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Flipped classrooms: Designed and implemented with colleagues collaboration

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Flipped classrooms: Designed and implemented with colleagues collaboration

Abstract

The aim of this study is to investigate the results of the flipped classroom model, which was prepared and applied in collaboration with colleagues, on the academic success on stereochemistry one of the topic the organic chemistry course of pre-service chemistry teachers, the views of the pre-service chemistry teachers about the flipped classroom model and the views of the collaborating faculty member about the practice. The study was designed and carried out according to the participatory action research method. Seventeen pre-service chemistry teachers participated in the study. In the study, short videos were shot in which the instructor of the course explained the lessons and the researcher provided pedagogical and technical support in order to carry out the stereochemistry lesson with the flipped classroom model. Quantitative and qualitative data were collected. The quantitative, which was collected with data the achievement test, was analyzed with the non-parametric Wilcoxon Test. The qualitative data were analyzed with the content analysis method. Quantitative results showed that there was a significant difference between the pre-test and post-test achievement scores in favor of the post-test. As a result of the qualitative content analysis, it was determined that the pre-service teachers had positive views toward flipped classroom such as support learning, solving plenty of questions, watching the videos as often as desired, and being prepared for the lesson. The instructor who conducted the course also stated that he had positive thoughts about using the same method in his lessons and sharing the course material on online platforms.

Practitioner Notes

1. Learning material to be used at home has a critical importance in the flipped classroom model. Therefore, special attention should be paid to the preparation of quality material in respect of sound, image and length of videos.
2. When the flipped classroom model is used in economically weak regions, sufficient internet facilities should be provided to the students so that they can easily and sufficiently access the course material.
3. Follow-up mechanisms should be established to ensure that students come to the lesson prepared.
4. While studying the course material at home, online forums should be created where students can ask questions to their teachers and friends and get instant feedback.
5. Collaborations should be encouraged among experienced faculty members who want to use the flipped classroom model in their lessons.

Keywords

flipped classroom model; stereochemistry; pre-service chemistry teachers; participatory action research

Results of the Flipped Classroom Model Designed and Implemented with Colleagues Collaboration

The organic chemistry course is described as a difficult course by students (Ellis, 1994; Fautch, 2015; O'Dwyer & Childs, 2017). This challenge pushes educators to seek to increase students' interest and motivation, and to enable them to learn better (Crucho, Avó, Diniz, & Gomes, 2020). The flipped classroom model stands out as an alternative teaching model in order to overcome the difficulties experienced in the teaching of courses such as organic chemistry course, which has comprehensive subject content and relatively difficult to understand concepts (Chen, Huang, & Hwang, 2019). There are many studies investigated the effect of the flipped classroom approach on students' cognitive and affective achievements, and their number is increasing (Bond, 2020; Chen et al., 2019; Seery, 2015). The results show that the flipped classroom approach has a positive effect on learning (Bond, 2020; Cormier & Voisard, 2018; Khan & Watson, 2018; Mooring, Mitchell, & Burrows, 2016; O'Flaherty & Phillips, 2015) by both students and also adopted by teachers (O'Flaherty & Phillips, 2015; Zuber, 2016). However, the effective implementation of approaches such as the flipped classroom approach, which has been rising recently, first of all, requires teachers to be competent both pedagogically and technologically (Lo & Hew, 2017; O'Flaherty & Phillips, 2015; Seery, 2015).

Organic chemistry course consists of intense content (Ellis, 1994), includes mechanisms and many symbols and shapes (Bhattacharyya, 2014; Bhattacharyya & Bodner, 2005) solving synthesis problems (Teixeira & Holman, 2008) and requires three-dimensional thinking (Teixeira & Holman, 2008) is described as a difficult course by students. The increase in studies revealing students' misconceptions about chemistry is seen as an indication that chemistry consists of concepts that are difficult to understand (Gabel, 1999). Despite this difficulty, most of the science lessons, including the organic chemistry lesson, are still taught with the traditional lecture method (Lund & Stains, 2015). Instead of traditional methods, the flipped classroom model, in which students take responsibility for their learning and are active both inside and outside the classroom, is seen as a way out (Mooring et al., 2016; Ryan & Reid, 2016).

The flipped classroom model is defined in many different ways (Abeysekera & Dawson, 2015). However, it is basically defined as an approach that replaces classroom lectures in the traditional method and reinforcement activities that students do at home for their learning (Abeysekera & Dawson, 2015; Bergmann & Sams, 2012; O'Flaherty & Phillips, 2015; Weaver & Sturtevant, 2015). In this approach, in-class lectures are given to the students as homework in the form of videos and similar course materials, while in-class time when the teacher is with the student is tried to be used more effectively with problem-solving, discussion and other interactive methods (Robert, Lewis, Oueini, & Mapugay, 2016; Weaver & Sturtevant, 2015). Courses are carried out as allowing more student-centered activities to be carried out in the classroom (Little, 2015; Weaver & Sturtevant, 2015). Outside of class, students are usually given videos to watch (Robert et al., 2016).

