The Effect of Motivation on Learners' Performance and Satisfaction under Flipped Strategy in Discrete Math

Martin K.-C. Yeh
Information Sciences and Technology
Pennsylvania State University - Brandywine
Media, USA
martin.yeh@psu.edu

Pei-Hsuan Lin
Department of Engineering Science
National Cheng Kung University
Tainan, Taiwan
n98054037@ncku.edu.tw

Nannette D'Imperio
Information Sciences and Technology
Pennsylvania State University - Brandywine
Media, USA
nxd13@psu.edu

***Abstract*—This Research Work in Progress paper presents preliminary data from an experiment study (N = 22) in investigating the effect of learners' motivation on learning outcomes, including learning performance and satisfaction. In STEM fields, learners are required to obtain declarative knowledge as well as apply them to solve real world problems. The flipped strategy has been a popular instructional approach and is used in many classrooms. Although many studies reported positive impact of the flipped strategy, the results are not consistent. The goal of this study is to explore whether learners' motivation in a flipped classroom affect their performance and their satisfaction. We use a quasi-experimental design with two groups based on the initial motivation scores. We find that our participants did not benefit from flipped strategy as much as the traditional strategy. We also found that the participants did not feel better (confident) about the subject. We conclude that students may not be comfortable with the flipped strategy because the flipped strategy is used for only about two weeks and that great instructional attentions may be needed to use the flipped strategy. In the end, we propose areas that are worthy of further investigation.**

Keywords— Flipped classroom, motivation, learning outcome, satisfaction, MSLQ, mathematical education

I. Introduction and Related Work

In STEM fields, learners are required to obtain declarative knowledge as well as apply them to solve real world problems. To master facts and definitions requires practices. In a traditional face-to-face classroom, learning the rudimentary knowledge takes up class time that could have been spent in facilitating high-level, problem-solving skills. The flipped strategy offers an opportunity to shift a portion of the time in learning trivial facts to before the lecture, which frees up lecture time for more productive use, such as teamwork, individual coaching, or problem-solving. To do so, homework or group activities are typically used to replace traditional class lectures.

The flipped strategy has been a popular instructional approach and is used in many classrooms. This blended learning design not only teaches students in face-to-face instruction but also provides students with learning materials to read or watch as off-school activities [1], [2]. One guiding principle of flipped strategy is to reserve more in-class instruction to individual coaching and problem-solving by providing instructional materials before class time for students to study. That way, rudimentary knowledge can be acquired through self-study.

In recent studies, researchers have reported the effect of a flipped strategy in the change of student's learning outcomes, such as learning performance [3], satisfaction [4], motivation [5], skills or abilities [2], [6], [7]. In addition, researchers have examined the pedagogical contribution of flipped strategy, like flexible learning [8], individualized learning [9], large group instruction [10]. However, the results are not consistent in flipped classroom experiments. Missildine, Fountain, Summers, and Gosselin [11] reported that students feel low satisfaction in flipped classroom when it compared to other learning methods. Sun, Wu, and Lee [12] had reported that students exhibited lower self-regulated behaviors in the flipped classroom.

Some of the unflattering results are understandable because the concept of "flip" is quite flexible. Similar to a traditional classroom, not all students strive in such an environment. Hoping a flipped strategy, or any other strategy, works for every student is no better than getting blood from a stone. With deeper understanding and thoughtful design, however, a flipped strategy may work for certain populations in certain conditions.

It is common to question that if students do not study before the lecture, will they be able to solve problems or collaborate meaningfully? If they are not motivated, how much would they enjoy the flipped strategy in an active learning environment? This study seeks to understand how students' motivation and self-regulation in STEM courses affect their acceptance of an outcome in flipped classrooms. This is one area that is important and, yet, not very well studied compared to other flipped-classroom related research. Specifically, the research question of the study is:

Does motivation affect students' satisfaction and performance in different teaching modalities (traditional and flipped)?

II. Methodology

We conducted a quasi-experimental study in a discrete math course at a university. The course was chosen because the modules in the course are relatively independent such that the performance in one module is not highly dependent on another module. This allows us to use two instructional strategies in one course. The study was approved by the IRB of the university. The detail of the experiment is described below.

A. The classroom and procedure

The course consists of four modules (sets, logics, counting principles, graphs) and students from both sections of the course were recruited to participate in the study. Both sections were taught by one of the authors using the same textbook in the same room at different times. Two modules (logics and counting principles) were chosen, primarily because correlation in the content is low, to implement traditional and flipped strategies. There were 33 students agreed to participate but the analysis is based on 22 participants who consented and completed all pre- and post-tests and questionnaires. Participants were divided into two groups, *High* (motivation pre-test score >= 5.06) and *Low* (motivation pre-test score < 5.06) for the purpose of analyses. Participants in the same group are from both sections of the course.

