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ORIGINAL ARTICLE

Flipped Learning Model - Learning Style Interaction: Supporting Pre-service Teachers on Science Teaching Methods and Personal Epistemologies

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ABSTRACT

This study revealed how the flipped learning model interacted with the learning styles of primary pre-service teachers. In addition, the impact of the flipped model on participants' science teaching course achievement and personal epistemologies was investigated. A mixed-method research design was conducted with 27 primary pre-service teachers enrolled in a Science Teaching Course. The flipped classroom model was applied for 15 weeks. The Kolb Learning Style Inventory was distributed to categorize participants under learning styles. Midterm and final exam scores were used as an indicator of course achievement and compared with 30 primary pre-service teachers' achievement from the previous semester. Lesson plans of the participants were analyzed qualitatively to investigate the personal epistemologies of the participants. Analysis indicated that flip learning environment supported "divergers" more than the others on course achievement. The level of sophistication on personal epistemologies changed across learning styles and the method of teaching differed across learning styles. Further studies need to be conducted to reveal how teacher education programs help pre-service teachers improve personal epistemologies and transfer them to their instruction.

KEY WORDS: Flip learning; flip classroom; learning styles; personal epistemologies; pre-service teachers

INTRODUCTION

The flipped learning (FL) model is currently gaining popularity among researchers especially at the tertiary level (Eryilmaz and Cigdemoglu, 2019; Robinson et al., 2020; Sletten, 2017). Having been aware of the unprecedented and rapid spread of the coronavirus disease-2019 (COVID-19); this method has gained more popularity, especially in higher education. Compared to studies conducted on students from science, technology, engineering, and mathematics (STEM) fields, studies on pre-service teachers are limited. As well as being exposed to different types of teaching methodologies, pre-service teachers are expected to develop professional competencies that match with the knowledge and skills needed to become effective teachers. Furthermore, based on its literature more FL studies are required to explain and explore how FL interacts with learning style, in-class teaching methodologies, and its impact on personal epistemologies of pre-service teachers.

Among others, FL as a relatively new instructional model, provides some benefits to instructors and students, for instance, this model is regarded as an excellent learning environment for efficient use of class time (Estes et al., 2014; Strayer, 2012) and it supports engagement and interaction (Gannod et al., 2008; Lage et al., 2000; Strayer, 2012). This model takes its name as "flipped" since with collaborative hands-on activities, that is; the content is available through online videos for students before the class hours, the class hours are devoted generally to a discussion, problem-solving, and student-student and student-teacher interactions. Since the content overload of courses is a common problem for almost all levels of education, it restricts the efficient use of class time. FL offers a solution to this critical problem by serving the content to the students with the help of technology at home, thus the class hours can be used for several activities. Furthermore, by this model the lecture has changed from slides, audio, podcasts, narrated presentations to videocasts that may also incorporate animations, screen captures, and other multimedia content (Garza, 2014). FL is an option to provide highly subscribed videos to students too. In addition to such reported benefits, this model foster students' responsibility for their own learning (Overmyer, 2012) and addresses multiple types of learning styles (Gallagher, 2009; Gannod et al., 2008).

Studies on FL emphasize positive outcomes on students' performances (González-Gómez et al., 2016; Hung, 2015; Yelamarthi et al., 2015), perceptions, interest, and motivation (Butt, 2014; Cigdemoglu, 2020; de Araujo et al., 2017; Jin-Young 2018; Strayer, 2012; Yelamarthi et al., 2015), decrease in anxiety (Eryilmaz and Cigdemoglu, 2019), as well as better learning gains as it increases levels of problem-solving structure and practice (Berrett, 2012; Davies

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et al., 2013; Missildine et al., 2013; Overmyer, 2012). The review of Graziano (2017) narrows FL studies into teacher education programs and points out the needs for further investigations, too. Most implementation efforts on the FL are not differentiated across learning styles of participants, yet studies rarely investigate the impact of the learning environment on participants' learning epistemologies too. In addition to unsteady existent research claims (Mok, 2014; Steinmetz, 2013) on FL outcomes, there is a further need for investigation of the model with pre-service teachers especially on interaction with the course content, learning styles, and personal epistemologies.

Theoretical Background

The flipped learning model is based on constructivist theories of learning. The instructional approach used with the FL environment varies, studies are framed on the assumptions of these varying approaches. According to Robinson et al. (2020), FL investigations usually employ scaffolded instruction (e.g., Vygotsky, 1978), active teaching (Prince, 2004), cooperative learning (Slavin, 1991), and problem-based learning (Dochy et al., 2003). In all, traditional instruction is replaced with active student engagement, students take an active role in their learning. Jensen et al. (2015) affirm that active learning strategies are the most likely source of positive learning outcomes in FL implementations. The FL is usually used with cooperative activities (Hayashi et al., 2015; Yelamarthi et al., 2015) since it provides small group learning environments to support the zone of proximal development. According to Springer et al. (1999), for undergraduates, small group work significantly impacts learning. Furthermore, Eryilmaz and Cigdemoglu (2019) differentiated the impact of cooperative work from a sole FL environment.

