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Investigating Flipped Laboratory Practices of Science Student Teachers

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ABSTRACT
Innovative activities carried out during school laboratory sessions include 'flipped learning' (FL), which is an interactive learning environment where the teacher guides students learn individually. This study examined the impact of the adoption of the FL approach on the academic performance of 2nd year science student teachers enrolled in the course General Chemistry Laboratory – III and on their opinions related with the course. Eighty-one student teachers acted as a control group i.e., followed the conventional course approach while 85 students participated in the experimental groups following the FL approach. Data collection tools were examination scripts and semi-structured interview questions. A significant difference was found in academic performance in favor of the experimental group. Besides, it was observed that the FL approach increased students' motivation, encouraged them to take responsibility for their own learning, and enabled more meaningful learning to take place. It is recommended for more practical lessons be designed with this approach and for more research to be conducted on the impact of this approach on learning motivation and self-efficacy of students as well as their academic performance.

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Introduction

Laboratory sessions, which constitute an important component of science education, enable students to reinforce theory directly through experience and for conceptual depth to be developed. Students who have difficulty in attaching meaning to theoretical information and in making its connection with real life can benefit from a meaningful learning process involving laboratory work (Erökten, 2010; Hofstein & Lunetta, 2004; Kurt, Devecioğlu, & Akdeniz, 2002). In this way, their levels of interest and motivation improve (Hofstein & Lunetta, 1982). The traditional structure of laboratory sessions, which involves a process of asking various questions to prepare students for an experiment, conduct of the experiment and reaching a conclusion through the data obtained (Tekin, 2008), cause students to focus on the results. Hence, it becomes difficult to establish a mental relationship between learning experiences and laboratory activities (Hart, Mulhall, Berry, & Gunstone, 2000; Saribas & Bayram, 2009). This situation, which is in favour of students who have stronger memorisation and recall may cause students who do not have these characteristics to fail, perhaps to re-take the course.

One of the criticisms made in relation to conventional laboratory practice is that presentation of experiments is similar to a "cookbook" and is designed for practice of the recipes in the book step by step This situation prevents meaningful learning and influences motivation of students negatively (Hofstein, 1988) Therefore, it is revealed that in order to have meaningful learning during practices carried out in the laboratory, scientific content must be presented by being correlated with daily life. This is a different theme The current structure of traditional laboratory (TL) practice cannot produce a solution for elimination of the criticisms made. Maybe we don't want to because the criticisms are ill-founded, being purely ideologically based Therefore, in order to overcome problems created with the traditional method and to eliminate the limitations caused, it is recommended for alternative teaching practices to be used in laboratory practices (Alkan & Erdem, 2013; Cengiz, Karataş, & Aslan, 2017; Duru, Demir, Önen, & Benzer, 2011; Güven, Çam, & Sülün, 2015; Tekin, 2008).

Flipped Learning (FL) is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter (Flipped Learning Network, 2014). In other words, flipped learning is a student-centred laboratory approach that enables learners to actively participate in information creation, and aims for conceptual depth (Hamdan, McKnight, McKnight, & Arfstrom, 2013). FL reorganises the learning process in line with individual learning speeds of learners and their own requirements (Bergmann & Sams, 2012; Davies, Dean, & Ball, 2013; Turan & Göktaş, 2015). FL, which is based on the approach that learning can take place anywhere (Wilson, 2013), involves subject content being given to the learner before the lesson takes place who then comes to class knowing and understanding the content. Practical activities can be made in relation to the analysis and synthesis steps while learners can work in cooperation with each other (Bergmann & Sams, 2012; Jensen et al., 2015; Yoshida, 2016). Contrary to the TL approach, where the subject is learned in the class and learning is enhanced with homework, FL supports the learning of pupils outside school and enables learning to take place while pupils work together in the class by assigning activities that support the learning process. While there are different methods in the application of the FL approach (Bergmann & Sams, 2012; Filiz & Kurt, 2014), generally a method where lesson content is recorded in the form of videos and given to pupils and where activities take place during the lesson process under the guidance of teachers is preferred (Tucker, 2012). In the teaching processes designed for university education with the FL approach, it is thought that presenting the information ready-made will not make teaching activities more effective and will negatively affect the students' ability to access information and choose the right information The form of application of the FL approach can be arranged so that students will take responsibility for their own learning. Learners who can conduct research, use and develop knowledge, and benefit from instructional technologies, that is, learn actively (Sivan et al., 2000), will take responsibility for their own learning during the FL process, although their teachers will guide them in this process (Davies et al, 2013; Roehl et al, 2013). In this context, arranging the FL approach to include active learning strategies at university levels will enable meaningful learning by increasing students' motivation (Saribas & Bayram, 2009; Roehl et al, 2013).

