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Flipping an EMI Physics Class: Implications of Student Motivation and Learning Strategies for the Design of Course Contents

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ABSTRACT

This paper studies the effect of flipping the classroom in undergraduate physics classes using English as the medium of instruction (EMI). Data on student use of learning strategies, course satisfaction level and perceptions of the flipped classes were collected through a survey including close-ended and open-ended questions. The sample size was 71 students in flipped classes, with 60 students in non-flipped classes used as a control group (total N=131). It was found that students in the flipped classes showed greater intrinsic goal orientation ($p<.05$), control of learning beliefs ($p<.05$), and use of critical thinking ($p<.01$) than those in the non-flipped classes. While the survey highlighted problems of student engagement with the pre-class activities, students who had previous experience with online classes committed more time to pre-class, suggesting that engagement may improve with exposure to blended learning. It is concluded that the flipped classroom helps students develop their identities as self-directed learners, but that more support is necessary for weaker students in the EMI context. Implications are drawn for the content design of flipped EMI classrooms.

Key words: *Flipped Classroom, English-mediated Instruction, Learning Strategies, Student Perceptions.*

1. INTRODUCTION

Under the flipped learning model students follow lectures in their own time prior to class, usually with the aid of e-learning technology, so that the classroom can be developed as a more collaborative learning environment, focusing on active discussion, critical analysis and application [1]. In Korea, the Ulsan National Institute of Science and Technology (UNIST) was one of the first higher education institutions to introduce flipped learning, with the first class opening in 2009. The trial was judged to be a success and energetic promotion of the model saw the proportion of flipped classes at UNIST rise to 20% in 2014, projected to be above 30% in 2017 [2]. Similarly, Korea Advanced Institute of Science and Technology (KAIST), one of the leading science and technology universities, rapidly expanded the proportion of flipped classes from a trial in 2012, again aiming for 30% of all classes to be flipped by 2017 [3]. Other major universities have since followed suit and as such the flipped classroom can now be said to be established as a major paradigm of science education in Korea. There has also been a parallel development of Massively-Open Online Courses (MOOCs) which overlap with the flipped classroom in their use of e-learning systems [2]. Further momentum towards educational reform has been generated by the Korean government's decision to place the so-called 4th Industrial Revolution at the center of its agenda, with the need to cultivate a more creative, learner-centered education culture cited as one of the major challenges [4]-[6].

Given the rapid increase in flipped courses both in Korea and internationally, several researchers have attempted to establish a theoretical framework for the flipped model. Reference [7] put forward a model based upon cognitive load and self-determination theories. Firstly, they argue that cognitive load is reduced through the use of multimedia instruction and the greater ability to tailor the flipped class to students' learning needs. Secondly, they argue that the active learning strategies employed in the flipped class foster students' senses of autonomy, competence and relatedness, which enhances their levels of intrinsic and extrinsic motivation in the course. Reference [8] developed a justification based upon the Revised Community of Inquiry (RCoI, [9], [10]) framework which views the learning environment in terms of the elements of cognitive presence, social presence, teaching presence, and learner presence. Further research is necessary to empirically

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validate these models, and reference [7] in particular calls for classroom studies in a variety of different educational contexts.

One unifying feature of the two theoretical models above is the weight they attach to student motivations and learning strategies in shaping the learning process. Thus, flipped class studies should pay close attention firstly to the initial characteristics of students, and secondly to how exposure to the flipped class changes these characteristics. With regard to the former, the established educational culture plays a key role; for example, in natural science classes in the Korean educational context, it is likely that the majority of students' early classroom experience took the form of passive listening to lectures, with an emphasis on memorization and rehearsal ([11] p.144, [12]), and this may well create a barrier to their acceptance of the flipped classroom. On the other hand, references [13] and [14] detail a four-year classroom study of flipped learning in a US college, in which the lack of statistically significant differences in learning outcomes between flipped and non-flipped classes is ascribed in part to a "highly collaborative environment, [in which] students may not benefit appreciably from new opportunities to work together in class because they already do so in and outside class." With regard to the latter, several studies have examined the roles of student motivation and cognition [14]-[22], with common – but by no means uniform – findings that flipping the classroom provides gains to students' intrinsic motivation, self-direction, and/or higher cognitive skills. References [23] and [24] examine the link between student learning strategies and their perceptions of the flipped classroom, finding that students with greater metacognitive skills and self-directed learning strategies were more likely to have positive perceptions.

Building on this research, this study aims to evaluate the relation between student learning characteristics and their responses to the flipped classroom, and draw principles for flipped class design. Such design principles can be expected to depend sensitively upon educational context (level and field of education, learning objectives, etc.) and this study focusses on undergraduate-level classes taught using English as a Medium of Instruction (EMI). Use of EMI is becoming increasingly common in Korea as universities seek to attract international students and prepare domestic students for the era of globalization [25]. However, a literature review reveals only few studies of flipped learning in the EMI context [25]-[28]; and none which directly examine student motivation and use of learning strategies in this context, which provides one of the major motivations of the present paper.