Miller (2002) states constructivism as a philosophy that "supports student construction of knowledge and since students uniquely construct their knowledge, instructional strategies that support constructivist philosophies naturally advocate student understanding" (p. 1). According to Miller (2002), "it is important to find pedagogical techniques that encourage students of all learning styles to learn" (p. 2). Thus, in a constructivist FL learning environment, one may consider how students of different learning styles are affected. Meanwhile, learning style is described as what individuals do with new information once their brains receive it (Miller, 2002). More detailed, Sims and Sims (1995) define it as a way of individuals' absorbing and retaining information and skills. Kolb (1984) develops an inventory to diagnose individual's learning styles and describe four styles: Accommodative, divergent, assimilative, and convergent. Students get information through audio, visual, and/or other means, in learning environments, they hear, see, and/or do something to obtain information. Based on those different learning styles, they are expected to have different levels of knowledge and satisfaction in the FL environment, too. According to Liaw (2008) in e-learning or blended learning, personality traits, learning styles, and satisfaction are among the most critical factors that have impacts on participants' performance. Similarly, Li and Armstrong (2015) stated that learning style has long been taken as a factor in determining students' performances and behaviors. When it comes to the learning styles of participants in FL, despite emphasis (Gallagher, 2009; Gannod et al., 2008), only Jin-Young (2018) quantitatively revealed students' learning gains across learning styles. This work reports that different learning styles were associated with different levels of total satisfaction with flipped learning classes. In more detail, assimilators indicated a higher extraversion trait in favor of FL, divergers showed the highest conscientiousness score and were not satisfied with the FL model.

Another aspect that might be investigated in a constructivist FL environment is how it supports the personal epistemologies of participants in constructing their knowledge. Barger et al. (2018) pointed out the importance of the need to understand how portrayals of knowledge in the classroom shape personal epistemology development in higher education. Learning environments are expected to contribute to knowledge construction, specifically for pre-service teachers, so we may also expect development in personal epistemologies. These beliefs are predictors of self-regulation (Bråten et al., 2014; Muis, 2007; Muis and Franco, 2009), also associated with the motivation of students (Bråten and Strømsø, 2004; Chen and Barger, 2016), later relates to achievement in different contexts (Bråten and Ferguson, 2014; Dai and Cromley, 2014; Muis, 2004; Trautwein and Lüdtke, 2007). Specifically, when participants are teacher candidates, their interaction with the learning environment became quite important since it may affect them and their students' beliefs. Studies show strong connections between teachers' beliefs, behaviors, and learning environment (Brown and Rose, 1995; Kagan 1992; Nespor, 1987).

Chan and Elliot (2004) stated that pre-service teachers' beliefs can change by training them and supporting their experiences. An interest in understanding what pre-service teachers believe about the nature of knowledge and learning (e.g., epistemological beliefs) may also grow. Chan and Elliot (2004) describe epistemology as an area of philosophy that is concerned with the nature and justification of individual's knowledge. Schommer (1994) claimed that personal epistemology is a belief system composing some aspects, such as the structure, certainty, and source of knowledge and the control and speed of knowledge acquisition. The hypothetical framework of Schommer proposes that epistemological beliefs of individuals vary along a continuum, from naive to sophisticated beliefs. People holding naive epistemologies usually believe that knowledge is simple, clear, and specific; it resides in authorities and is certain and fixed; concepts are quickly learned, and the ability of learning is innate and unchanging. Contrary, people holding sophisticated epistemologies have beliefs of the complex nature of knowledge, its' uncertainty and tentativeness; knowledge can be attained gradually through reasoning and can be constructed by learners (Howard et al., 2000; Schommer, 1994).

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The FL environment provides students' active engagement, based on that we assume beliefs of participants will be affected since they are related to meta-cognitive activities such as reading comprehension, monitoring, interpretation of information, problem, and case solving (Kardash and Scholes, 1996; Schoenfeld, 1985; Schommer, 1990; 1994; Schommer et al., 1992). According to Hashweh (1996), teachers' epistemological beliefs/epistemology affects their use of teaching strategies. Besides, Clement (1991) states that constructivism proposes that epistemology and theories of learning will promote much needed and substantial changes in the attitudes of teachers toward learning. A teaching method course offering different strategies through videos and advocating class time to hands-on and minds-of practices are expected to impact on personal epistemologies of the participants. In addition, it is questionable how personal epistemologies are affected for those who perceive school and teacher as a learning and knowledge source and those who guide their learning out of the school environment. Based on all these issues it is worth delving into more details in a flip learning environment.

Purpose and Significance

Being a relatively new approach and therefore having a limited number of research studies on the interaction of the learning styles of pre-service teachers and flipped classroom, makes the flipped learning model worth studying. Although there are claims on the advantages of the model, the implications for student learning, and what has been published so far seem far from conclusive (Mok, 2014). Furthermore, a transformative era on education in such a digital and pandemic affected age, requires more elaborations on this fruitful model. Therefore, the study purposes to reveal the impact of the FL model on performances and personal epistemologies of pre-service teachers across their learning styles. Specifically, the following research questions will be addressed:

- What is the impact of the flipped learning model on primary pre-service teachers' performance (science teaching course achievement) compared to conventional teaching?
- Is there a difference in performance across their learning styles in the flipped learning environment?
- How primary pre-service teachers' personal epistemologies differ across their learning styles and teaching strategies in the flipped learning environment?

