DETECTING THE FACTORS AFFECTING THE LEARNING PERFORMANCE OF STUDENTS WITH DIFFERENT LEARNING STYLES IN FLIPPED LEARNING

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ABSTRACT. *This study employed a rigorous procedure to validate the proposed factors of students with different learning styles affecting their learning performance in flipped learning. The participants in the study were pre-service teachers in China, with a total of 42 students majoring in science. Two pre-validated scales including the scale of online self-regulation and the scale of peer assessment were completed and the reliabilities were calculated. The Felder-Soloman Index of Learning Style Questionnaire was used to identify students' learning styles. The data were analyzed using exploratory factor analysis, correlation analysis, and t test. The results revealed that the flipped learning significantly promoted the students' learning performance. Students' attitudes toward online self-regulation and peer assessment significantly affected their learning performance. Students with different learning styles had different needs for their online self-regulation and peer assessment. The findings can provide good references for the improvement of flipped learning.*
Keywords: Flipped learning, Learning style, Online self-regulation, Peer assessment, Student engagement

1. **Introduction.** The flipped concept is driven by the constructive learning theory and provides an active learning environment with added benefits which allow teachers to use modern technology to engage students in the learning process [1,2]. Flipped learning intentionally shifts instruction to a learner-centered model in which more class time can be used to explore topics in greater depth and to create meaningful learning opportunities, while educational technologies such as online videos are used to deliver content at home [3]. Along with its many benefits, however, based on some previous research on the implementation of flipped classrooms, some challenges have been found. There is a big possibility that those less motivated students get less done as in flipped learning students learn knowledge and skills at their different learning paces, and this relies heavily on the students' self-motivation [4,5]. As the online learning environment is characterized by autonomy, self-regulation becomes a critical factor for success in online learning [6]. In addition, Topping addressed that peer assessment can increase learners' understanding in the cognitive and metacognitive domains, and they can develop social and transferable skills [7]. Taylor explained that a learning style is the manner in which a learner interacts with and responds to the learning material or environment, and students may also use different learning strategies depending on the task [8]. Compared with previous studies, the major contributions and significance of this study are that it further highlighted a specific learning environment setting and provided an integral research perspective regarding college

students' engagement in online self-regulation and peer assessment for learning performance that proposed a link between them in flipped learning. Three specific research questions in this study were posed. a) What indicators can be used to assess students' online self-regulation for flipped learning? b) To what extent do students exhibit their peer assessment attitudes toward flipped learning? c) What are the implications of this study for flipped learning research?

This paper is organized as follows. Section 2 provides an overview of the literature on flipped learning and factors affecting learning performance in flipped learning. Section 3 addresses the research design of the present study, the method of data collection, and the analytical tools used to interpret the data. Section 4 presents the results of the EFA and t tests, and Section 5 discusses the findings and their implications. Finally, the conclusions are presented and suggestions for future research are also given in Section 5.

2. Literature Review.

2.1. **Flipped learning.** The Academy of Active Learning Arts and Sciences developed an updated definition of flipped learning as a framework that enables educators to reach every student. The flipped approach inverts the traditional classroom model by introducing course concepts before class, allowing educators to use class time to guide each student through active, practical, innovative applications of the course principles [9]. Bergmann and Sams proposed that the flipped classroom can be combined with problem-based learning, project-based learning, individual learning, or other learning strategies in class to engage students in higher order thinking via the activities they perform before and during class [10]. Sun et al. confirmed that flipped learning is an effective strategy for helping teachers and students identify higher level competence development during the learning process [11].

2.2. **Factors impacting learning performance in flipped learning.**

2.2.1. *Online self-regulation.* Carver and Scheier defined self-regulation as self-correcting adjustments, such as suppressing an urge arising from inside or anxiety originating from the individual for staying connected in the process of achieving the learner's goal [12]. Chen and Hwang suggested that self-regulation in terms of metacognition and motivation is directly related to performance expectancy, effort expectancy, and social influence [13]. We adopted the scale of online self-regulation developed by Barnard et al. which includes six sub-scales consisting of 24 items to measure online engagement. The indicators are a) Environmental Structuring (ES); b) Goal Setting (GS); c) Time Management (TM); d) Help Seeking (HS); e) Task Strategies (TS); and f) Self-Evaluation (SE). A study was conducted by Barnard et al. with 434 university students who took online courses. The Cronbach's alpha coefficient of reliability was calculated as .93. Confirmatory factor analysis was performed to ensure the structural validity of the measure [6].