The effect of the flipped classroom model on students' achievement theoretically is being based on cognitive workload (Abeysekera & Dawson, 2015; Seery, 2015) and social constructivism (Bancroft, Fowler, Jalaeian, & Patterson, 2020; Bancroft, Jalaeian, & John, 2021; Flynn, 2015; Mooring et al., 2016). Cognitive workload theory predicts that the information that people can include in long-term memory is limited by the capacity of short-term memory (Seery, 2015). In the flipped classroom model, students' ability to access learning materials over and over again whenever they want help to learn by reducing their cognitive workload (Abeysekera & Dawson, 2015; Ponikwer & Patel, 2018). Social constructivism, on the other hand, is based on the principle that individuals construct knowledge by taking an active role in individual and social interaction in the learning process (Atkinson, Krishnan, McNeil, Luft, & Pienta, 2020; Kim, 2001). This theory especially emphasizes social interactions in the construction of knowledge (Palincsar, 1998). In the flipped classroom model, students are allowed to learn in collaboration and interaction with their peers and teachers in classroom activities (Karabulut-Ilgu, Cherrez, & Hassall, 2018; Ponikwer & Patel, 2018).

The flipped classroom model has attracted more and more attention in recent years (Seery, 2015). In particular, the number of studies on chemistry education is increasing (Bancroft et al., 2021; Chen et al., 2019; Khan & Watson, 2018). According to the results of the research, the flipped classroom model positively affects academic achievement (Akcayir & Akcayir, 2018; Dogan, Batdi, & Yasar, 2021; Fautch, 2015; Flynn, 2015; O'Flaherty & Phillips, 2015; Robert et al., 2016) both students (Dogan et al., 2021; Flynn, 2015; Mooring et al., 2016; Ojennus, 2016; Ponikwer & Patel, 2018; Rossi, 2015; Seery, 2015) and teachers (O'Flaherty & Phillips, 2015; Seery, 2015) have a positive attitude towards the flipped classroom model. Studies revealing that there is a negative effect on academic achievement, especially although this effect is not statistically significant, indicate that the rate of students who get high grades increases (Mooring et al., 2016; Ojennus, 2016), while the rate of students who dropped out from the course and those who get low grades decreases (Bancroft et al., 2020; Flynn, 2015; Mooring et al., 2016; Shattuck, 2016). There are also many results reported in studies that students with low academic achievement are more successful (Casselman et al., 2020; Cormier & Voisard, 2018; Ryan & Reid, 2016). Fautch (2015) attributes this to teachers ' ability to individualize instruction, such as allowing them to communicate one-on-one with students, hold them accountable for their preparation for the lesson, and ask more questions. The increase in the success of the students is connected to the attributes of the flipped classroom model such as creating an active learning environment (Bond, 2020; Lo & Hew, 2017; Seery, 2015; Shattuck, 2016), providing easy access to the teaching materials (Seery, 2015), increasing the time of discussion and interactions in the classroom (Karabulut-Ilgu et al., 2018; Mooring et al., 2016), allowing students to learn and reinforce concepts on their own, and spending time for learning both outside and inside the classroom (Tekane, Pilcher, & Potgieter, 2020; Trogden, 2014). One of another important reasons for this increase in success is that students develop positive attitudes towards learning with this approach (Rocabado, Kilpatrick, Mooring, & Lewis, 2019; Villafañe & Lewis, 2016). Shi, Wang, Ma, MacLeod, and Yang (2018) stated that the flipped classroom model positively affects students' cognitive and affective skills, as well as enabling them to take responsibility for their own learning and to positive attitudes toward learning. Mooring et al. (2016) also states that students who are positively affected emotionally improve their motivation towards learning, their self-confidence, and their metacognitive skills.

As stated above, the number of studies showing that the flipped classroom model positively affects the academic achievement of students in chemistry courses increases gradually (Bancroft et al., 2021; Seery, 2015). However, in order for this expected effect to occur, it is necessary to effectively plan the lesson (McLaughlin, White, Khanova, & Yuriev, 2016), to prepare quality materials and activities for outside and inside the classroom (Flynn, 2015; Lo & Hew, 2017), students should adapt to this approach (Lo & Hew (Lo & Hew, 2017; McLaughlin et al., 2016; Mooring et al., 2016) and teachers who follow the developments and eager to use the approach in their classrooms should be supported both pedagogically and technologically (Bancroft et al., 2020; Bond, 2020; Lo & Hew, 2017; McLaughlin et al., 2016; O'Flaherty & Phillips, 2015). Planning in-class and out-of-class activities and preparing videos are the most difficult and time-consuming aspects of applying the approach (Flynn, 2015; Lo & Hew, 2017). It is suggested that this difficulty can be overcome with cooperation among teachers (Schultz, Duffield, Rasmuseen, & Wageman, 2014). In their review, O'Flaherty and Phillips (2015) determined that the biggest obstacle for educators to use the flipped classroom model is their ability to design, implement and evaluate their lessons in accordance with this approach. They also state that teachers appreciate the value of such approaches, but they need support for this. It is stated that colleague cooperation is very valuable for faculty members to successfully implement the flipped classroom model by overcoming many difficulties (Long, Cummins, & Waugh, 2017). In this study, the results of the flipped classroom model, which was prepared and applied in cooperation with the faculty member, will be examined based on these needs and suggestions.

In addition, because the majority of the studies on the flipped classroom in the literature were conducted in the USA (Bond, 2020), it is stated that there is a need for studies conducted in different classroom environments, different courses and in different countries that prove the validity of the effects of the flipped classroom model (Abeysekera & Dawson, 2015; Bancroft et al., 2021; Bond, 2020). It is thought that this study will also contribute to meeting this stated need.