METHODS

Design of the Study

We used a mixed-method design including static group comparison to compare participants' performances from two different cohorts registered in a course name "Science Teaching Couse-II" at a university level, one-group pre-post-test design for comparison of performance across learning styles, and qualitative content analysis of lesson plans for personal epistemologies. The science teaching course was flipped for 15 weeks of the spring semester. Before the intervention, a learning styles inventory was administered to determine pre-service teachers' learning styles, and groups were formed in line with their learning styles. Midterm, final exam, and lesson plans were used as data sources and analyzed to find out how flipped learning model interact with the learning styles of the participants on science teaching course achievement and their personal epistemologies.

Participants

The participants of the study were 27 (21 females and 6 males) junior primary pre-service teachers enrolled in the Science Teaching Course II in the spring semester of the 2018–2019 academic year in a state university in Turkey. The control group composed of 30 primary pre-service teachers enrolled in the same course in the spring semester of the previous academic year in the same university. Their age range was 21–24 years old. Both experiment and control groups have similar academic background, took the university entrance exam, and placed in the same department, and took the same courses. In the first five semesters of the pre-service teacher education program, they took courses on science education as General Biology, General Chemistry, General Physics, Instructional Technologies, and Material Design, Science and Technology Laboratory Applications, Life Science Education, Science Teaching Course I, and courses on educational sciences as Introduction to Education, Instructional Principles and Methods, and Measurement and Evaluation. After graduation, they become primary teachers, the main actors for the primary school students' first 4 years of their education journey. They are expected to give several courses on reading and writing, mathematics, life sciences, physical education, music, art, science, social sciences, and traffic. Therefore, primary teachers should be well educated in a holistic manner. Specific to science education, they have to know the science teaching basics, teaching strategies, and the structure of the national primary science teaching curriculum. The curriculum covers the vision, purpose, teaching approach, and learning areas of primary science education. Furthermore, the curriculum includes subjects under units of each grade, the objectives of each unit, and the cautions for the concepts that should not be instructed. Both groups were the same except their academic year, the control group attended the course in the previous academic year.

Description of the Course

The Science Teaching Course II is a compulsory course in the sixth semester of the primary teacher education program of a university and focused on teaching methods and strategies used in science education. In the fifth semester of the program, there is Science Teaching Course I which covers basic concepts related to science teaching, scientific literacy, the interconnected relationship among science, technology, society, and environment, attitudes toward science, main principles of science education, the historical development of science education in the country that the study conducted, and the structure of the national science education curriculum. The aim

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of *The Science Teaching Course II* is to get primary pre-service teachers to comprehend current teaching methods and strategies, measurement, and evaluation related to them. *The Science Teaching Course II* covers the 5E learning cycle, argumentation, multiple intelligence theory, problem-based learning, context-based learning, inquiry, maker education, flipped learning, and Science, Technology, Engineering, and Mathematics (STEM) approach. The course is 3 h a week and there are 15 weeks in a semester. This course had been taught in a traditional lecture format, emphasizing teaching strategies by the instructor in the first 8 weeks of the semester and the last 5 weeks, pre-service teachers prepare lesson plans with the objectives of the "primary science teaching curriculum" developed by the Ministry of National Education and do micro-teaching following the selected teaching strategies. However, the instructor observed that the last 5 weeks was not enough to support pre-service teachers' skills of using science teaching methods as intended. During the present study, pre-service teachers studied teaching methods/strategies at home and the course time was spent on microteaching and feedback to improve their skills of using these methods/strategies. The pre-service teachers were expected to spend between 8 and 10 h/week which included preparing for lectures, micro-teaching, and preparing for two exams (midterm and final exam). The instructor has 6 years of experience in teaching this course.

Intervention

The main steps of the intervention are summarized in Figure 1 to make the process clearer. The details of the intervention are given below.

In the present study, the aim of *The Science Teaching Course II* was the same as the previous years; the only difference was the teaching method; the flipped learning model was used for introducing teaching methods and strategies. Therefore, course time could be spent on doing more practice to improve pre-service teachers' teaching skills with related methods and strategies than in the traditional manner. The intervention was conducted in the spring semester of the 2018–2019 academic year. In the 1st week of the course, the pre-service teachers (experimental group) were informed about the course content and the procedure. Videos related to each teaching method/strategy were uploaded to the course portal in the learning management system of the university. Pre-service teachers could enter the system by their password and download these videos through laptop, smartphone, or tablets through free Wi-Fi on campus or through their internet connection outside the campus. Table 1 presents the course content for each week. The pilot study of the flipped classroom for the course was implemented in the previous semester by the same instructor in *The Science Teaching Course I*. Video generation and the procedure developed according to the feedback of the enrolled pre-service teachers of that semester and the instructors' experiences. The videos of each teaching method were pre-recorded lectures including the main characteristics, advantages, disadvantages, and tips on using methods/strategies. The videos were approximately 15–20 min long (shorter than a traditional class time).

Before the class

Before coming to class, pre-service teachers were expected to watch the pre-recorded lecture, take notes, and write questions for class discussion. The groups (each was formed with two or three pre-service teachers having the same learning style) selected objectives of one subject from the curriculum and prepared a lesson plan related to the teaching method or strategy of the week. They sent their lesson plans 2 days before the day of the course and revised them according to the feedback of the instructor. The main aim of that piece of feedback was to improve the effectiveness of the lesson plans with the related strategy that the plan focused on. The groups were the same throughout the semester. In each week, the objective of each group was different, but their teaching method or strategy was the same.

