place at my convenience.	4	-
+	It was good since I could skip the parts that I know and selectively listen to the parts that I find it difficult.	-	2
-	I hardly ended up listening to the video lecture as it was provided through online.	1	-
-	It was regrettable to have less interaction that usually occurs in the classroom.	1	-
-	Even though online lectures can be taken repeatedly, it was burdensome to take lectures delivered in English through online.	-	1
-	Once one gets behind the schedule, one helplessly falls behind the whole course.	-	1

### 3.2.2 Learners' Responses to Learning Activities during Class

Learning activities for the Calculus 2 course were composed of quizzes and cooperative learning. The largest number of respondents said the quizzes were not helpful to learning (8 learners), but at the same time a large number of people also responded that learning was naturally induced as they were checked whether they viewed the online video lecture or not (8). Learners probably felt the quizzes were relatively challenging as they got to know the learning content for the first time during the quiz time, and also burdensome as the quiz scores were reflected in course credit. Learners gave positive reviews for the collaborative learning activities, which proved to be helpful to problem-solving as they were able to engage in various kinds of thinking (5), enhance their understanding (4) and exchange ideas with each other (3). Other opinions included 'cooperative learning itself was very interesting,' and 'the more challenging the problem is, the more efficient it will prove to be.'

Learners enrolled in the Nonlinear System Theory course were required to view the online video lectures and raise any questions either through LMS before class or directly during class. In addition, learning activities were mostly focused on questions and answers during class. First, learners were asked what kinds of answering methods they preferred during the Q&A time at the class. The result showed that they preferred

the most when one or several learners answered the questions while the instructor added relevant opinions and additional answers (5). This was followed by instructor-led Q&A type (4). In conclusion, learners were overall satisfied with the Q&A activities during their inverted learning; and new measures were drawn up to expand learners' participation and have some time for brief class review of the online video at the beginning of the class.

### 3.2.3 Learners' Responses to After-Class Homework

Daily reviews, RSR (Resource Search & Review) and team reports were given to the learners as homework for the Calculus 2 course. Learners' opinions on individual homework such as daily reviews and RSR were that daily reviews were helpful (6) for reviewing the learning content (5) and enhancing understanding (2). However, some responded that daily reviews were not helpful at all (3). It is probably because they thought daily reviews to be inefficient and artificial. Moreover, some pointed out that if questions that genuinely encouraged reviews were suggested, it would lead to more productive reviews.

One of the most frequently suggested opinions in regards to RSR, for which learners searched research theses or the Internet such as Navercast and shared such learning with others, was that it did not prove to be that helpful (7). It is probably because learners, freshmen in an undergraduate course, are not that familiar with researching activities, which led them to feel reluctant and challenged. However, there were some positive responses saying that it helped them to increase their interest in mathematics (4), deepen understanding (2), and engage in further study (2). Other opinions included improvement of information searching ability, time management practice, and unfair reflection in course credit.

Unlike Calculus 2, the Nonlinear System Theory course gave relatively little homework, which required learners to voluntarily upload questions and answers. Completing and submitting homework was not counted for credit. Accordingly, after interviewing five learners who took the course, three learners mentioned the importance of homework.

*For this subject, it's good to have time for questions, (...) but it would be better and much more efficient if we had some problems to solve as homework before class and have some time for discussion over the problems with the professor during the class (Interviewee 2).*

*As it is a challenging subject, it would have been better if professor gave us some problems as homework before class; since we had to solve the problems during class, it was very challenging and even though having homework itself maybe burdensome, it might be more efficient if we could think it over before class. (Interviewee 3).*

*It would be more efficient if we had homework. With no homework, we don't do any problem-solving on our own. Regardless of how difficult or easy the course is, homework is necessary. In particular, easy questions should be handed out for difficult subjects and difficult questions for easy subjects. That is what homework is all about. If too difficult questions are given for difficult subjects, it's not only impossible but also meaningless. Likewise, if too easy questions are given for easy subjects, it really doesn't help. (Interviewee 5).*

Based on the opinions provided by learners, it was concluded that Q&A during class could be more motivated and efficient if homework and learning materials were provided along with the online video lecture learners took before class. In particular, since the course is a graduate school course that is relatively difficult and less sensitive with regard to credit, learning materials or homework related to in-class Q&A can be suggested during online video lecture prior to the class so that learners have some time to be better-prepared for the class.