This study follows four EMI classes in the physics major at a private university in the Seoul suburban area of the Republic of Korea, two of which were taught as flipped classes and two using a traditional lecture format. Student responses were collected through surveys which include demographic data and mixed quantitative and qualitative items to measure their expectations and satisfaction with the course content (henceforth referred to as *student satisfaction*), and student learning characteristics were evaluated using the Motivated Strategies for Learning Questionnaire [29]. It is hoped that this study can contribute to the general empirical grounding and development of flipped learning models, and in particular to evaluate the application of these models in the EMI context.

2. MODELS OF THE FLIPPED EMI CLASSROOM

The term 'flipped classroom' is applied to a very wide range of class designs. Pre-class activities can be based upon readings, video lectures, or more structured e-learning modules; while in-class activities form a mixture of lectures, individual or group work, with varying degrees of instructor involvement (for reviews, see [1], [30], [31]). Given the variety of changes flipped learning implies in terms of use of learning technology and pedagogical techniques, the effectiveness of the flipped classroom can be expected to depend sensitively upon the design of the course contents. Thus, classroom studies of flipped learning, such as the one presented here, must pay close attention to the design of course contents in order for the conclusions reached to be useful in the development of future courses. This section outlines the implications of previous research for the design of flipped EMI classes.

2.1 Flipped Class Design Principles

Reference [31] observes that "an emerging barrier for staff to support instructors who are interested in developing flipped-learning course curricula meaningfully seems to be a lack of pedagogical understanding of how to effectively translate the flipped classroom concept into practice" (p. 94). Drawing on the results of classroom studies, several researchers have attempted to draw general design principles for the flipped classroom. Reference [8] develops a 9-point guide covering the implementation of pre-class and in-class activities. They stress the need to provide incentives for students to participate in the pre-class activities, for example through provision of online forums, quizzes, or direct award of course credit for participation. This is backed up by studies which show significant numbers of students failing to engage in the pre-class activities, and that such failure is a significant predictor of poor performance [17], [32], [33]. In-class activities should be designed to allow regular assessment of student understanding, as well as fostering a learning community amongst students. Ref. [34] provides some practical examples of how this can be achieved in flipped classes with large (>100) numbers of students. Finally, [8] emphasizes the importance of a clear linkage between pre- and in-class activities, with the latter building on the former.

With regard to the design of pre-class materials, cognitive load theory [35] has been used as a starting point for multimedia instructional design [7], [36]. It is suggested that materials should be designed so as to minimize the cognitive load associated with each learning task, which leads to a number of practical design principles such as the breaking down of materials into smaller pieces (segmentation), the use of cues to highlight the key information, and ensuring the complementarity of visual and audial parts of the materials [37].

Given that the flipped classroom is still a new experience for many students, several studies stress the need for clear guidance from the start of the course [8], [23], [32], [34]; and in particular to prepare and acquaint students with the e-learning components [24]. The need for specific help aimed at students with lower motivation or self-efficacy is also stressed [32], [33]. Citing studies which show that student attitudes to flipped

learning improve with prior exposure, [23] concludes that "it is only with practice that most students can realize the benefits of a flipped class."

2.2 EMI Class Design Principles

The use of blended and active learning, which are features of the flipped class, is frequently cited by researchers as beneficial to EMI [2]. Active communication in class is found to help students to master the content [25], [28], promote collaboration, and help students with weaker English ability keep up [38]. The use of video lectures was reported to aid comprehension, as students could pause and review the lectures as needed [25]. However, the flipped EMI classroom also carries challenges, most significantly increased demands on students in terms of time and cognitive load [27], and the reduction in student expressiveness in a second language [28], [39]. Reference [25] stresses the need to establish a learning environment in which students feel comfortable and motivated. Suggestions on how to achieve this include providing ways to promote dialogue other than face-to-face in class, for example through use of online forums [25], [40]; ensuring immediate feedback in-class so that students and instructor can better judge comprehension and adapt as necessary [38]; and allowing code-switching to the native language when severe difficulties in understanding or elaboration are discovered [39].

2.3 Research Questions and Hypotheses

The present study began with the two research questions. First, the study aimed to examine the differences in learning strategies and motivation between students in flipped and non-flipped EMI classes. Second, this study also examined the relations between student use of learning strategies, motivation, and student satisfaction in the flipped and non-flipped EMI classes. For the purpose of the study, it was expected that students in the flipped classes would show greater use of higher cognitive learning strategies and peer-learning than those in the non-flipped classes. Further, a relation between a learning strategy and student satisfaction was interpreted as a sign that the strategy is in demand in that class format, based on the literature review. This led to the following hypotheses.