In the class

At the beginning of the class, the teaching method or strategy of the week was discussed with the whole class. For instance, the underlying framework of the 5E learning cycle, the teacher's role, the student's role, and the purpose of each step were discussed. Then, five groups of pre-service teachers did micro-teaching according to prepared lesson plans with the 5E learning cycle model. The instructor and the other members of the class expressed their opinions on the micro-teachings in terms of whether each step of the 5E learning cycle model

Table 1: The learning styles of the experimental group

Learning Styles	Frequency (%)	Group formation
Convergers (AC and AE)	7 (25.9)	3 groups (3,2,2)
Divergers (CE and RO)	9 (33.4)	3 groups (3,3,3)
Accommodators (AC and RO)	5 (18.5)	2 groups (3,2)
Assimilators (CE and AE)	6 (22.2)	2 groups (3,3)

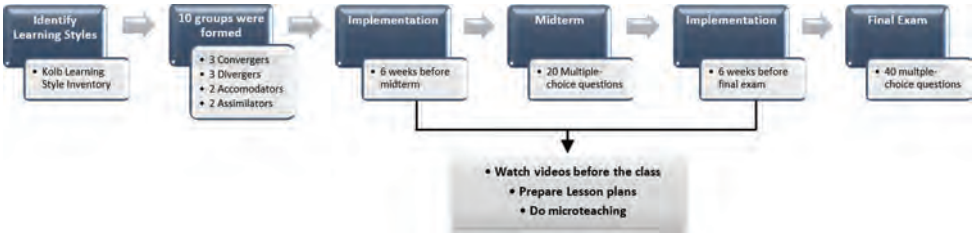

Figure 1: Intervention process of the study

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was implemented effectively and how they could improve their teaching.

The control group experienced the more traditional teaching method. As such, they did not watch videos, but they prepared lesson plans and did microteaching in groups (1–2 groups in a week). Each group did not have a chance to perform microteaching on each teaching strategy/method since most of the course hours spent for lecturing on the teaching methods. Identical assessments to evaluate course performance were administered and analyzed as the experimental group.

Data Collection and Analysis

Data of this study were collected through instruments and lesson plans. Instruments were the Kolb Learning Style Inventory and their Midterm and Final exams.

Kolb learning style inventory

Learning style inventory version II (Kolb, 1985) was administered to determine pre-service teachers' learning styles. The inventory was translated and adapted by Askar and Akkoyunlu (1993). There are 12 items with four choices in the instrument, each choice reflects one of four stages of a learning cycle: Abstract Conceptualization (AC) (1 point), Concrete Experience (CE) (2 points), Reflective Observation (RO) (3 points), and Active Experience (AE) (4 points). Scores ranged between 12 and 48 points and two different scores calculated by AC - CE and AE - RO. These scores ranged from –36 to +36, and then participants were categorized under learning styles via Kolb's interpretation grid. Pre-service teachers were categorized under four learning styles: convergers, divergers, assimilators, and accommodators (Table 2). Thus, 7 (25.9%) of the pre-service teachers were convergers, 9 (33.4%) were divergers, 6 (22.2%) were assimilators, and 5 (18.5%) were accommodators. Ten groups were formed according to learning styles (two groups from accommodators and assimilators, three groups from convergers, and divergers) (Table 2). Convergers are good at problem-solving, decision making, and logical analysis of ideas. Divergers could review concrete situations from a different point of view and organize meaningful relationships of these situations. Assimilators are known as good at abstract conceptualization and construct models. Accommodators carrying out plans and abide by them, they are open-minded and accommodate changes easily.

Midterm and final exams

Pre-service teachers' science teaching course performance was evaluated through midterm and final exams. The exam questions were prepared by the researchers. The midterm exam consisted of 20 multiple-choice questions on the learning cycle, argumentation, and multiple intelligence theory. The final exam included 40 multiple-choice questions on all course content. Both have a maximum score of 100. Questions of both exams were reviewed by two experts in science education to check face and content validity. Descriptive statistics, independent sample t-test, Split-Plot ANOVA, Kruskal–Wallis-H, and Wilcoxon Signed-Rank Tests were conducted through IBM SPSS Statistics 25.

Table 2: The learning styles of the experimental group

Learning styles	Frequency	Group formation
Convergers (AC and AE)	7 (25.9%)	3 groups (3,2,2)
Divergers (CE and RO)	9 (33.4%)	3 groups (3,3,3)
Accommodators (AC and RO)	5 (18.5%)	2 groups (3,2)
Assimilators (CE and AE)	6 (22.2%)	2 groups (3,3)