We illustrate the study design in a diagram in Fig. 1. In week 2 of the semester, students completed a motivation questionnaire adopted from Motivated Strategies for Learning Questionnaire (MSLQ) [13]. On the first day when the logic module was taught, students completed a competency pre-test that consisted of multiple-choice questions (concept) and open-ended word problems (problem-solving) created by the instructor. The first class after the logic module was completed, students completed a post-test that was the same format as the pre-test, but different questions. Students were not told to prepare or study for the post-test. In addition, in the same class, students completed a satisfaction questionnaire with regard to the logic module. Similarly, for the counting module, students completed a pre-test, learned counting techniques and principles, and then

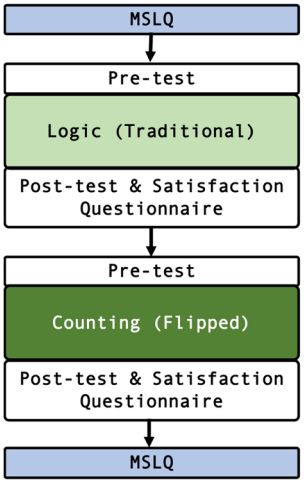

Fig. 1. Study design diagram for all participants

completed a post-test and satisfaction questionnaire. At the end of the semester, students completed the MSLQ again.

In the traditional strategy, the instructor presented the materials on a projector, explained concepts and terminologies using examples. Students were then asked to do simple problems on the computer. This was the strategy for all modules but the one that was chosen to use for the flipped strategy. This module lasted about three weeks.

In the flipped strategy, students were assigned learning materials to study along with simple exercise questions at home before each class. The exercise questions were part of a student's participation grade. When students came to the class for lecture, they formed groups of three of four people and were given a worksheet, which contained word problems related to the topics that were assigned before class. Students were also given whiteboard markers and a whiteboard space for each group to discuss and solve problems. Students were instructed to solve the problems on the worksheet as a group by using the whiteboard for collaboration. The instructor observed students' discussion and provided guided questions when the instructor noticed students were having difficulties or did not solve a problem correctly. This module lasted about two weeks.

B. The measurement instruments

There were 35 7-level Likert-type scale questions, from strongly disagree (1) to strongly agree (7) in MSLQ covering motivation and learning strategies. Components in motivation include intrinsic and extrinsic. Components in learning strategies included rehearsal, elaboration, critical thinking, and self-regulation. There were 22 7-level Likert-type scale questions in the satisfaction questionnaire, from strongly disagree (1) to strongly agree (7) covering four components—classroom structure, peer learning, help seeking, and feeling. All questionnaires were administered online.

III. Data Analysis and Results

We first removed participants who did not complete all measurements, including learning performance tests, and questionnaires. The rest of the participants were then divided into two groups—High (N = 11) and Low (N = 11)—based on the motivation component (intrinsic and extrinsic combined) of the first MSLQ questionnaire. We then used a descriptive statistic to compare the differences between these two groups. The results of these students' learning performance before and after being exposed to traditional and flipped strategies are shown in TABLE I. Both the conceptual and problem-solving components in the learning performance test are illustrated below.

TABLE I. Results of Learning Performance in Concept and Problem-Solving Under Two Teaching Strategies

Learning Performance	**Group**	**Traditional (Logic)**	**Flipped (Counting)**
		Mean (sd)	**Mean (sd)**
Concept	$High_{pre}$	39.3% (14.6%)	32.2% (2.04%)
	$High_{post}$	63.3% (15.5%)	53.8% (2.37%)
	Low_{pre}	32.4% (8.6%)	22.4% (4.1%)
	Low_{post}	54.9% (15.7%)	43.1% (15.0%)
Problem-Solving	$High_{pre}$	3.6% (8.1%)	0% (0%)
	$High_{post}$	39.1% (20.7%)	20% (26.5%)
	Low_{pre}	0% (0%)	0% (0%)
	Low_{post}	18.2% (20.9%)	3% (9.5%)

Observing the numbers from TABLE I. , the pre-test in both concept and problem-solving components are similar in both groups, except the lower performance in the pre-test of the flipped module.

TABLE II. DIFFERENCE BETWEEN PRE-TEST AND POST-TEST IN LEARNING PERFORMANCE UNDER TWO TEACHING STRATEGIES

Learning Performance	Group	Difference Between Pre and Post Tests	
		Traditional	Flipped
Concept	High	24.0%	21.6%
	Low	22.5%	20.7%
Problem-Solving	High	35.5%	20.0%
	Low	18.2%	3.0%

The performance difference between the pre-test and post-test are illustrated in TABLE II. For the concept component, both teaching strategies seem to benefit the students equally, regardless of the group. For the problem-solving component, the students' learning gain is significantly higher in the High group (35.5% for traditional and 20.0% for flipped), compared to the Low group (18.2% for traditional and 3.0% for flipped), regardless of the teaching strategy. However, both groups seem to benefit from the traditional strategy more than from the flipped strategy (Fig. 2).