H1) Students in the flipped environment show greater intrinsic goal orientation and greater use of higher cognitive and meta-cognitive strategies (critical thinking, metacognitive self-regulation) and peer-learning.

H2)(a) Student satisfaction in the flipped classes is positively correlated with use of higher cognitive and meta-cognitive strategies, and with peer-learning; and (b) these correlations are stronger than in the non-flipped classes.

3. METHODS

3.1 Class Design and Sample

This study followed two flipped classes and two non-flipped classes over the course of two years. All classes were electives in the physics major and class sizes ranged from 8 to 32 students. Demographic variables and the details of the classes are shown in Table 1.

Table 1. Demographic variables and the details of the classes

	Gender	2nd	3rd	4th	UR	Sub-total	Age (M)	Age (SD)
Flipped (n=71)	M=47	16	19	12	0	47	22.0	2.2
	F=21	13	6	2	0	21		
	UR=3				3	3		
Non-flipped (n=60)	M=40	22	9	9	0	40	22.1	1.9
	F=20	10	3	4		17		
	UR=3				3	3		
Total (N=131)		61	37	27	6	131	22.1	2.1

Note. The flipped classes (n=71) were Thermal and Statistical Physics I and Introduction to Mathematical Physics. The non-flipped classes (n=60) were Concepts and History of Physics and Modern Physics. In both flipped and non-flipped classes, three participants did not indicate gender (UR=unreported).

Among the participants in the flipped classes, the groups of students across year-in-school differ by online course-taking experience. The gap of taking online courses was greater among the 3rd year students than the other two groups [Chi-square (2, N = 40) = 7.84, p = .02]. The results of the pre-screening of the sample shows that 3rd year students had more online course-taking experience than 2nd or 4th years.

Table 2 summarizes the main activities used in the flipped classes. Pre-class materials comprised video lectures, problem sheets, and a feedback exercise based upon the Watch-Summarize-Question (WSQ) method. The video lectures were produced by the instructor based upon the contents of previous years' classes. After watching the videos, students completed a two-part feedback form, with the first section containing questions designed to summarize the video material and the second section asking them to assess their own understanding of the material, its relation with what they have previously learned, and how the content could be applied or extended. This feedback report fulfills three of the flipped-class design principles of [8]: it incentivizes students to prepare for class (the reports also contributed towards the final grades), it provides a mechanism to assess student understanding, and it formed a bridge between pre-class and in-class parts of the course, being discussed in the first in-class activity each week. An example of a feedback form used in these courses is shown in Table 3.

In the flipped classes, activities comprised small-group and whole-class discussions, concept quizzes, problem solving sessions, and mini-lectures given by the instructor (lectures comprised less than 30% of class time). In comparison, the non-flipped class activities comprised lectures, student presentations, and class discussions, with lectures making up more than 80% of class time. In order to acclimatize students to the flipped-class format the first week of each course was given to an orientation period, in which the basic idea of the flipped class was introduced, students practiced simpler versions of the in-class activities, and students took part in exercises designed to make them feel more comfortable communicating in the class environment.

As these were English-mediated courses (EMCs), special steps were taken to encourage student participation and reduce the cognitive load associated with learning in a second

language. Firstly, English subtitles were added to some of the video lectures, which received very positive student feedback (lack of resources prevented the subtitling of further videos).

Table 2. Description of main pre-class and in-class activities used in the flipped classes

Activity	Duration (minutes)	Description
Video lectures	60-120 (pre-class)	Divided into 10-30 minute lectures
Video feedback reports	30-60 (pre-class)	Students summarize each video, answer questions to analyze own understanding, and pose new questions.
Problem sheets	60-120 (pre-class)	Students attempt problems based upon the videos (full solutions are not required, but students should identify the problems they find difficult for further study in class).
Video feedback discussion	40-60 (in-class)	Students compare and discuss feedback reports in small groups, followed by full-class discussion and instructor-led lecture (as required).
Concept quiz	40-60 (in-class)	Students answer questions to test conceptual understanding; first individually, followed by explanation in small groups or by instructor as necessary (5-15 minutes per question)
Problem solving session	50 (in-class)	Working individually or in groups, students solve problems based upon the videos and problem sheets.
Problem solving review	30-40 (in-class)	Instructor-led review of difficulties identified on the problem sheets and during the problem solving sessions.

Table 3. Example of a feedback form for a video from the Thermal and Statistical Physics class

Section A: Comprehension

1) What are the three phases of matter?
2) Define the latent heat of vaporization
3) What are the names given to the transitions from solid to liquid, and from liquid to gas?
4) What is meant by a supercritical fluid?
5) Sketch the phase diagram of a typical substance. Indicate the triple point and the critical point.

Section B: Self-Review

1) What do you think is the most important point in this lecture?
2) What where the part(s) you understood best?
3) Where there any part(s) you didn't understand well?
4) Is there anything from this lecture you would like to know more about?
5) Make your own question based upon this lecture.