### 3.2.4 Learners' Responses to the Overall Inverse Learning

Learners' overall responses to the flipped classroom can be broadly classified into positive and negative aspects. For the positive aspects, learners of both courses gave the same opinions in regards to interaction and online video lecture. In terms of interaction, learners held positive views toward flipped classroom as it enabled constant and active interaction between instructor and learners during class. Moreover, in terms of online video lecture, learners positively evaluated it because it made the class more efficient as learners were

able to preview the learning before class, participate in the class more easily and repeatedly study the difficult parts.

Learners who took the Calculus 2 course responded that their overall studying time increased and they were able to acquire an efficient learning method. Learners who took the Linear System Theory course responded that they were able to prepare for in-class Q&A, have in-depth thinking as they reviewed their own questions, and prevent themselves from asking questions irrelevant to the class. Furthermore, learners responded that they could better understand the lecture through flipped classroom compared to the traditional lecture class. Following is a table that summarizes the strong points of flipped classroom pointed out by the respondents.

Table 4. Learners' Opinions on the Positive Aspects of Flipped Classroom

Category	Learners' Opinions	
	Calculus 2	Nonlinear System Theory
<b>Interaction</b>	Constant exchanges between instructors and learners and active participation	
<b>Video</b>	Repetitive learning is possible through online video lecture before offline class Efficient learning and participation	
<b>Learning</b>	Increased individual learning time Acquisition of learning method	In-depth thinking over learning through Q&A Fruitful discussion and enhanced understanding

Negative aspects of flipped classroom pointed out by learners who took the Calculus 2 course were focused on too much workload, content limitation, and online video lectures. As it was impossible to follow the class without viewing the online video lectures in advance, and plenty of homework was given, learners felt heavily burdened; they also complained that the range of subjects covered during flipped class was much more limited. Moreover, having no interaction during online video class was also pointed out as another negative aspect. However, negative aspects pointed out by learners who took the Linear System theory course were mostly focused on the online video lectures. They said that it was very difficult to participate in and follow the class without viewing the online video lecture in advance as class was led mostly through Q&A between instructors and learners; and they also said it was very boring. Following is the table that summarizes the weak points of flipped classroom pointed out by the respondents from each course.

Table 5. Learners' Opinions on the Negative Aspects of Flipped Classroom

Category	Learners' Opinions	
	Calculus 2	Nonlinear System Theory
<b>Learning Burden</b>	Too much homework (daily reviews, RSR, etc.) Pressure to engage in participatory discussion Complying with class schedule	-
<b>Learning Content</b>	Covering relatively small amount of content that one should be learning through the course	-
<b>Video</b>	No interaction possible	Impossible to follow the class if online video lecture is not viewed Boring

## 4. CONCLUSION

After applying flipped classroom to two different courses, this study compared and observed different application types and learners' responses depending on the different instructors, learners, subjects, and teaching methods of the original class. The result showed that various types of flipped learning could be devised and run and learners' responses also differed accordingly. In particular, it was possible to devise and manage different types of flipped classroom depending on instructors' experience and motivation for applying flipped classroom; learners' responses to the overall flipped learning and its relevant activities also differed depending on the courses' category, learners' purpose in learning and sensitivity to course credit. This study is expected to pave the way for further studies on designing and making guidelines for flipped classroom based on various factors in different courses.

## REFERENCES

- Bates, S., & Galloway, R., 2012. *The inverted classroom in a large enrolment introductory physics course: a case study*. Paper presented at HEA STEM conference, London, UK
- Bergmann, J., & Sams, A., 2012. *Flipped Your Classroom: Reach Every Student in Every Class Every Day*. Washington, DC : International Society for Technology in Education.
- Berrett, D., 2012. How 'Flipping' the classroom can improve the traditional lecture. *Education Digest*, Vol. 78, No. 1, p. 36
- Frydenberg, M., 2013. Flipping Excel. *Information Systems Education Journal*, Vol. 11, No. 1, pp. 63-73.
- Gannod, G., Burge, J., & Helmick, M., 2008. Using the inverted classroom to teach software engineering. *Proceedings of the 30th international conference on Software engineering*, pp. 777-786
- Johnson, L. W., & Renner, J. D., 2012. *Effect of the flipped classroom model on a secondary computer applications course: student and teacher perceptions, questions and student achievement* (Unpublished doctoral dissertation). University of Louisville, KY: Louisville.
- Lee, T., 2012. Teaching & Learning Innovation at KAIST: Education 3.0 Initiative. *Proceedings of International Presidential Forum on Global Research Universities: Effective Education and Innovative Learning*. Seoul, Korea.
- Stone, B. B., 2012. Flip your classroom to increase active learning and student engagement. *Proceedings of the 28<sup>th</sup> Annual Conference on Distance Teaching & Learning*. WI: Madison.