Lesson plans

The experimental group was required to watch a video of the science teaching method or strategy of the week and then they prepared lesson plans related to the teaching objectives of the National Science Teaching Curriculum based on that method in groups. Lesson plans were prepared by groups of students each week related to the topic of the week. They could contact the instructor to ask questions and get help. The national science teaching curriculum includes 82 objectives for the 3rd and 4th grade level in total, groups selected objectives before the class, prepared lesson plans, and did microteaching in line with those plans during the class time. The lesson plans needed to be composed of the following parts: Objectives of the course, related requirements, materials, or technologies used, the implementation of the course, and evaluation. Lesson plans were examined using the rubric developed by researchers in line with Hofer and Pintrich (1997). They asserted two dimensions: the nature of knowledge (including the simplicity of knowledge and the certainty of knowledge), the processes of knowing (including the source of knowledge and justification of knowledge). In the present study, lesson plans were not evaluated in terms of justification of knowledge because the determination of this dimension is difficult through just lesson plans and so the process of knowing was examined in general. In this rubric, how personal epistemology aspects reflected in the lesson plan were examined. The following table shows the rubric for evaluating pre-service teachers' lesson plans in terms of personal epistemologies (Table 3). Four lesson plans (on argumentation, multiple intelligence, problem-based learning, and 5E learning cycle) of the participants were examined by each author separately (88% consistency achieved), then they discussed the different codes and reached a consensus.

RESULTS

Science Teaching Course Achievement

Descriptive of midterm and final scores is presented in Table 4. Mean scores at midterm of the experimental and control groups are closer to each other than the final scores of them. The distribution met the assumption of normality. Independent sample t-test indicated that their midterm scores were not different ($t_{(55)} = –0.733$, $\rho = 0.467$).

Split-Plot ANOVA output showed that there was a non-significant main effect of group, $F(1, 55) = 0.182$, $\rho > 0.005$. Therefore, it can be said that control and experimental group course achievement were the same if all other variables were

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Table 3: The rubric for the level of sophistication of personal epistemologies of pre-service teachers

Personal Epistemology Aspects	The level of sophistication on personal epistemologies		
	Sophisticated	Moderate	Naïve
The source of knowledge	Reasoning	Both reasoning and authority	Authority
The simplicity of knowledge	Complicated, integration of the knowledge	Some knowledge is complicated and some simple.	Simple. Each knowledge is separate.
The certainty of knowledge	Tentative	Some knowledge is tentative and some certain.	Certain

Table 4: Descriptive of midterm and final scores of the experimental and control groups

Group	N	Minimum	Maximum	Mean	SD
Control Group					
Midterm	30	27.00	93.00	65.37	19.57
Final	30	52.00	90.00	69.93	10.68
Experimental Group					
Midterm	27	33.00	84.00	61.93	15.35
Final	27	55.00	94.00	76.44	11.85

ignored. However, there was a significant main effect of time, F (1, 55) = 35.737, ρ < 0.005. This effect means that science teaching course achievement of the participants was different in midterm and final exam when all other variables were ignored. The estimated marginal means of the control and experimental group are 63.65 and 73.19, respectively. Results also displayed that there was a significant interaction between the group and time, F (1, 55) = 9.717, ρ < 0.005. This interaction effect showed; the science teaching course achievement of the participants was different for control and experimental groups from midterm to final exams. Partial eta squared is calculated.15 interpreted as large effect size (Cohen, 1988).

Science Teaching Course Achievement across Learning Styles

The descriptives for experimental group pre-service teachers' learning styles in terms of midterm and final scores were presented in Table 5.

The Kruskal–Wallis H test indicated that there was no statistically significant difference among participants' science achievement in the midterm scores ($X^2_{(3)}$ =2.570, ρ = 0.463) and final scores ($X^2_{(3)}$ =2.406, ρ = 0.493) across the learning styles (Table 6).

Wilcoxon signed-rank test was conducted to determine whether there was a difference between midterm and final achievement scores of the participants with different learning styles. Since four tests were performed, the Bonferroni correction is necessary, and the alpha value should be.0125. Results are summarized in Table 7. Thus, there is a statistically significant difference between midterm and final scores of divergers (Z = –2.670; ρ < 0.0125) with large effect size (r = 0.63). There is no significant difference between pre-service teachers' achievement scores with the other three learning styles before and after the FL intervention.

Table 5: Descriptive of experimental group exam scores according to learning styles

Learning styles	N	Minimum	Maximum	Mean	SD
Accommodators					
Midterm	5	57.00	83.00	69.80	11.61
Final	5	60.00	92.00	80.80	13.10
Convergers					
Midterm	7	49.00	84.00	63.57	13.65
Final	7	58.00	94.00	72.57	12.41
Divergers					
Midterm	9	33.00	81.00	55.44	16.74
Final	9	55.00	94.00	74.44	12.32
Assimilators					
Midterm	6	37.00	82.00	63.17	17.37
Final	6	67.00	91.00	80.33	9.97

Table 6: The ranks for pre-service teachers' learning styles in terms of exam scores

Exams	Learning styles	Mean rank	SD	χ^2	ρ
Midterm	Accommodators	18.00	3	2.570	0.463
	Convergers	14.36			
	Divergers	11.06			
	Assimilators	14.67			
Final	Accommodators	17.20	3	2.406	0.493
	Convergers	11.36			
	Divergers	12.67			
	Assimilators	16.42			

Figure 2 shows the difference of course performance across learning styles. Even accommodators and assimilators have the highest score on the final exam; the total gain of the divergers is more than their gain. From this point of view, convergers are the least affected group from the flipped classroom intervention with the lowest gain score.