Secondly, collaborative online vocabulary lists were created, to which students added the words or phrases they were unsure of, with other students providing translations or explanations. Thirdly, students were allowed to choose whether to use English or Korean in the small-group discussions. Whilst it was found that most – by no means all – groups opted to use in Korean, the loss of English language practice was considered justified by the improved student participation. Whole-class feedback and discussion were carried out in English only, but students were given additional time and instructor support to formulate their responses. Fourthly, in the feedback reports and class discussions students were encouraged to use a variety of visual (diagrams and graphs) and mathematical forms of communication, in addition to spoken language.

3.2 Measures

As described above, theories of the flipped learning model stress the importance of student motivation and use of learning strategies to the attainment of learning outcomes [7], [8]. To monitor student motivations and learning strategies the Motivated Strategies for Learning Questionnaire (MSLQ) was used [29], [41]. The MSLQ comprises 81 items scored on a 1-7 Likert scale which are divided into six motivation scales (intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, test anxiety), five cognitive learning strategy scales (rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation), and four resource management strategy scales (time and study environment management, effort regulation, peer-learning, help seeking). The consistency and high reliabilities of the scales have made the MSLQ a popular tool for researchers in education (for a review, see [41]), and has been previously used to study student responses to flipped learning (e.g. in [8], [14], [15]).

A survey of 11 items scored on a 1-7 Likert scale was used to assess student satisfaction. The items were divided into three scales – overall satisfaction, perceived instructor encouragement, and perceived instructor organization – adapted from a study measuring the effects of the learning environment on students' sense of belonging [42]. Initial analysis of internal consistency reliability was run and the variables with low reliability were treated with factor analysis. The revised variables identified as organization, time study and environment management, effort regulation, and peer-learning & help seeking, showed improved reliability. The same analysis demonstrated the relatively high reliability of the scales used. The scales used in this study are listed in Table 4.

Table 4. Internal consistency reliability of motivation, learning strategies, student satisfaction, and perceptions on the use of flipped instruction

Scale	Cronbach's Alpha	Num. of Items
Motivation Scale (7-Point Scale)		
1. Intrinsic Goal Orientation	.72	4
2. Extrinsic Goal Orientation	.80	4

3. Task Value	.90	6
4. Control of Learning Beliefs	.72	4
5. Self-Efficacy for Learning and Performance	.93	8
6. Test Anxiety	.85	5
Learning Strategies Scale (7-Point Scale)		
1. Rehearsal	.70	4
2. Elaboration	.83	6
3. Organization(R)	.67	7
4. Critical Thinking	.79	5
5. Metacognitive Self -Regulation	.76	12
6. Time & Study Environment Management (R)	.73	4
7. Effort Regulation (R)	.70	4
8. Peer-Learning & Help Seeking (R)	.82	3
Satisfaction Scale (7-Point Scale)		
1. Overall Satisfaction	.89	4
2. Instructor Encouragement	.83	5
3. Instructor Organization	.79	4
Positive Perception of Flipped Instruction (5-Point Scale)	.90	4

Finally, a separate survey was administered in the flipped classes only, with a series of questions on their perceptions of the flipped method graded on a 5-point Likert scale, the amount of time they spent in preparation for class, their previous experiences of e-learning, and some open-ended items on their general impressions of the class. Demographic variables were gender, age, and year of school. All surveys were administered together in the second half of each semester (between the mid-term and final exams), over the course of four semesters.

3.3 Analysis

Statistical data analysis was performed with SPSS 17.0. For the compatibility of the sample, Levene's tests for equality of variance were run on the two flipped classes and the two non-flipped classes. The results showed that the two classes in flipped and non-flipped conditions were not significantly different in terms of the homogeneity of variance. Therefore, the assumption of the homogeneity was met.

4. RESULTS

Independent samples t-tests on student satisfaction, motivation, and learning strategy scales were run on instruction type (i.e., flipped vs. non-flipped instruction). A second set of independent samples-t-tests was also run as part of a within-group analysis on perceived usefulness. For the within-group analysis the participants were divided into two groups based upon the distribution of the frequency of responses on the usefulness of flipped learning and of the online materials. The groups are labeled as "Not Useful" and "Useful" and are coded as 1 and 2, respectively. Both results on instructional type and perceived usefulness are shown in Table 5 below.

In flipped class condition, students showed higher scores in intrinsic goal orientation (M=5.58, SD=.79, t=2.29, p< .05) than students in non-flipped class condition (M=5.24, SD=.90), in line with hypothesis H1. Control of learning belief was greater in flipped class condition (M=5.97, SD=.73, t=3.29, p< .01) than in non-flipped class condition (M=5.50, SD=.91). Critical thinking skill was also higher in students in flipped class condition (M=4.82, SD=.91, t=3.60, p< .01) than students in non-flipped class condition (M=4.24, SD=.92), again in line with hypothesis H1. However, the peer-learning and help-seeking scale was lower in the flipped class condition (M=4.10, SD=1.34) than in the non-flipped condition (M=4.21, SD=1.38), although the difference was not statistically significant (p=.66).