In this study, the flipped classroom model was conducted in cooperation with a faculty member who was willing to implement new approaches such as the flipped classroom model, but had difficulties in terms of both time and technological competencies. The study was conducted in stereochemistry, which is one of the difficult topics of the organic chemistry course (Luján-Upton, 2001). In the study, the results of the flipped classroom model, which was designed, implemented, and evaluated in collaboration with the instructor of the course, on the academic achievement of the pre-service chemistry teachers (PCTs) in the stereochemistry course and the attitudes of the PCTs and the instructor towards the flipped classroom model were investigated.

For this purpose, the following problems were investigated:
How did the flipped classroom model affect students' academic achievement in the stereochemistry course?
How much did students come to the lesson prepared?
What are the views of the students about the flipped classroom model?
What are the opinions of the assisted faculty member about the flipped classroom model?

Method

When educational research does not involve teachers or educators, it is difficult for research results to be disseminated and widely accepted (Yildirim, İlhan, Sekerci, & Sozbilir, 2014). General education research does not focus enough on practical problems (Hordern, 2021). Studies are not systematically associated with practices, the needs in practice are not taken into account, and teachers are not included in the process (Yildirim et al., 2014). Participatory action research offers an alternative to overcoming these controversies (Laudonia, Mamlok-Naaman, Abels, & Eilks, 2018). The aim of this method is to obtain widely applicable results based on empirical observations of teaching and learning in collaboration with a teacher and a researcher. While the researcher focuses on organizing the process, designing the application and measuring the resulting effects, the teacher concentrates on applying these approaches in his/her own class (Eilks & Ralle, 2002). The purpose of action research is to improve the function of practice by solving problems. The method also aims to improve the teaching of practitioners participating in the study (Laudonia et al., 2018). There is no concern to generalizing the results obtained in the action research. On the contrary, it is aimed to improve the teaching process of an ongoing course and to reveal the work done in all its details. Objectives of the participatory action research process is summarized as the following:

- Developing teaching strategies and materials that can improve teaching and learning practice, evaluating and disseminating these strategies,
- Gaining general information about learning processes and teaching practices,

- Reporting of teaching practice and experiences (Beyhan, 2013; Brydon-Miller & Maguire, 2009; Eilks & Ralle, 2002).

This research was planned and carried out according to the participatory action research approach. The study was carried out by collaborating with the lecturer teaching the organic chemistry course. In the study, it is aimed to determine the effects of the flipped classroom model in the teaching of stereochemistry concepts in the organic chemistry course, which is difficult to teach compared to other subjects in the organic chemistry. In addition, PCTs' views about the process of teaching the lesson with the flipped classroom model and the views of the faculty member participating in the study are examined.

Course content and intervention process

The intervention was carried out in the organic chemistry course attended by the PCTs studying in the chemistry teaching at undergraduate level. Organic chemistry course is taught for two hours per week. The intervention was designed and implemented for stereochemistry, which lasted for four weeks. Therefore, the intervention covers a total of 8 hours of lessons, 2 hours per week for four weeks.

Table 1:
The stereochemistry course content

Week	Theme
1.	Introduction to stereochemistry Cis - Trans E-Z naming system The Geometric isomer of Cyclic Compounds
2.	Open-chain conformation Conformation in cyclic compounds Axial and Equatorial Disubstituted cyclohexenes compound
3.	R and S naming system Optical isomer Conversion of plane polarized light
4.	Compound with more than one chiral carbon Meso compounds

Before starting the intervention, videos, the sample screenshot of which is shown in Figure 1, were prepared cooperating with the instructor of the organic chemistry course for the intervention. Video editing software was used to edit the captured videos. In the light of the suggestions made in the literature, the duration of the videos was limited to between 5 to 10 minutes (Schultz et al., 2014; Tekane et al., 2020) and attention was especially paid to the fact that the instructor's image should be seen in the videos. The videos in which instructors seen on the screen are more preferred and watched by the students (Bond, 2020; Cormier & Voisard, 2018). The videos were shared with the PCTs through the Edpuzzle web application. In order for the PCTs to use this platform, information about the use of the platform was given at the beginning of the intervention. Through the intervention, PCTs were given the opportunity to watch videos both with mobile devices and with their computers. With the help of the Edpuzzle reporting system, it was followed whether the PCTs watched the videos before coming to the lesson. In addition, at the beginning of each lesson, quizzes consisting of short questions were made to check whether the students watched the uploaded videos. For this, 1. How many minutes of videos have been uploaded? 2. How many videos have been uploaded? 3. Which of the following concepts are included in the videos uploaded for this course? questions were asked to the PCTs.

In the classroom, interactive activities similar to card games were done with students, questions were solved, molecular models were constructed using ball-rod models, and PowerPoint presentations were prepared for each lesson to enable students to follow the activities done in the lessons.