Personal Epistemologies across Learning Styles and Teaching Methods/Strategies

Lesson plans of the pre-service teachers were examined to identify their personal epistemologies. According to Table 8, when lesson plans designed for argumentation were investigated, assimilators held sophisticated and moderate beliefs, and divergers showed moderate beliefs. However, accommodators and convergers' lesson plans on argumentation showed no information on their personal epistemologies.

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Table 7: Wilcoxon signed-rank test results of exam scores across learning styles

Learning styles	Pre-post science teaching course achievement	N	Mean rank	Sum of ranks	z	ρ
Assimilators	Negative ranks	1	1.00	1.00	-1.997	0.046
	Positive ranks	5	4.00	20.00		
Divergers	Negative ranks	0	0.00	0.00	-2.670	0.008*
	Positive ranks	9	5.00	45.00		
Convergers	Negative ranks	0	0.00	0.00	-2.366	0.018
	Positive ranks	7	4.00	28.00		
Accommodators	Negative ranks	1	1.50	1.50	-1.625	0.104
	Positive ranks	4	3.38	13.50		

*Indicates significant results that the ρ<0.0125

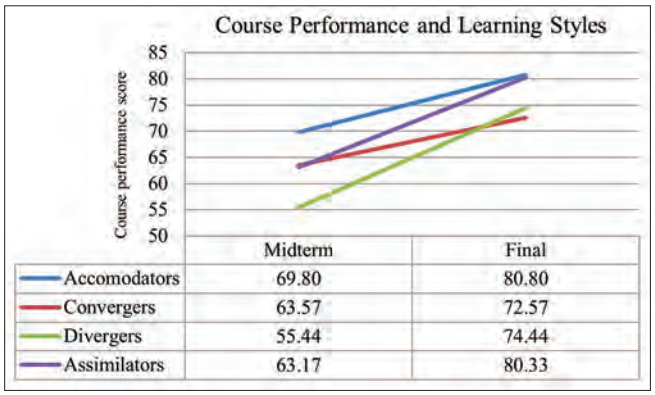

Figure 2: The change in the course performance in terms of learning styles of pre-service teachers

Multiple intelligence is the method that least reflects certainty of knowledge dimension of the personal epistemologies among the others. Pre-service teachers designed teaching and learning environments with naïve and moderate personal epistemologies in multiple intelligence method of teaching. However, the same pre-service teachers whether they were assimilating learning style or accommodation, generally used sophisticated personal epistemologies while preparing lesson plans on problem-based learning. All the learning styles showed a higher level of personal epistemology on problem-based learning.

While preparing lesson plans about the 5E model accommodators and assimilators showed a moderate level on the source of knowledge by showing the solution of problems. Only accommodators held sophisticated knowledge about the certainty of knowledge in 5E lesson plans. The convergers and divergers' lesson plans on 5E reflected no information or naïve personal epistemologies. When we compared learning styles and personal epistemologies, we can see that assimilators held more satisfying beliefs when compared to others. Convergers had more naïve beliefs in the 5E learning cycle model and argumentation; divergers also had naïve beliefs in the 5E teaching method. It could also be stated that accommodators pre-service teachers had more sophisticated personal epistemologies in the 5E model compared to the other three styles. Assimilators and accommodators both held sophisticated beliefs in problem-based teaching, whereas accommodators had naïve on argumentation.

Based on the lesson plans prepared for each applied teaching method, there was evidence that pre-service teachers' science teaching orientations included constructivist practices. Pre-service teachers' lesson plans included inquiry elements and/or methods of scientific inquiry. Lesson plans included inquiry elements and/or methods of scientific inquiry. One reason for including these elements may be that they have heavily encountered these strategies in a flip learning environment. Another reason may be the content of teacher education programs in the country of the study. Pre-service primary teachers were expected to have developed science process skills when they completed their degrees. Skills such as investigating, problem-solving, hypothesizing, observing, questioning, experimenting, and manipulating apparatus and materials are usually mentioned in teacher preparation programs and, thus, may be reflected in their lesson plans.

The density and variability of indicators such as asking questions, designing experiments, providing claims, and justifications are changeable across the methods used by pre-service teachers. However, even though some aspects were provided in the lesson plans, it was rare to detect statements in the same way across the learning styles. In an action-oriented lesson plan, diagnosis of epistemic issues was usually restricted to asking questions and creating a discussion environment. The fruitfulness of discussion is usually high in more inquiry-oriented lesson plans.

DISCUSSION AND CONCLUSION

This study revealed the impact of the flip learning environment in a teaching method course of pre-service teacher education program on achievement and personal epistemologies across learning styles and teaching methods. Findings extend the knowledge on the field based on some aspects; first, a comparison of course achievement of the flipped learning group students and the control group students indicated higher achievement in favor of the flipped learning group. Second, science teaching course performance across learning styles differed. Pre-service teachers who were accommodators and assimilators demonstrated higher course achievement mean

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Table 8: Personal epistemology aspects in pre-service teachers' lesson plans