The participants of the within-group study were analyzed according to their preference for the different in-class activities. The results are shown in Fig. 1, below. The students in the 'not-useful' groups showed significantly more preference for content teaching in-class rather than pre-class, and significantly less preference for the video feedback discussions.

There was a wide variation in time spent in accessing online materials per week (M=150 min., SD=98 min., $Median$= 120 min.) and the time spent aside from class hours (M=181 min., SD= 150 min., $Median$= 132 min.). One-way between-subjects ANOVA revealed a significant effect of the online course-taking experience on the number of hours spent on course work aside from class hours [F(3, 52)=3.10, p=.035]. Post-hoc comparisons using the Bonferroni test indicated that the time spent on course work by students with no online-course taking experience was significantly different from that by students who had taken online courses three times. Students with no previous online course experience spent significantly less time than those who had taken online courses three times.

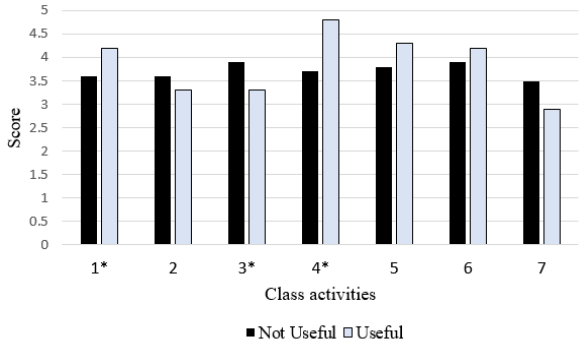
Independent sample t-tests were also run to examine gender differences. Male students showed higher scores in self-efficacy in learning performance (M=4.82, SD=1.01, t=2.75, p< .01) than did female students (M=4.15, SD=1.27). Female students showed higher scores on test anxiety (M=4.96, SD=1.23, t=2.15, p<.05) than did male students (M=4.40, SD=1.36). There were no significant differences in the rest of the student satisfaction, motivation and learning strategy measures. One-way between-subjects ANOVA were conducted to compare the effect of year-in-school on motivation, learning, and student satisfaction. There were significant effects of year-in-school on intrinsic orientation [F(2, 121)=3.77, p<.05)], control of learning beliefs [F(2, 121)=3.02, p<.05] and critical thinking [F(2, 121)= 4.34, p<.05)]. There was no significant effect of year-in-school on student satisfaction. Post hoc comparisons using the Bonferroni test indicated that the mean score of control of learning beliefs for the 2nd year students (M=5.55, SD=.88) was significantly different from the mean score of 3rd year students (M=6.03, SD=.72). The mean score of critical thinking for the 2nd year students (M=4.33, SD=.96)

was also significantly different from the mean score of 3rd year students (*M*=4.91, *SD*=1.06). The Bonferroni test examining the post hoc comparison showed that the mean score of intrinsic orientation for 2nd year students (*M*=5.27, *SD*=.86) was significantly different from the mean score of 4th year students (*M*=5.80, *SD*=.76). The details of the one-way ANOVA are shown in Fig. 2. As Fig. 2 shows, the 3rd year students had greater scores in control of learning beliefs and critical thinking than the 2nd year and the 4th year students.

Table 5. Satisfaction, motivation, and learning strategies in instruction type and perceived usefulness