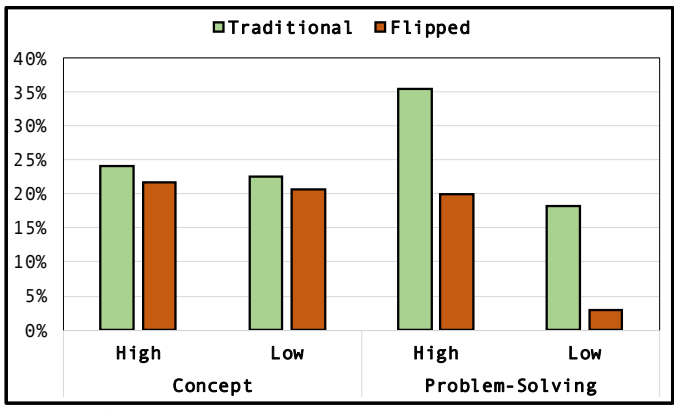

Fig. 2. Performance gain by knowledge type

The results of students' satisfaction after each teaching strategy are illustrated in TABLE III. We can see from the numbers in the table that both High and Low groups felt the class was less structured as the mean satisfaction in the classroom structure dropped more than 10% from tradition to flipped strategy. The peer learning component increased by more than 20% from traditional to flipped strategy. Both groups' feelings about the flipped strategy is about 10% less than the traditional strategy, which is similar to a previous study [11]. Furthermore, the High group enjoyed the course much greater than the Low group whether it was the traditional or the flipped module.

In terms of learning performance, it seems that students have better learning gain in the module that used the traditional strategy than the module that used the flipped strategy. The difference between the two teaching strategies is particularly significant in the problem-solving components. This observation is true for both the High and the Low group in our study. In terms of students' satisfaction, students in both groups prefer traditional strategy over flipped strategy because it is perceived as better structured. The only advantage of flipped strategy is that the Low group felt more satisfied with peer learning—a 23.4% gain.

TABLE III. RESULTS OF SATISFACTION QUESTIONNAIRE UNDER TWO STRATEGIES

Satisfactory Dimension	Group	Traditional (Logic)	Flipped (Counting)
		Mean (sd)	Mean (sd)
Classroom structure	High	73.2% (11.1%)	62.7% (8.5%)
	Low	66.1% (9.8%)	53.1% (13.2%)
Peer learning	High	73.4% (17.8%)	76.0% (20.0%)
	Low	51.3% (19.6%)	74.7% (12.9%)
Help seeking	High	64.6% (15.8%)	67.9% (12.5%)
	Low	60.1% (12.0%)	64.0% (16.7%)
Feeling	High	83.4% (12.2%)	70.9% (12.0%)
	Low	54.5% (14.1%)	45.5% (26%)

The fact that the flipped strategy is ineffective in learning, particular in problem-solving, may be attributed to the in-class structure being too loose, in that students spent the entire time solving problems on worksheets with peers and the instructor. It is also possible that the student population for the class (mainly freshmen and sophomore) was not ready for the flipped strategy, which was demonstrated in the feeling component in the satisfaction survey.

IV. DISCUSSION & FUTURE WORK

In this study, we report preliminary results from an on-going, quasi-experimental study that investigates the role of motivation in using the flipped strategy by measuring students' learning outcomes, including performance and satisfaction. Twenty-two participants completed all measurements, including learning performance tests and questionnaires. Each participant went through the modules which were taught using traditional and flipped strategies. In the analyses, participants' data were divided into High and Low groups based on their motivation in the beginning of the semester.

Our descriptive statistics suggest that learning concepts in Math is not sensitive to whether the teaching strategy is traditional or flipped. They also show that the traditional strategy benefits students, both High and Low groups, more than the flipped strategy. The results of our leaning performance are different from some previous research studies [14], [15]. Those studies found that learning performance was better in the flipped classroom. One reason for the difference could be that the learning subjects are different. Learning discrete math relies on conceptual knowledge and logical thinking. If students do not understand the basic concepts or are not prepared before class, the in-class group activities may not help them obtain problem-solving skills. It is also possible that the activities used in class are not optimal. As van Alten, et al. [15] mentioned, sustaining

face-to-face time and adding quizzes are critical features in designing flipped strategy. We will improve and adjust these two features in the follow up experiments.

From the satisfaction questionnaire results, both groups of participants feel that the traditional strategy provides better classroom structure, which probably contributes to more positive feeling in their ability about the module that was delivered under the traditional strategy. It suggests that our participants prefer more structured classroom. We also see a strong gain in peer learning in the flipped strategy. It is not surprising to see the increase because they were forced into groups and participated in more frequent student-to-student interactions.

It was a surprise for us to see that the High group did not benefit more from the flipped strategy than the traditional strategy; we thought the High group would enjoy the challenge of solving problems using the knowledge they studied on their own. It is equally surprising that the High group does not have higher satisfaction toward the flipped module despite the much greater peer learning that was observed in class. The reason could be that the participants are mostly underclassmen who are still developing their self-regulation and metacognitive skills.

It is worthy of further exploration to determine why students do not perform better in and do not feel strongly about the flipped strategy. Several issues could be explored, including the subject of learning, the student population, the students' self-regulation skills, and the in-class activities. As we alluded to previously, many factors can affect the outcome of the flipped strategy. We believe more specific documentations of using the flipped strategy will benefit students, instructors, and the community as a whole.

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