2.2.2. *Peer assessment.* Peer assessment, which is mutual assessment among learners [14], is an effective method for monitoring and assessing processes and outcomes of projects without burdening instructors [15]. Thus, the process enhances students' meta-cognitive understanding of their own learning process [16,17], develops their social and transferable skills [7], and helps them to clarify their misconceptions [18]. Moreover, critical thinking may be improved due to evaluation among peers [18]. In our study, we adopted the scale of peer assessment developed by Wen and Tsai which includes four sub-scales: a) the Positive Attitude Subscale (PAS); b) the Online Attitude Subscale (OAS); c) the Understanding-and-Action Subscale (UAS); and d) the Negative Attitude Subscale (NAS). A study was conducted by Wen and Tsai with 280 university students in Taiwan in which a 20-item instrument was developed to investigate university students' attitudes toward and perceptions of peer assessment. The composite reliability of this 20-item instrument was

0.80 [16]. The reliability values of the four sub-scales were all satisfactory, ensuring the structural validity of the measure.

2.3. **Learning style.** A learning style is a manner in which a learner interacts with and responds to the learning material or environment. A person's cultural background may influence his/her learning style. The student may also use a different learning strategy depending on the task [8].

The Index of Learning Styles Questionnaire (ILSQ) is an online instrument used to assess preferences on four dimensions (active/reflective, sensing/intuitive, visual/verbal, and sequential/global) of a learning style model formulated by Felder and Silverman. Based on the classification of the participants in our study, two different learning styles (active/reflective and sequential/global) were applied to characterizing the participants' learning styles [20,21].

- Active style vs. reflective style: "active style" refers to active learners who show learning by doing and learning by discussing and group work. They improve retention and understanding of information by discussing or explaining it to others. Relatively, "reflective style" is more introverted, that is, students who show learning by thinking things through, and like to work alone. They prefer to think about the material first.
- Sequential style vs. global style: the sequential-style students are good at using partial knowledge, are interested in details and learn in linear steps, gaining understanding via linear, logical steps. Relatively, the global-style students who need the "big picture" are interested in an overview, and learn in large leaps, randomly absorbing material until they suddenly "get it".

3. **Methodology.**

3.1. **Research design.** Prior to attending the MOOC, the students had to be taught in a regular class to master the flipped learning requirements in the first week. Meanwhile, a pre-test on prior knowledge and the ILSQ were conducted in class. The flipped learning consists of two phases. In the first phase, all participants finished watching the online pre-recorded video lectures and completed the quizzes at home. In the second phase, all participants participated in the classroom activities raised by the teacher, inclusive of completing more challenging tasks with the teacher's guidance, and peer discussion in class. After the discussion activities, students were required to finish a peer assessment in class. A post-test about learning achievement evaluation, an online self-regulation questionnaire, and a peer assessment questionnaire were conducted in the last class. The experiment lasted 8 weeks, involving one 90-minute session per week, including 1 week for the pre-test and the ILSQ, 6 weeks for flipped learning, and 1 week for the post-test and the post-questionnaires. Every student conducted one before-class learning activity and one in-class learning activity each week.

3.2. **Participants.** The participants in the study were pre-service teachers who had registered for a school-based curriculum development methodology course in China, with a total of 42 students (average age = 20.5) majoring in science. They were selected since the college was located in an area representing the average economic level; moreover, the ranking of the college was around the average. All participants had to complete the 6-week session of flipped learning and provide the required information for analysis. Based on the ILSQ, as proposed by Soloman and Felder, 18 students were assigned to the active-style group, and the other 24 were assigned to the reflective-style group. In addition, 26 students were assigned to the sequential-style group, and the other 16 were assigned to the global-style group. The other two classifications (sensing-style/intuitive-style and visual-style/verbal-style) were not considered in this study due to the sample distribution, as shown in Table 1.