Construct	Flipped *(M, SD)*	Non-flipped *(M, SD)*	t	sig.	Not Useful (*M, SD*)	Useful (*M, SD*)	t	sig.
1.	6.1(.9)	6.0 (1.0)	.31	n.s.	5.6 (1.1)	6.5 (.7)	-3.40	<.01
2.	5.9(.9)	5.8 (.9)	1.02	n.s.	5.7 (1.1)	6.2 (.8)	-1.69	n.s.
3.	6.1 (.8)	6.1 (.8)	.02	n.s.	5.7 (1.0)	6.4 (.8)	-2.52	<.05
4.	5.58 (.79)	5.2 (.9)	2.29	p<.05	5.5 (.9)	5.9 (.7)	-1.49	n.s.
5.	5.13 (1.1)	5.2 (1.3)	-.19	n.s.	5.7 (1.2)	4.8 (1.1)	2.66	<.05
6.	5.7 (.8)	5.6 (1.0)	.10	n.s.	5.5 (.9)	5.9 (.8)	-1.77	n.s.
7.	6.0 (.7)	5.5 (.9)	3.29	p<.05	5.9 (.8)	6.2 (.8)	-.98	n.s
8.	4.6 (1.1)	4.6 (1.2)	.19	n.s.	4.2 (1.5)	4.9 (.8)	-2.06	<.05
9.	4.6 (1.3)	4.6 (1.4)	.14	n.s.	5.4 (1.3)	4.5 (1.3)	2.27	<.05
10.	4.8 (1.0)	4.5 (1.2)	1.32	n.s.	4.8 (1.1)	4.7 (1.1)	.25	n.s.
11.	5.2 (.8)	5.1 (1.0)	.41	n.s.	5.0 (.8)	5.4 (.8)	-1.53	n.s.
12.	5.1 (.8)	4.9 (.8)	.86	n.s.	5.0 (.9)	5.2 (.8)	-.74	n.s.
13.	4.8 (.9)	4.2 (.9)	3.60	p<.01	4.6 (1.2)	4.9 (.9)	-.88	n.s.
14.	4.5 (.7)	4.5 (.8)	-.15	n.s.	4.5 (.7)	4.5 (.8)	-.05	n.s.
15.	5.0 (1.0)	4.7 (1.2)	1.56	n.s.	5.1 (1.2)	5.0 (1.1)	-.27	n.s.
16.	3.5 (1.1)	3.2 (1.1)	1.50	n.s.	3.0 (1.1)	3.4 (1.1)	-1.46	n.s.
17.	4.1 (1.3)	4.2 (1.4)	-.44	n.s.	4.4 (1.4)	4.1 (1.5)	.61	n.s.

Note. 1. Overall satisfaction, 2. Instructor encouragement, 3. Instructor organization, 4.Intrinsic goal orientation, 5. Extrinsic goal orientation, 6. Task value, 7. Control of learning beliefs, 8.Self-efficacy for learning performance, 9. Test anxiety, 10. Rehearsal, 11. Elaboration, 12. Organization (R), 13. Critical thinking, 14. Metacognitive self-regulation, 15. Time study environment management (R), 16. Effort regulation (R), 17. Help seeking & peer-learning (R)



Note: 1. Overall positivity towards flipped instruction, 2. Favoring of traditional lecture/instruction, 3. In-class content lectures, 4. Video feedback discussion, 5. Problem solving session, 6. Concept quiz, 7. Problem solving review.

Fig. 1. Perceived usefulness of class activities in the two student groups in the flipped classes

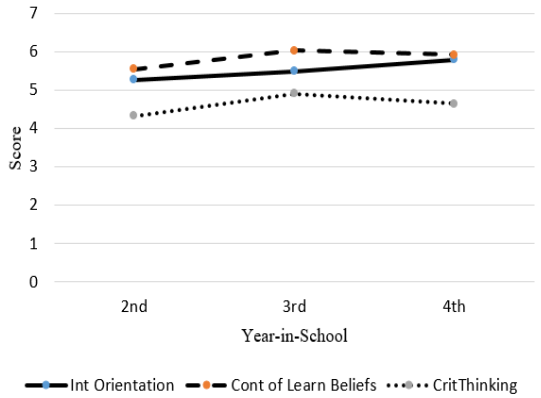


Fig. 2. Means of selected motivation and learning strategy scales by year-in-school.

Correlation analyses were run to examine the association among the student satisfaction measures, motivation and learning strategies, with the results summarized in Table 6.

Table 6. Correlation coefficients of satisfaction scales with motivation and learning strategy scales in the flipped and non-flipped classes

Var.	Overall Sat.		Instructor Encour.		Instructor Organization	
	F	NF	F	NF	F	NF
1	.37**	.20	.23	.38**	.31**	.42**
2	-.11	-.16	.01	-.04	-.05	-.08
3	.29*	.30*	.25*	.30*	.32**	.35**
4	.20	.10	.25*	.26*	.29*	.14
5	.37**	.33**	.42**	.20	.46**	.32*
6	.02	-.34**	.08	-.23	-.03	-.32*
7	.28*	.14	.26*	.13	.26*	.20
8	.26*	.16	.25*	.15	.30*	.13
9	.31**	.21	.25*	.05	.36**	.19
10	.17	.11	.20	.23	.29*	.15
11	.27*	.34**	.30*	.20	.37**	.32*
12	.29*	.06	.36**	.02	.32**	.08
13	.14	.29*	.11	.23	.13	.14
14	.25*	-.11	.17	-.18	.11	-.11

(*) denotes p<.05 and (**) denotes p<.01.

Note. 1.Intrinsic goal orientation, 2. Extrinsic goal orientation, 3. Task value, 4. Control of learning beliefs, 5. Self-efficacy for learning performance, 6. Test anxiety, 7. Rehearsal, 8. Elaboration, 9. Organization (R), 10. Critical thinking, 11. Metacognitive self-regulation, 12. Time study environment management (R), 13. Effort regulation (R), 14. Help seeking & peer-learning (R). F=Flipped class, NF=Non-flipped class.