Figure 1:
Example video captured screen

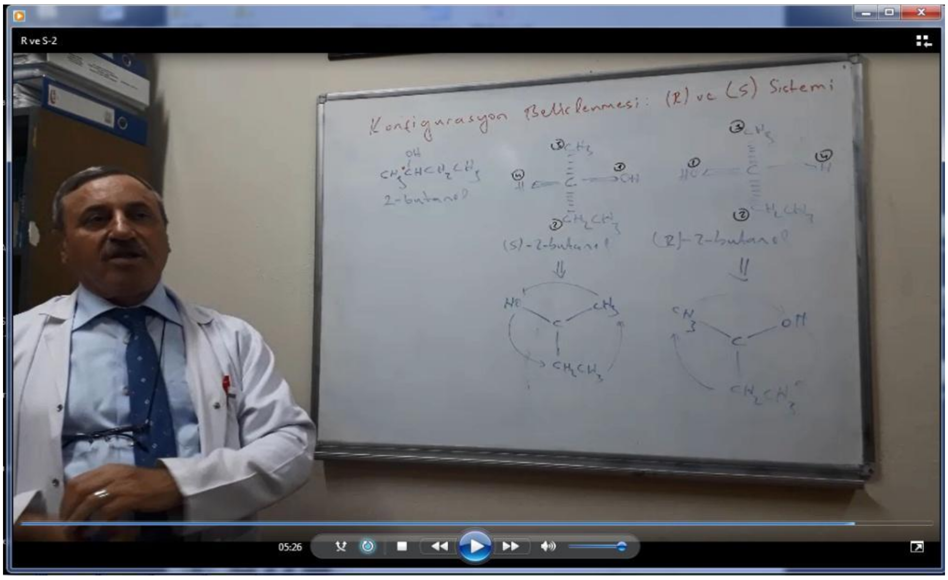
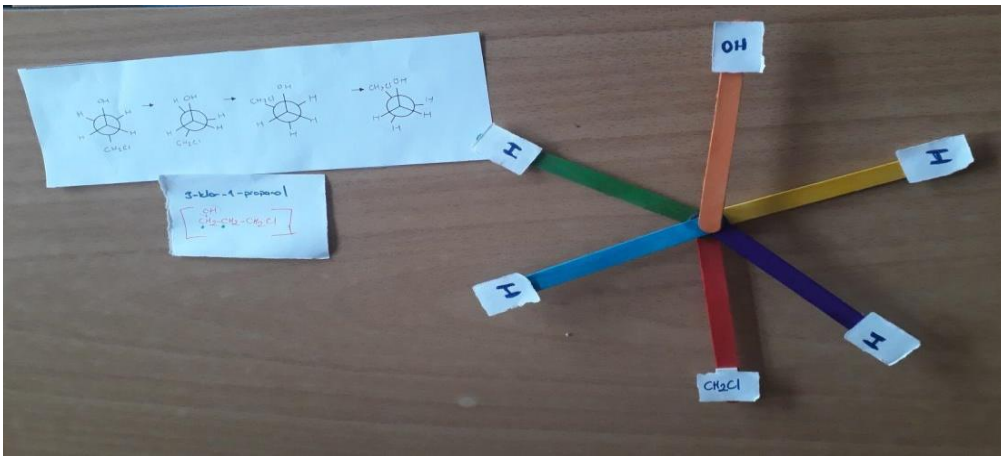


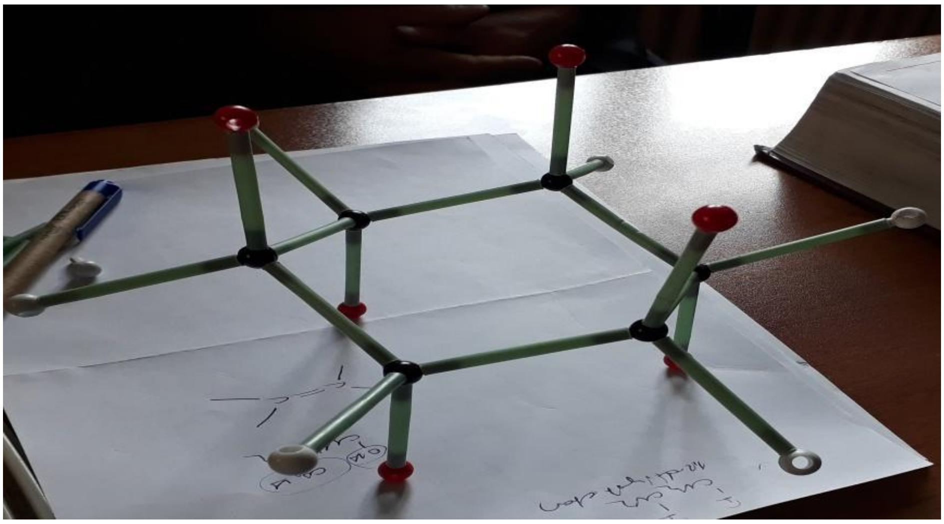
Figure 2:
A sample image of the Newman projection activity done in the classroom



Groups of two to three students were asked to design their open projections in accordance with the sequence shown in Figure 2. In this activity, students were asked to design the examples shown on paper in three dimensions.