TABLE 1. Sample distribution of the learning styles

	Classification A		Classification B		Classification C		Classification D	
	Active style	Reflective style	Sensing style	Intuitive style	Visual style	Verbal style	Sequential style	Global style
Frequency	18	24	41	1	38	4	26	16
Percentage	42.9%	57.1%	97.6%	2.4%	90.5%	9.5%	61.9%	38.1%

3.3. **Instruments.** The quantitative research method uses questionnaires to collect statistical data; the pre-test aimed to test the students' prior knowledge of curriculum pedagogy. It consists of 20 multiple-choice items, giving a total of 100 points. The post-test, related to the advanced knowledge of curriculum development methodology, was used to evaluate the students' learning achievements after the learning activities. There were 20 multiple-choice items with a perfect score of 100. Two questionnaires were completed; the scale of attitudes toward online self-regulation was adapted by Barnard et al. [6], and the scale of attitudes toward peer assessment was measured by Wen and Tsai [16]. Students were surveyed with a 5-point Likert-scale (1 = strongly disagree, 5 = strongly agree). The Index of Learning Style was developed by Soloman and Felder, and contains 44 items (11 per dimension). Each learner was characterized by four values between +11 and −11 [21].

4. **Results.**

4.1. **Effect of prior knowledge and flipped learning upon learning-style classification.** In order to determine if the two groups with different learning styles had the same levels of prior knowledge in this course before the flipped learning treatment, an independent samples t test was performed on the two groups' scores of the knowledge pre-test. Since the Levene test on homogeneous variance was not significant ($F = 1.562$, $p = 0.219$) in the classification of the active-style group vs. the reflective-style group, and it was also not significant ($F = 0.041$, $p = 0.841$) in the classification of the sequential-style vs. global-style groups, the pre-test results revealed that these two groups had similar levels of prior knowledge before proceeding with the experiment.

To determine if the effect of flipped learning upon learning-style classification worked significantly, the Levene test on homogeneous variance was adopted. Since the Levene test on homogeneous variance was not significant ($F = 1.469$, $p = 0.233$) in the classification of active-style group vs. reflective-style group, and it was also not significant ($F = 0.127$, $p = 0.723$) in the classification of sequential-style vs. global-style, the post-test results revealed that these two groups had similar levels of performance after proceeding with the experiment.

4.2. **t test analysis of students' achievements in flipped learning.** To investigate the effect of the learning strategies in the flipped classroom, the paired sample t test was adopted. The mean values and standard deviations of the pre-test were 84.52 and 14.22, while those of the post-test were 89.50 and 5.51, respectively. The t test result of these achievements showed that a significant difference was found between the scores of the pre- and post-test with $t = -2.262$ ($p = 0.029 < 0.05$, $d = -0.46$), showing that the flipped learning promoted the students' achievements. The t test result revealed that the score of the students' post-test was significantly higher than that of their pre-test, which means the effect of the flipped learning upon their achievement worked significantly. Cohen indicated that a Cohen's value between 0.3-0.5 represents a small-to-moderate effect size, indicating that the experimental result was reliable [22].

4.3. **Exploratory factor analysis results of students' attitudes toward online self-regulation and peer assessment.** To validate the questionnaires of the students' attitudes toward online self-regulation and peer assessment, Exploratory Factor Analysis (EFA) with varimax rotation was performed to clarify the structures. According to the EFA results of students' attitudes toward online self-regulation and peer assessment, there were no items with a factor loading of less than 0.3. All items were therefore retained in the final version. The Cronbach's alpha coefficients for the factors of students' attitudes toward online self-regulation were .79, .57, .63, .70, .75 and .83 with 54.60%, 69.84%, 49.34%, 63.47%, 57.92%, and 66.19% of variance explained, respectively. The overall alpha was .88, and the total variance explained was 75.19%. The KMO value was 0.59, and the Bartlett χ^2-value was 620.933 ($p < .001$), suggesting that these factors had highly acceptable reliability for assessing the students' attitudes toward online self-regulation. In addition, the Cronbach's alpha coefficients for the factors of peer assessment were .88, .78, .63 and .84 with 69.19%, 53.77%, 61.51%, and 68.21% of variance explained, respectively. The overall alpha was .88, and the total variance explained was 71.10%. The KMO value was 0.69, and the Bartlett χ^2-value was 502.036 ($p < .001$), suggesting that these factors had highly acceptable reliability for assessing the students' attitudes toward peer assessment.