Critical thinking showed significant correlation only with instructor organization, and only in the flipped condition (r=.29, p<.05). Metacognitive self-regulation showed significant correlations in both class conditions with overall satisfaction (r=.27, p<.05 flipped; r=.340, p<.01 non-flipped) and with instructor organization (r=.37, p<.01 flipped; r=.32, p<.05 non-flipped). Peer-learning and help seeking showed significant correlation only with overall satisfaction, and only in the flipped condition (r=.25, p<.05). Task value showed some significant positive correlation with the three student satisfaction variables, in both class conditions. The motivation and learning strategy scales which show significant correlations with more satisfaction measures in flipped condition than in the non-flipped condition are control of learning beliefs, self-efficacy for learning performance, rehearsal, elaboration, organization, metacognitive self-regulation, and time study environment management.

Regarding the open-ended items on students' qualitative perceptions of the flipped class, the following themes can be identified. A significant majority of students agree that the flipped environment improved the way they study and helped them to better understand the material. Many students identified the greater participation and better use of class time as the strong points of the flipped approach; a smaller number said it helped them to concentrate and made the material more interesting. However, when asked whether they would prefer a more traditional, lecture based class the number of positive and negative responses were roughly equal. The most common cited disadvantages were the amount of preparation time required and the difficulty to follow the class if they didn't do the preparation. Surprisingly, several students complained it was more difficult for them to ask questions in the flipped class.

The majority of students preferred in-class lectures to video lectures, and watching the video lectures was frequently cited as the least enjoyable part of the class. Reasons given include: 1) poor quality of the material, 2) the amount of time required, 3) the difficulty in concentrating by themselves, and 4) unfamiliarity with online study. However, several students identified the convenience and the potential for repeated study as benefits of the video lectures. With regard to the English-mediated instruction of the classes, there were a similar number of positive and negative comments. The negative comments all focused on the difficulty of using the language, while positive comments included: 1) improvement to their English skill, 2) usefulness for future study abroad, and 3) the greater variety of English-language materials. A selection of student responses is given in Table 7.

Table 7. Selected student responses to the open-ended questions. Responses originally in Korean have been translated into English

Feedback from Students on Flipped Instruction	
Positive Feedback	**Negative Feedback**
Discussing how other students completed the pre-class assignments helped with my understanding.	In a lecture, students who have questions can immediately ask them, and get answers quickly. This isn't necessarily the case for flipped learning.
It was interesting to hear other students' opinions on the video lectures through the video feedback discussion.	Video lecture [is] hard to understand & bad quality.
I can understand the class better compared to other classes because we watch the online videos first.	I find the B section of the video feedback reports to be a little annoying. [B section is the 'Q' of WSQ]
In the flipped class it is convenient to watch the online videos and it helps me become a self-directed learner.	When I don't know the English vocabulary or terminology I can't follow the class.
Rather than compete we get to collaborate and try to work on problems together.	It is a bit hard for me because it takes double time compared to a traditional class (i.e., we watch the videos and we do it again in class). I have to watch the videos alone so it is hard to concentrate.
The class is taught in English which is good for us if we go abroad for study, and is right for the era of globalization.	When I didn't watch the online videos in advance it was hard to follow in class.
EMI is helpful because it means we can make use of more varied materials with wider scope.	

5. DISCUSSION

According to the model of the flipped classroom put forward by [7], a successful flipped class should help students develop as self-directed learners. This should lead to an increase in student motivation (both intrinsic and extrinsic) as they develop greater senses of competency, autonomy and relatedness in the flipped class. Consistent with this proposition, students in the flipped classes of this study showed higher scores in the motivation scales of the MSLQ than their counterparts in the non-flipped classes, for example in the scales of intrinsic goal orientation and control of learning beliefs.

The higher critical thinking score found in the flipped condition provides some evidence that the flipped class requires students to make more use of the higher cognitive strategies. However, the difference of metacognitive self-regulation scores between the two conditions was small, which may show that students need more support to develop the self-regulation skills necessary to reap the potential benefits of the flipped classroom. This is backed up by the observation of the instructor that the 'question' section of the video feedback reports – in which students are asked to assess and apply what they have learned – was attempted only half-heartedly by the majority of students, in comparison to the more objective 'summary' section.

The open-ended survey highlighted the problem of some students not watching the video lectures before class. A significant number of students interpreted their subsequent inability to follow the class as a weakness of the flipped model, rather than a problem of their own regulation. This may point to the need to help those students develop a greater sense of autonomy. Previous studies have addressed similar challenges with use of pre-class materials, and suggest that weaker (less motivated, less self-directed) students may need special measures to ensure they engage with the material [27], [32], [33]. It is notable that students with more experience of online learning spent more time on study outside of class, suggesting that more experience with e-learning may help students adapt to the pre-class component of flipped classes.