The desire for laboratory activities in science education to be carried out as teaching processes that learners can actively participate in is not a new trend (Hibbard, Sung, & Wells, 2016), but the common point of the teaching methods used is how students can learn better in the classroom and how knowledge is structured (National Research Council [NRC], 2000). As stated before, due to the result-oriented nature of TL students obtain the information ready-made rather than having access to the information. This functioning in laboratory practices is not sufficient to gain the qualifications that 21st century individuals should have, such as needing information, accessing information, and choosing information. The FL approach, which enables students to create a teaching environment at any time and place in line with their wishes and needs, and provides the opportunity to access information with the tools they want, stands out one step ahead of other student-centred approaches (Bergmann & Sams, 2012; Davies et al, 2013).

In the related literature there are descriptive studies and practical studies about FL approach in education. There are also studies focusing on the philosophy of the FL approach and its importance in teaching activities (Ash, 2012; Fulton, 2012; Herried & Schiller, 2013; Jensen et al, 2015; Kardaş & Yeşilyaprak, 2015; Philips & Trainor, 2014; Roehl et al, 2013; Tucker, 2012). (Filiz & Kurt, 2015), examining the effectiveness of the FL approach in higher education (Brewer & Movahedazarhouligh, 2018; Howell, 2021; O'Flaherty & Philips, 2015) and there are studies reviewing the relevant literature about FL approach (Aydın & Demirer, 2017; Cheng, Hwang & Lai, 2020; Hew, Bai, Dawson & Lo, 2021). Besides, Li, Lund & Nordstein, (2021) examined the link between FL and active learning in order to what extent and how this relationship was clarified. In addition, the impact of FL approach academic achievements has been examined in many studies Studies have been carried out on this approach in the areas of chemistry (Bergman & Sams, 2012; Bokosmaty, Bridgeman, & Muir, 2019; Fitzgerald & Li, 2015; Göğebakan-Yıldız, Kıyıcı, & Altınbaş, 2016; Hibbard et al, 2016; Ponikwer & Patel, 2018; Schultz, Duffield, Rasmussen, & Wageman, 2014; Serry, 2015; Trogden, 2015), biology (Barral, Ardi-Pastares, & Simmens, 2018; Marlowe, 2012; Tomas, Evans, Doyle, & Skamp, 2019), and physics (Çakır, 2017; Kettle, 2013).

As a result of examinations made in relation to studies carried out with the FL approach, as there is common opinion that this approach will make a positive contribution to academic success of students (Barral et al, 2018; Bokosmaty et al, 2019; Davies et al, 2013; Hibbard et al, 2016; Kuroki & Mori, 2021; Ryan & Reid, 2016; Tomas et al, 2019. FL has been shown to enhance the lab teaching skills and technological, pedagogical and content knowledge of student teachers (Bae, Lee & Park, 2021; Candaş, Kiryak & Özmen, 2021; Çakiroğlu, Güven, & Saylan, 2020; Widyasari, Masykuri, Mahardiani, Saputro &Yamtinah, 2022). It is believed that the examination of the outcomes of the teaching process which is rearranged according to the FL approach, will contribute to the literature. In addition, it is thought that students' taking responsibility for their own learning, investigating the content before coming to the lesson and being prepared for the lesson will help enhancing students' motivation and academic success (Abeysekera & Dawson, 2015). Finally, besides the fact that skills attained by students before and during training with the FL approach are similar to the qualities they are expected to have after graduating (Brewer & Movahedazarhouligh, 2018), it is expected that laboratory activities designed with this approach will contribute positively to the academic success of students, as well as fostering the skills that individuals need to possess for the 21st century.

Data on the effectiveness of the FL are generally obtained from the participants in the experimental group of studies (Barral et al., 2018; Çakır, 2017; Davies et al., 2013; Göğebakan et al., Hibbard et al., 2016; Ryan & Reid, 2015). In general, students in experimental group have no experience with the traditional method for the subjects on which the intervention is carried out. One of the ways to determine the opinions of those who have studied the same subject with both FL and traditional approaches is to ask the students who re-take this course. In this direction, the opinions of repeaters who took General Chemistry Laboratory III course with both approaches will provide more detailed data about both approaches.