Type of learning style	Personal epistemology aspects	Teaching Method/Strategy			
		Argumentation	Multiple Intelligence	Problem-based learning	5E Model
Accommodators 4	Certainty of knowledge	No information	No information	Sophisticated. "Students discuss the problem situation to create an environment for knowledge change".	Sophisticated. "In explore stage, students are confronted with the problem and asked to solve it".
	Source of knowledge	No information	Naïve. "The teacher explains the concepts".	Sophisticated. "Students in groups solve the problems such as "how do we protect our body from infections?", "what are the reasons of illness?".	Moderate. "Students exhibit how the problem is solved, what are the steps of the problem solving".
	Simplicity of knowledge	No information	Naïve. Each concept is given without integrating each other.	Sophisticated. "Prior experiences of students related to problem are required".	No information
Convergers	Certainty of knowledge	No information.	No information.	No information.	Naïve. "The teachers should make correct explanation".
	Source of knowledge	No information.	Moderate. "The definition of natural voice is asked to students; students try to find out what is artificial voice. Natural and artificial voice examples put into play cards. Students pull one card and explain whether it is example from natural voice or artificial voice".	Sophisticated. "Although bird voice is natural, why ring bell of bird voice is artificial voice".	Naïve. "The teacher tells the concepts".
	Simplicity of knowledge	No information.	Naive. "Students decide whether the voice is natural or artificial by listening different types of voices".	Sophisticated. "The teacher states -Now, let's try these judgments by testing each- without explaining the answer is right or wrong".	Naïve. In explain stage, the topic is explained without integrating each other.
Divergers	Certainty of knowledge	No information.	No information.	No information.	No information.
	Source of knowledge	Moderate. "Teacher explains the concepts and starts the discussion by using concept cartoon. Teacher asked if we are exposed to smell for a long time in a room; after a while can we smell it? Possible answers: (1) Yes, because the smell molecules do not disappear in the air and we could smell until leaving the room. (2) No, because our smell cells get tired just like we could not smell our perfume during the whole day."	Moderate. "At the beginning of the class, teacher told the concepts. Then, teacher asks "please write the nose function by your own words?"	Sophisticated. "Students work in groups, get necessary information for solving the problem and they share their suggestions to solve the problem with each other".	Naïve. "Teacher told the concepts".
	Simplicity of knowledge	Moderate. The concepts are explained without integration.	Naïve. "The teacher tells the concepts and asks question to write your own words?".	Sophisticated. "Students try to understand the problem using their prior knowledge. They benefit from prior experience and knowledge while constructing knowledge".	Naïve. There is no integration of the concepts.

(*Contd...*)

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Table 8: (*Continued*)

Type of learning style	Personal epistemology aspects	Teaching Method/Strategy			
		Argumentation	Multiple Intelligence	Problem-based learning	5E Model
Assimilators	Certainty of knowledge	Sophisticated. "The teacher encourages students to convince each other in a discussion." Tentativeness of knowledge was emphasized.	No information.	Sophisticated. "While solving the problem, groups discuss and at the end they reach to the common point. They perceive how knowledge can change".	No information
	Source of knowledge	Sophisticated. "The teacher asks whether hand is one of the sense organs. and engages students in argumentation."	Naive. "The teacher designs the activities and then students should do the activities in the class."	Sophisticated. "The teacher promotes students to do research while solving the problem."	Moderate. "The teacher tells students to close their eyes and sprays perfume, asks students whether they smell or not. The teacher asks smelling of perfume is related to closing their eyes or not".
	Simplicity of knowledge	Moderate. "Some compounds could be perceived more than one sense."	Naïve. Lesson plan did not integrate the knowledge with each other.	Sophisticated. "Students' prior knowledge is integrated to new knowledge. The teacher asks questions for finding out students' prior experiences and knowledge".	Moderate. "Students realize relations among sense organs".

scores about teaching methods. However, there was statistically significant difference between the divergers' performance on midterm and final exams. Third, personal epistemologies across learning styles of the pre-service teachers were investigated. Findings based on lesson plan analysis show that assimilator students held a higher level of personal epistemologies compared to other types of learning styles. Another comparison was made across the teaching methods and it was seen that students' lesson plans on problem-based teaching were more fruitful on personal epistemologies for all learning styles.

First, the impact of flipped learning model on primary pre-service teachers' performance on science teaching course was compared to conventional teaching. The results indicated that the course achievement of the pre-service teachers was different for control and experimental groups from midterm to final exams in favor of the experimental group. In the experimental group, usually lecturing was replaced with student centered discussions of the methods and content fit. The class time was more devoted to questioning and discussion on teaching models/strategies, microteaching, and feedbacks on the appropriateness of pre-service-teachers' microteaching activities. As, the literature points as a benefit of FL, we also observed that there was more time for cognitive engagement in classroom activities than the control group had. Experiencing the basics of the content before class hour let students to think over the flow of course and facilitated the classroom discussions. Thus, pre-service teachers had a chance to increase their knowledge level related to teaching models/strategies more than the control group. Similar findings were reported by Vaughan (2014) in the investigation of the use of the FL model in an introductory teaching course. He stated that "students would leave with a large amount of introductory content into the field of education and a plethora of instructional strategies modeled for them" (Vaughan, 2014, p. 38). Although, the study design is relatively weak compared to true experimental settings, still we could test previous year as control scores, so testing the hypothesis. Based on findings, it could be possible to claim that the FL model helps to improve achievement than lecturing for the study context.