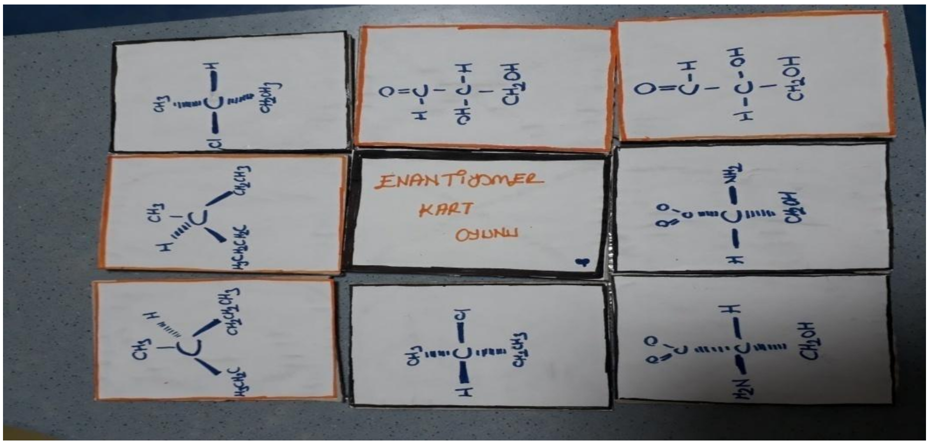
The PCTs were asked to construct molecules using ball-rod models in order to better learn the types of conformations and the transitions between them. In Figure 3., a sample image of the activity done in the classroom with ball-rod models is presented.

Figure 3:
A sample image of the activity of ball-rod modeling in the classroom



Enantiomer Card Game in Figure 4, which was prepared for a better understanding of the subject with teacher-student interaction in the classroom, attracted great attention of the PCTs, and the lesson was made more enjoyable.

Figure 4:
A sample image of the Enantiomer Card Game in the classroom

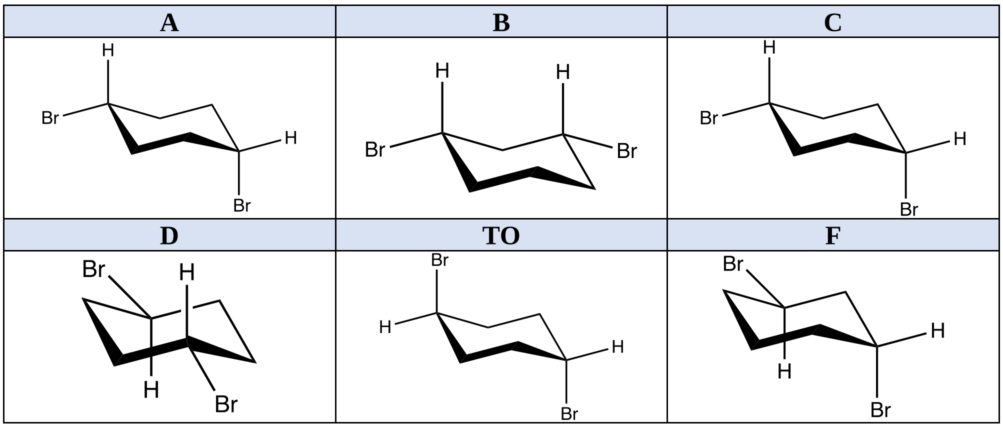


PowerPoint presentations were also prepared for the PCTs to follow the activities in the classroom and were reflected on the screen during the lesson.

Data collection

In the study, quantitative and qualitative data were collected. Quantitative data were collected to determine the effect of the flipped classroom model on the PCTs' stereochemistry achievement, and qualitative data were collected to determine the PCTs' views about the flipped classroom model. The Stereochemistry Achievement Test was used to measure student achievement. The original test was developed by Kurbanoğlu (2003). This test was adapted for this study together with the help of the instructor, according to the learning objectives of the course. At the end of the adaptation, a test consisting of 52 short-answer questions asked under eleven directions was created. The distribution of the questions in the test is given in Table 2. A sample question for the questions in the test is presented in below. After the pre-test application, reliability analyzes were made for the test. KR-20 was calculated for reliability since the answers given to each test item was scored with 1 when correct and 0 when incorrect. The result of KR-20 was found as 0.67.

Direction 6. In the boxes below, six structural formulas (A, B, C, D, E, F) of dibromo cyclohexane in different notations are given. Three questions were asked about these formulas. Write the correct answers to these questions in the blank boxes provided.



1. Which molecules; are they exactly the **<u>same?</u>**
2. Which molecules; **conformational** <u>are isomers?</u>
3. Which molecules; **structural** <u>isomers?</u>

Table 2:
Stereochemistry achievement test coverage

Directions	Number of Formulas in the Direction	Topic	Number of Questions
1.	2 Structure formula	Hybridization, sigma and p bond	10
2.	6 Structure formula	Structural isomers	3
3.	6 Structure formula	Geometric isomer	2
4.	3 Structure formula	Geometric isomer	3
5.	4 Structure formula	Newman projection	4
6.	6 Structure formula	Conformational isomers	3
7.	6 Structure formula	Chirality	6
8.	4 Configuration	Enantiomer	2
9.	4 Configuration	R, S Configuration	4
10.	4 Fisher projection	Fischer projection	4

11.	8 Fisher projection	Fischer projection	11
		Total	52

A structured opinion form was used to collect the views of the participants about the flipped classroom model. Through this form, the following open-ended questions about the flipped classroom model were asked to the PCTs.
What are the positive aspects of the flipped classroom model you attend that influence your learning?
What are the negative aspects of the flipped classroom model you attend that influence your learning?
What do you suggest to do in order to eliminate the negativities you mentioned?
Which of your other courses would you like to be taught with the flipped classroom model?