4.4. **Correlation analysis of students' attitudes toward online self-regulation and peer assessment with achievements.** According to Cohen, a correlation value of 0.5 is large, 0.3 is moderate, and 0.1 is small [22]. In investigating the relationship between independent variables (students' attitudes toward online self-regulation) and the dependent variable (post-test), the independent variable, "time management" ($r = -0.311$, $p < 0.05$) had a moderate correlation to the dependent variable, the post-test. Meanwhile, "help seeking" showed the highest correlation ($r = 0.781$, $p < 0.01$) with "self-evaluation". This finding indicates that students' time management online had a moderate relation with their achievements. That is, the factor of students' time management affected their achievement. In addition, in investigating the relationship between the independent variables (students' attitudes toward peer assessment) and the dependent variable (post-test), the results indicated that all correlation values ranged between 0.1 and 0.3; thus, all correlations values can be considered as small. Meanwhile, "positive attitude" showed the highest correlation ($r = 0.781$, $p < 0.01$) with "online attitude". This finding indicates that students' attitudes toward peer assessment had a small relation with their achievements in class.

4.5. **Effective factors of students' attitudes toward online self-regulation in the flipped learning.** The results of a paired sample t test showed that there was no significant difference in students' attitudes toward online self-regulation between before and after the flipped learning. No matter what the conditions (goal setting, environment structuring, task strategies, time management, help seeking and self-evaluation), students' attitudes toward online self-regulation tended to be consistent. This finding reveals that the flipped learning intervention did not significantly affect students' attitudes toward online self-regulation. Furthermore, the results of an independent t test showed that there was a significant difference in students' attitudes toward online self-regulation (post-test) between learning styles (active-style group and reflective-style group) in the sub-scales of "task strategies" ($t = 2.085$, $p = 0.043$), "time management" ($t = 2.643$, $p = 0.012$) and "help seeking" ($t = 2.858$, $p = 0.007$). The active-style students showed better attitudes than the reflective-style students did in "task strategies" (mean = 3.81, $SD = 0.56$ vs. mean = 3.47, $SD = 0.49$), "time management" (mean = 4.07, $SD = 0.52$ vs. mean = 3.67, $SD = 0.51$), and "help seeking" (mean = 4.17, $SD = 0.45$ vs. mean = 3.74, $SD = 0.50$). In addition, the results of an independent t test showed that there was a significant difference in students' attitudes toward online self-regulation (post-test) between learning

styles (sequential-style group and global-style group) in the sub-scale of "environment structuring" ($t = 2.112$, $p = 0.041$). The sequential-style students showed better attitudes than the global-style students did in "environment structuring" (mean = 4.32, $SD = 0.44$ vs. mean = 4.00, $SD = 0.52$). This finding indicates that students with different learning styles had different needs in their online self-regulation. To be more explicit, the students with an active learning style tended to more agree than those with reflective learning style with the "task strategies" subscale, the "time management" subscale, and the "help seeking" subscale. In addition, the students with a sequential learning style tended to more agree than those with a global learning style with the "environment structuring" subscale.

TABLE 2. Summary of independent t tests on students' attitudes toward online self-regulation and learning styles

Subscale	Learning style	Mean	SD	t-value	p-value	Learning style	Mean	SD	t-value	p-value
GS	active-style	4.18	0.39	1.711	0.095	sequential-style	4.05	0.43	0.116	0.908
	reflective-style	3.95	0.45			global-style	4.04	0.46		
ES	active-style	4.19	0.50	-0.22	0.982	sequential-style	4.32	0.44	2.112*	0.041
	reflective-style	4.20	0.50			global-style	4.00	0.52		
TS	active-style	3.81	0.56	2.085*	0.043	sequential-style	3.63	0.60	0.326	0.746
	reflective-style	3.47	0.49			global-style	3.58	0.44		
TM	active-style	4.07	0.52	2.643*	0.012	sequential-style	3.82	0.61	-0.191	0.849
	reflective-style	3.67	0.51			global-style	3.85	0.45		
HS	active-style	4.17	0.45	2.858**	0.007	sequential-style	3.90	0.62	-0.295	0.769
	reflective-style	3.74	0.50			global-style	3.95	0.31		
SE	active-style	4.13	0.45	1.792	0.081	sequential-style	3.97	0.56	0.015	0.988
	reflective-style	3.85	0.51			global-style	3.97	0.40		

*$p < 0.05$, **$p < 0.01$. (active-style group $n = 18$ and reflective-style group $n = 24$; sequential-style group $n = 26$ and global-style group $n = 16$)