Next, we tested whether performances differ across learning styles in flipped learning environment. Related to the course achievement of the ones from different learning styles, Kim (2012) revealed relationships among the learner's types, characteristics, and academic achievement in a blended learning environment and found that extraversion achieved higher. Kim (2018) focused on learning style and satisfaction and observed that assimilators had the highest total satisfaction scores while divergers had the lowest satisfaction scores. Tadayonifar and Entezari (2020) compared achievement across learning styles and concluded that FL had a significant impact on the students' performance for all learning styles, they claim FL supports all groups based on performance. In our case, the gain score of the divergers was the highest and the difference was statistically significant. Kim (2018) found that divergers have higher extraversion and conscientiousness scores and discussed based

on the previous studies that a computer-assisted instruction is negatively related to these qualifications, thus the divergers could not benefit from flipped videos to support the results of the lowest satisfaction scores of the divergers. However, as Bishop and Verleger (2013) emphasized flip is not just computer-assisted instruction, it helps to use class time for more activities. The FL implementation required more group work compared to traditional ways, so one may also state that more extraversion traits benefit more from FL. Thus, divergers as more extraversion individuals tend to be caring and emphatic and able to see the body language of the others get the highest gain score. The results show that even accommodators and assimilators were more successful than others; the difference from midterm to final is not statistically significant. Accommodators are the best at the concrete experience and active experimentation and their satisfaction could be explained that the FL provides more time for concrete experience. Related with that, Kim (2018) states that assimilators show higher extraversion personality with divergers. Extraverted learners might feel better in collaborative learning when they have social interactions. The class hour spent with collaboration and discussion in this study, and these activities might explain the achievement of the assimilators. Convergers had relatively low mid-term and final exam scores compared to assimilators and accommodators. Fahy (2005) states that convergers are more willing to spend time on the network in a similar learning environment and also Kim (2018) revealed that they have a lower level of extraversion, and they may not feel confident in group works. Huglin (2004) studied adults' different learning styles and their preference for learning and reveled that assimilators and convergers prefer more traditional learning strategies (such as behaviorism and cognitive information processing) and divergers and accommodators prefer learning environments that are more constructivists. In FL environment of this study, we obtained consistent outcomes to the work of Huglin (2004). Further studies may explore interaction patterns across learning styles. Personalized instructional design is important for the different characteristics of the learners of different learning styles. According to Kim (2018), teachers should identify students' learning styles at the beginning of the course and design teaching models/strategies, and also materials with holding that knowledge in his/her mind, thus the teachers have a chance to engage all students. More long run works are necessary to test and verify students learning styles and interaction in learning environment.

Third, we questioned personal epistemologies across learning styles and teaching strategies in flipped learning environment. The study contributed to the field on comparisons of pre-service primary teachers' personal epistemologies reflected in lesson plans across learning styles. Although few works reported on how academic achievements differ across learning styles (see, Shaw, 2012), no work speculate regarding personal epistemologies and use of teaching strategies in FL environment. Personal epistemologies of the participants are figured out through their lesson plans since it was not meaningful to ask them directly as Schommer, (1990) did and Hammer and Elby (2002) criticized. Our findings showed that assimilator students reflect a higher level of personal epistemologies in their lesson plans. We saw an association between the level of personal epistemologies and teaching strategy used in lesson plans for different learning styles. Assimilators reflected more on the source of knowledge compared to others, reflected equally on the certainty of knowledge with accommodators. Converger students reflected the least about their beliefs on certainty, simplicity, and source of knowledge compared to the students with other learning styles. Concerning the relations between learning styles and personal epistemologies, we can state similar patterns with achievement. According to Kang (2008), personal epistemologies of the students do not change in a short period time (15 weeks of a method course) since they have a long science learning experience compared to the implementation period. Our findings reflect the same idea; there was no progression (from naïve to sophisticated) in personal epistemologies of the pre-service teachers that was seen in lesson plans before and after the midterm. However, it was very clear that personal epistemologies of the participants were context-dependent and activated by contexts as Hammer and Elby (2002) emphasized. Kang (2008) also stated that "the preservice teachers' personal epistemologies activated by the course tasks, and hence may be showing parts of their belief sets" (p. 484). Lesson plans on argumentation reflect low personal epistemologies compared to lesson plans on problem-based strategy. Participants' prior experiences with the teaching strategy might also have an impact on their reflections of personal epistemologies. Watson (2009) assessed evaluations of different age groups concerning two different teaching methods (lecture vs. discussion) and found that epistemological development level was the predictive of evaluations of teaching methods. She revealed that higher epistemological levels were predictive of more critical evaluations of lectures and a preference for discussions. Despite such deductions, our findings do not show a pattern across personal epistemologies reflected in lesson plan and learning styles. Furthermore, Kang (2008) suggested understanding the structure of belief system of teachers provide guidance to teacher education programs. Furthermore, Hashweh (1996) found that epistemological beliefs of teachers affect their teaching strategies and the way that they treat the alternative conceptions. Therefore, we strongly suggest further studies to focus on how teacher education programs help pre-service teachers to improve personal epistemologies that are transferred to their instruction.

Ethical Statement

All of the pre-service teachers volunteered to be participants of the study and signed a consent form that clearly stated the aim and procedure of the study, the right to withdraw at any time they wanted, how the anonymity and confidentiality assured. As a result, no official ethical permission was necessary from the Ethical committee due to no obligation for participants to participate in the study.

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