Data analysis

In the study, two different data analyses were carried out, since both quantitative and qualitative data were collected. It was investigated whether there was a significant difference between the pre-test and post-test mean scores of the PCTs. For this purpose, the normality test was applied in the first step and it was determined whether the data collected with the achievement test was normally distributed. For the normality test, the Shapiro-Wilk test results are checked when the sample size was less than 30. The results obtained showed that pre-test scores were in accordance with $W(17)=0.937$, $p=0.280$ normal distribution, but post-test scores were not suitable for $W(17)= 0.892$, $p=0.050$ normal distribution. Because one of these data was not suitable for normal distribution, the Wilcoxon Test, which is a non -parametric equivalent of the paired sample t-test, was applied.

The qualitative data collected with the interview form were analyzed with the content analysis method (Büyüköztürk, Çakmak, Akgün, Karadeniz, & Demirel, 2017). The content analysis process is carried out in stages. All written responses were first reviewed. Then these written responses were coded. After the coding process was completed, similar codes were combined. then the frequencies of the codes were calculated. This coding process was repeated by the second author to ensure the reliability of the analysis. When the two coding results were compared, it was seen that there were very few differences between the analyses because the expressions with the same meaning were coded with different codes. When the codes with consensus were compared with the total number of codes, it was determined that there was 91% similarity between the coders. Differences in coding were also eliminated by negotiation between the two coders by reviewing the contents of different coding.

Results

In the study, firstly, the findings related to the influence of the flipped classroom model on the stereochemistry academic achievement of the PCTs, which is related to the first research problem, are presented. The mean and standard deviation values of the pre-test and post-test scores of the PCTs, out of 52 points from the applied achievement test, are given in Table 3.

Table 3:
Means and standard deviation of the stereochemistry test

Time	M	N	SD
Pre-test	22.59	17	5.58
Post-Test	37.47	17	2.65

Significantly different at the $p<0.005$ level

In order to check whether there is a difference between the pre-test and post-test scores of the PCTs as a result of the academic achievement test applied, it was first checked whether the collected data were suitable for normal distribution. As a result of the analysis, Shapiro-Wilk Test shows that pre-test $W(17)=0.937$, $p=0.280$ scores are not suitable for normal distribution, and post-test $W(17)= 0.892$, $p=0.050$ scores are suitable for normal distribution. In this case, the assumption that both test data should be in accordance with the normal distribution is not met in order for the parametric tests to be applied.

Wilcoxon Signed Ranks Test, a non-parametric test, was used to determine the influence of the flipped classroom model on the academic achievement of the PCTs participating in the study in stereochemistry course, in order to determine whether there is a difference between the pre-test and post-test scores. The pre-test and post-test scores of the PCTs were compared. Wilcoxon Signed Ranks Test results show that students got higher scores from the post-test when compared to the pre-test and the difference was statistically significant $T=153$, $Z=-3.62$ $p<0.001$.

The answers given by the students to the questions asked at the beginning of each lesson in order to determine whether they watched the videos shared with them on the Edpuzzle application before coming to the lesson are summarized in Table 4.

Table 4:
Students' answers to questions at the beginning of the classes

	True				Partially True				Wrong			
Questions	1. C	2. C	3. C	4. C	1. C	2. C	3. C	4. C	1. C	2. C	3. C	4. C
1	11	12	8	12	4	2	5	5	0	0	0	0
2	15	14	12	15	1	0	0	1	0	0	2	0
3	4	13	9	13	0	1	4	0	13	0	1	0

C: Class

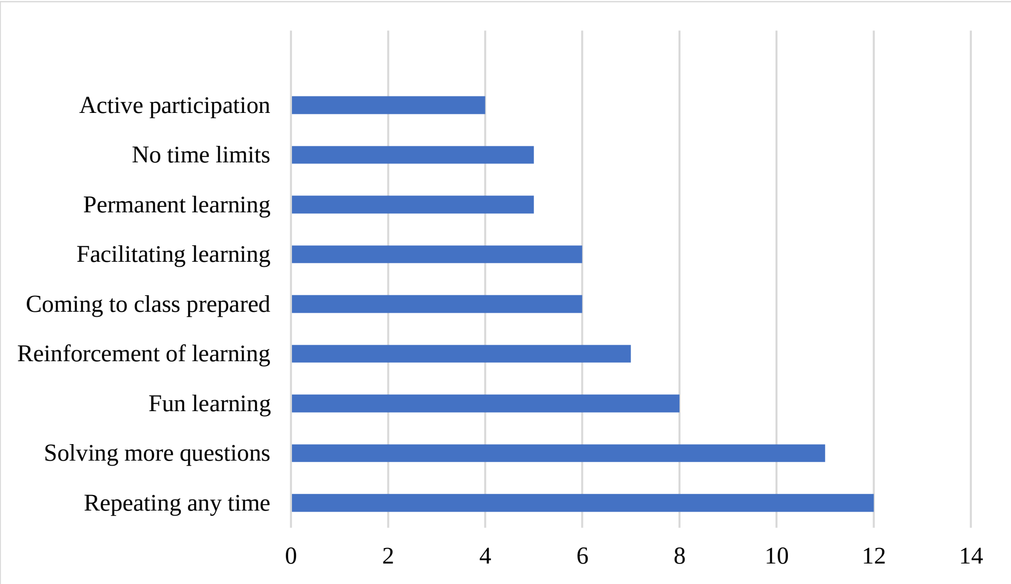
Table 5:
The rate of watched videos

	Videos											
	1.		2.		3.		4.		5.		6.	
	IW	U	IW	U	IW	U	IW	U	IW	U	IW	U
Lesson 1 (5 Videos)	1	0	0	0	0	0	1	0	1	1		
Lesson 2 (6 Videos)	2	0	1	2	0	3	0	2	1	3	2	1
Lesson 3 (5 Videos)	2	3	0	3	1	4	0	3	1	6		
Lesson 4 (3 Videos)	0	6	0	7	2	6						