4.6. **Effective factors of students' attitudes toward peer assessment in the flipped learning.** The results of an independent t test showed that there was a significant difference in students' attitudes toward peer assessment between learning styles (active-style group and reflective-style group) in the sub-scales of "positive attitude" ($t = 3.123$, $p = 0.003$), "online attitude" ($t = 2.644$, $p = 0.012$) and "understanding-and-action" ($t = 2.453$, $p = 0.019$). The active-style students showed better attitudes than the reflective-style students did for "positive attitude" (mean = 4.35, $SD = 0.55$ vs. mean = 3.86, $SD = 0.45$), "online attitude" (mean = 3.99, $SD = 0.67$ vs. mean = 3.55, $SD = 0.40$), and "understanding-and-action" (mean = 4.33, $SD = 0.52$ vs. mean = 3.99, $SD = 0.38$). In addition, the results of an independent t test showed that there was a significant difference in students' attitudes toward peer assessment between learning styles (sequential-style group and global-style group) in the sub-scale of "online attitude" ($t = 2.630$, $p = 0.012$). The sequential-style students showed better attitudes than the global-style students did for "online attitude" (mean = 3.91, $SD = 0.62$ vs. mean = 3.46, $SD = 0.34$). Participating students held positive attitudes toward the use of peer assessment.

5. **Conclusions.** Quantitative evidence from this study found that due to the homogeneity of the participants, no matter what kind of learning style students adopted, the t test result of the pre- and post-test showed that the flipped learning significantly promoted their achievements. The results revealed that students' attitudes toward online self-regulation determined the effective factors; however, the flipped learning intervention did not significantly affect students' attitudes toward online self-regulation. Enfield addressed that the flipped classroom method enabled students to use out-of-class instruction in hopes of promoting their self-efficacy in regards to learning independently [23].

TABLE 3. Summary of an independent t test on students' attitudes toward peer assessment and learning styles

Subscale	Learning style	Mean	SD	t-value	p-value	Learning style	Mean	SD	t-value	p-value
PAS	active-style	4.35	0.55	3.123**	0.003	sequential-style	4.16	0.55	1.409	0.167
	reflective-style	3.86	0.45			global-style	3.92	0.51		
OAS	active-style	3.99	0.67	2.644*	0.012	sequential-style	3.91	0.62	2.630*	0.012
	reflective-style	3.55	0.40			global-style	3.46	0.34		
UAS	active-style	4.33	0.52	2.453*	0.019	sequential-style	4.24	0.47	1.767	0.085
	reflective-style	3.99	0.38			global-style	3.98	0.45		
NAS	active-style	2.32	0.95	-0.373	0.711	sequential-style	2.38	0.88	0.081	0.936
	reflective-style	2.41	0.66			global-style	2.36	0.65		

*$p < 0.05$, **$p < 0.01$. (active-style group $n = 18$ and reflective-style group $n = 24$; sequential-style group $n = 26$ and global-style group $n = 16$)

This finding of this study restates the importance of students' time management in online self-regulation. Moreover, the active-style students showed better attitudes than the reflective-style students did for the sub-scales of "task strategies", "time management", and "help seeking" of online self-regulation while the sequential-style students showed better attitudes than the global-style students did for "environment structuring" of online self-regulation. This finding indicates that students with different learning styles have different needs in their online self-regulation. In addition, the result indicates that students' attitudes toward peer assessment had a small relation with their achievements online. The students held positive attitudes toward the use of peer assessment activities, but the active-style students showed better attitudes than the reflective-style students did for "positive attitude", "online attitude", and "understanding-and-action" of peer assessment in flipped learning. The sequential-style students showed better attitudes than the global-style students did for "online attitude" of peer assessment. This finding indicates that students with different learning styles had different attitudes toward peer assessment in flipped learning. Chandler stated that the amount an individual learns is directly related to the degree to which the educational experience is geared toward his/her learning style, rather than his/her intelligence. The emphasis was placed on having teachers address learning styles in the classroom through adjustments to the curriculum that incorporate each style, giving an equal chance for students to learn [24]. The present study proposes a concept change in learners' student engagement mechanism for flipped learning to promote students' learning performance and teachers' teaching approaches. It provides teachers and researchers with a good reference for implementing effective flipped classrooms as well as a new direction for flipped learning studies with effective strategies.

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