Reference [8] stresses the need to build a learning community between students in the flipped classroom. The positive correlation between peer-learning and overall satisfaction, and the comments in the open-ended survey welcoming the opportunities for discussion provide some evidence for such a community in the flipped classes used in this study. However, it is notable that overall the peer-learning score in the flipped condition was lower than that in the non-flipped condition, suggesting many students struggled to participate fully in the group activities. In this last regard, the use of EMI is a further obstacle: students already reluctant to engage are even less likely to do so in a language in which they are not confident in expressing themselves clearly [27]. As found by [25], in an EMI setting more care must be taken to establish a learning environment in which students feel comfortable and engaged, and thus enhance their sense of relatedness.

In conclusion, while this study presents some evidence that the flipped classroom can increase student motivation and practice of higher cognitive skills, there is also evidence that weaker students need more support to adapt to the new conditions and become more confident self-directed learners. While some measures to address this were included in the current class design (section 2.2) it is necessary to consider what more can be done to improve the experience for these students.

Firstly, it is clear more needs to be done to increase student engagement with the pre-class materials. Possible approaches include making the materials more interactive (for example by including video annotations and discussion forums), providing more instant feedback (for example with online quizzes), increasing the quality and variety of media to keep student interest (the current courses used only video lectures based on the recording of previous years' classes), and taking steps to make the task less daunting for weaker students (for example by reducing the total time, making some contents optional viewing, increasing the availability of subtitles for EMI). Secondly, more activities to guide the students into critically analyzing their own learning would be beneficial. This could include more focus on such skills in the initial orientation period, instructor modelling of the 'question' section of the feedback reports, or the keeping of learning diaries [22]. Finally, care must be taken to cultivate a safe learning environment in class, where weaker students feel confident enough to participate in the learning community. Measures could include a way for students to ask questions anonymously (for example by collecting written questions at the start or end of each class), the deliberate mixing of weaker and stronger students in collaborative group activities, and more 'ice-breaking' activities in the orientation period.

The decision of whether to run a given class with EMI should be based upon consideration of the added cognitive load of learning in a second language on the one hand, and the benefits of learning to communicate in that language in a technical setting on the other. In this regard, this study provides some evidence for the benefits of flipping the EMI classroom. In particular, students appreciated the additional opportunities for in-class communication, and the ability to pause and review the online lectures. However, the need to improve the quality and accessibility of the pre-class content was also highlighted, as was the need to provide extra support and encouragement to students with weaker mastery of English.

6. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

This study aims to provide some basis for implementing flipped instruction in physics college classes in Korea. However, there are some limitations. First, regarding the sampling, this study used convenience sampling which involved including students who were available in the selected classes taught in English. Further, data was collected only once during the semester, meaning it is not possible to directly track changes to students' motivation and use of learning strategies throughout the course. While a Levene's test for the equality of the variance showed homogeneity of the samples in both the flipped and non-flipped conditions, ideally, it would have been

better if sample randomization and a pre-/post-test design had been implemented.

Second, the long period of data collection is also a limitation. The data were collected over four semesters, which might have affected students' motivation, learning strategies, and satisfaction with the courses. Methodologically, it would have ideal to have the data collected over a single semester.

Third, the flipped classes were taught by only one instructor. The teaching style of the instructor was not assessed by the third person outside of the classes, and it cannot be checked whether the instruction remained objectively steady amongst classes. Further, while all the classes sampled cover core topics in the physics major and so have much in common, they differ in terms of their detailed contents. It is possible that students' motivation to learn might have been affected by the instructor's teaching approaches to these specific contents, more so since the data were collected throughout four semesters. It would have been ideal to compare courses with identical contents under flipped and non-flipped conditions, with external monitoring of instructional approaches. However, given the nature of research in higher education in Korea, conducting a more objective, randomized study of flipped and English mediated instruction is a challenging task.

These limitations impact the generalizability of the results. Few, if any, previous studies have examined the effects of flipped and English mediated instruction on physics major students' motivation, learning, and satisfaction in Korea. Since the present study is one of the precursors of flipped and English mediated instruction research in the area of natural science, and relied on a convenience sample of one instructor's classes, findings in this study cannot be generalized. Therefore, there is a need for further research examining the effects of flipped and English mediated instruction, including more diverse samples with broader backgrounds, in order to test the robustness of the findings presented here, and to establish the causal relations suggested between student learning strategies, student satisfaction, and flipped class design. In particular, close monitoring of student use of resources and language, and objective measures of learning outcomes are necessary to draw strong conclusions for the design of course contents. However, despite these limitations the present study provides some basis for teaching practitioners and higher education researchers interested in applying and researching flipped instruction in combination with EMI. It is hoped that this study can add to the growing literature of classroom studies of flipped learning and student cognition, and can contribute to the creation of empirically-grounded design principles for the flipped classroom.

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