IW: Incomplete Watches Numbers of PCTs
U: Unwatched Numbers of PCTs

PCTs' Views About the Flipped Classroom Model

Figure 5:
The positive aspects of the flipped classroom according to the PCTs

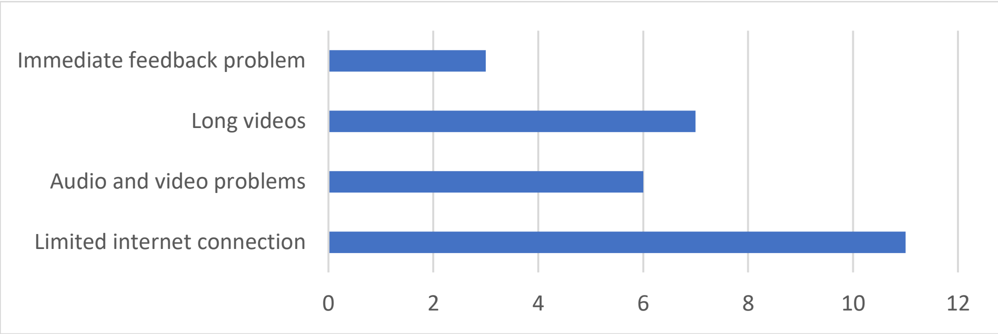


As seen in Figure 5, to be able to watch the course videos repeatedly and to solve more questions in the classroom environment emerges as majors of the positive aspects of the flipped classroom model according to the majority of the PCTs. In addition, the features such as the students coming to the lesson prepared by watching the videos as many times as they want, providing permanent learning, facilitating learning, increasing the student-student interaction by changing the classroom environment from being teacher-centered to student-centered, and enabling learning the lesson by having fun were positively received by the PCTs. It was also stated that they liked the short videos more. The views of two of the of them expressing these issues are given below:

> *"In the flipped classroom model, watching the video and solving the examples in the lesson increases the permanence more. Learning the subject and ensuring that it is reinforced in the classroom has a positive effect. It makes the lesson more fun with the models and tools brought to the classroom." (S-13)*

> *"We listened to the lesson comfortably at any time we wanted. We have a chance to replay the videos. The short duration of the videos prevents us from getting bored. It becomes more instructive when we learn the lesson time through examples." (S-11)*

Figure 6:
The negative features of the flipped classroom according to the students



In addition to the positive views about the flipped classroom model, negative views were also expressed. PCTs stated that they had difficulties in watching the videos due to the limited internet facilities and that they had problems due to technical problems such as sound and images in the videos. Among these negativities, it is seen that especially the limited internet connection problem comes to the fore. The majority of the PCTs stated that they had problems accessing the videos because they did not have a free internet connection or a sufficient internet subscription because they stayed in the student dormitories. In addition, some PCTs stated that they did not like long videos, and that the sound and image quality of some videos was not good. Sample PCTs' views on these issues are given below:

> *"Videos are not watched due to internet problems. Videos may have audio and video problems. Long videos are both distracting and boring." (S-6)*

> *"It is a negativity that I cannot ask the teacher about the parts that I do not understand while watching the video." (S-7)*

The PCTs were also asked what they would suggest in order to eliminate the negative aspects encountered during the implementation of the flipped classroom model. They made suggestions for the solutions of the problems stated in their answers to about obstacles they confronted during the process. In particular, they suggested that measures should be taken to easily watch the videos uploaded for the course without experiencing data usage problems. In addition, it was suggested by the PCTs that the video lengths should be short, the shooting quality of the videos should be increased, and the arrangements should be made so that the questions of the students could be answered instantly while they are watching the videos. Sample answers of the PCTs regarding these suggestions are presented below:

> *"Internet problem should be fixed. The camera can be a better camera so that the focusing problem can be fixed." (S-11)*
> *"Videos may be shorter." (S-17)*

The PCTs were also asked which other courses they would like to be taught using the flipped classroom model. They answered this question as physical chemistry (7 students), all courses (5 students), inorganic chemistry (4 students) and organic chemistry (3 students). Some other them also stated that they want other courses to be taught with this model.

Instructor's Thoughts on the Flipped Classroom Model

The instructor of the organic chemistry course has over 25 years of teaching experience of organic chemistry. In his professional life, the instructor generally teaches organic chemistry using the direct instruction method. After this application, the instructor made the videos prepared for the stereochemistry lesson available to everyone on his social media accounts. He states that he will use these videos in his lessons in the future as well. He also states that the videos he shared for everyone to watch are watched by many people and the comments and feedback made by the viewers make him happy. After this lesson, the instructor created a web page for himself in order to share the contents he prepared for his other lessons. It is observed that he developed attitudes towards sharing materials for the lessons he conducted through technology channels after this collaboration.

Discussion and Conclusion

In this study, the results of teaching with the flipped classroom model, which was developed and applied to the PCTs in stereochemistry lessons with the cooperation of colleagues, on the academic achievement of the PCTs, their views about the flipped classroom model, and the views and behaviors of the instructor about the integration of technology into education after the collaboration on teaching with flipped classroom model were examined.

The academic achievement test, which was prepared to determine the change in the academic achievement of the PCTs who took the stereochemistry course with the flipped classroom model, was applied to them at the beginning and end of the course. According to the results obtained, it was determined that a statistically significant change was observed in the achievement of the PCTs in the stereochemistry course. This result also was obtained in the literature reporting that the flipped classroom model has a positive effect on academic achievement (Akcayir & Akcayir, 2018; Fautch, 2015; Schultz et al., 2014; Shi et al., 2018; Turan, 2021; Weaver & Sturtevant, 2015) agree with the results.

In order to show the relationship of these results with the teaching and activities in the flipped classroom model, observations about the activities performed in this study were also reported. Whether the videos shared with the pre-service chemistry teachers were watched or not and to what extent they were watched were also examined in the study. The related results showed that the students gave correct answers to the questions of the three-question quizzes applied at the beginning of each lesson. In addition, the Edpuzzle application records show that the students watched the uploaded videos almost in full before coming to the lesson. However, although it is rare, it is seen that some of the PCTs did not watch the videos completely or did not watch a few of them at all. An increase was observed in the number of videos unwatched in the last lesson. It is thought that this situation arises from the difficulties of accessing the internet, which the PCTs stated in the interviews. On the other hand, the fact that students do not come to class without adequate preparation is one of the problems encountered in the flipped classroom model (Akcayir & Akcayir, 2018; O'Flaherty & Phillips, 2015). It was observed that the same problem emerged more prominently towards the end of the course in this study.

It is accepted that watching the course content from videos at home has an important role in the success of teaching with the flipped classroom model. In order to achieve this effect, both the quality of the videos prepared and the students' access to these contents should be ensured. The fact that students watch the videos fully and come to the lesson prepared is to some extent an answer to the question, asked by Shi et al. (2018), of whether the positive change in the success of the students in the flipped classroom model is due to the way the teaching is delivered or the pedagogical process. Likewise, Casselman et al. (2020) also state that the increase in students' success is mostly due to online materials, so care should be taken to prepare these materials.

In this study, qualitative data were also collected from the PCTs who participated in the teaching practice with the flipped classroom model, with an open-ended form that included questions about the positive and negative aspects of the model, suggestions for overcoming encountered problems, and what other courses they would like to be taught with this method. According to the results, students can repeat the lesson as many times as desired (Ojennus, 2016; Schultz et al., 2014), come prepared to the lesson, solve plenty of questions during the lesson (Ponikwer & Patel, 2018), doing activities and active learning interactions with both teachers and friends in the lesson (Fautch, 2015; Karabulut-Ilgu et al., 2018; Lo & Hew, 2017; Ponikwer & Patel, 2018). On the other hand, in addition to these gains, the students also stated that they had problems with the internet in order to access the videos shared with them, that they found the long videos boring, that they could not ask questions immediately when they did not understand while watching the videos, and that they had problems with the audio and video quality of the video content. Limited internet access problems have also been mentioned in other studies (Lo & Hew, 2017). In the literature, there are studies (Bhagat, Chang, & Chang, 2016; Schultz et al., 2014) reporting that students feel the need to ask questions instantly while watching online videos. This problem can be overcome by creating discussion forums where students can ask questions to both their friends and teachers in online environments. In this way, situations that prevent learning at home or in the classroom can be eliminated (Lo & Hew, 2017). The flipped classroom model focuses more on material that students can use on their own. In addition, it is stated that attention should be paid to issues such as following students' learning and creating discussion forums (Chen et al., 2019). The fact that the students stated that they felt the need to ask questions while watching the videos on their own shows that the care shown in preparing the material should also be given to issues such as following their learning and discussion forums. Although attention was paid to limit the video length to 5-10 minutes in light of the recommendations in the literature (Turan & Gökaş, 2015), as it is revealed in the literature (Schultz et al., 2014; Tekane et al., 2020), PCTs in this study also complained about the long and technically insufficient quality videos. When the PCTs were asked which other courses they would like to be taught with the flipped classroom model, it was observed that they mostly mentioned the courses they thought were more difficult, such as physical chemistry and inorganic chemistry in their answers. This shows that PCTs agreed that the flipped classroom model helped them learn in the lessons they think are more difficult.

As the results of this study show, the flipped classroom model reflects positively on the academic success of the students, and the process contributes to the students' development of positive attitudes towards learning. In addition, it is seen that the faculty member participating in the study has developed positive attitudes towards the integration of technology into teaching and the flipped classroom model, which ensures active participation of students in the learning process. More technically qualified videos should be prepared in order to ensure and maintain these gains even more strongly. In addition, internet connection questions should be minimized so that students can access these videos easily. There is a need for more specific studies on which types of video content are found to be more useful by students in the future, and which components of the flipped classroom model affect learning, how and to what extent.

One of the limitations of this study is that the quantitative phase of the study was designed according to the pre-experimental design of the pre-test post-test without the control group. This limitation was tried to be overcome by presenting the information on how the study was carried out in detail and by presenting the views of the PCTs and the instructor about the process. The other limitation of the study is related to the way of qualitative data collection. The qualitative data of the study is limited to the data collected through the structured written opinion form applied to the pre-service teachers. More detailed qualitative data could have been collected through semi-structured interviews or focus group interviews.

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