The aim of this study was to examine the effect of the inclusion of the FL approach in the General Chemistry Laboratory III course on the academic achievement and opinions of second-year science student teachers. The Research Questions were as follows:

1. Do the academic achievements of science teaching students differ according to the teaching approach in which laboratory practices are carried out?

2. Do the academic achievements of the repeaters, who are exposed to the courses conducted with both the TL and the FL approaches, differ significantly according to the teaching approaches?

3. What are the views of the repeaters about the FL practices?

Methodology

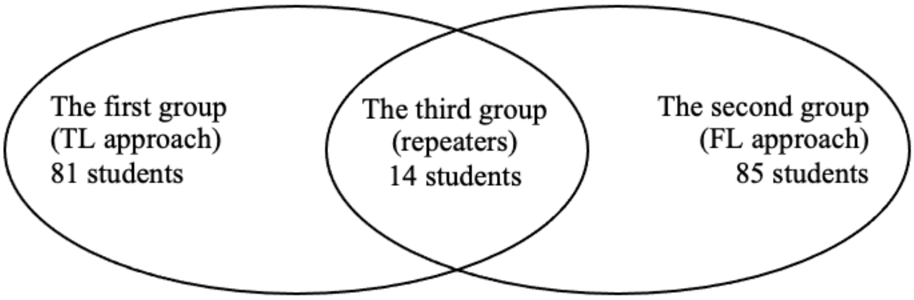
In this study, multi-method research model was used. Quantitative and qualitative inquiries were used to comprehend the effect of the FL approach on students' academic achievement and on their perceptions (Tashakkori & Teddlie, 2003). Qualitative data were used for explaining the findings arising from the quantitative data in depth.

Study Group

The quantitative dimension of the study was conducted with 3 different groups (Figure 1). While the first group of 95 science teaching students taking the General Chemistry Laboratory III course in a faculty of education in the 2016-2017 academic year was taught in line with the TL approach, the second group consisting of 100 students who took the course in the 2017-2018 academic year were lectured as per the FL approach. In the third group, there were 14 students who had failed in the course conducted with the TL approach and had to re-take the course but conducted with the FL approach this time. Therefore, the third group of repeaters consisted of 14 students. The distribution of the study group is shown in Figure 1.

Figure 1

Distribution of Study Group



The qualitative phase of the study was carried out with 9 repeaters who were found to have participated in the laboratory lesson at the maximum level, since the repeaters who received training based on both the FL and the TL approaches had more experience in comparing these two approaches. Students participating in the interview were coded as S1, S2 ... during the analysis.

Data Collection Tools

Written exam questions were used to find answers to the first and second research questions of the study. In the General Chemistry Laboratory III course designed for FL and TL approaches, students were given two written exams, a mid-term and a final exam. The mid-term exam questions prepared for both groups consisted of 6, and the final exams consisted of 7 open-ended questions. Written exam questions were prepared by two science education experts, and the questions were finalised by consulting the opinion of a chemistry education expert Examples of written exam questions are given below (Table 1).

Table 1

Examples of Written Exam Questions

Examples of mid-term exam questions
Question directed to first group (period is 50′) *How do you prepare 100 ml 0.1 M $KMnO_4$ solution? Explain laboratory materials you will use and stages of solution preparation*. (*$KMnO_4$: 158 g/mol)* Question directed to second group (period is 60′) *How do you prepare 100 ml 0.1M $NaNO_3$ solution? Explain laboratory materials you will use and stages of solution preparation. ($NaNO_3$: 85 g/mol)*
Examples of final exam questions
Question directed to first group (period is 50′) *Write down four fundamental aspects on which the qualitative analysis method is based.* Question directed to second group (period is 60′) *Explain quantitative and qualitative analysis methods. Classify the analysis we performed in the laboratory under the headings of quantitative analysis and qualitative analysis.*

Semi-structured interviews were used to answer the third research question. The interviews were conducted with the repeaters after the applications carried out with the FL approach were completed. In order to reveal the differences, gains and experiences between the two approaches, 6 open-ended questions were asked to the students. Examples of the questions asked to the students are presented below.

"Last year when you took this course you were unsuccessful. You had to take it again this year. Can you compare the two years with respect to teaching methods?"

"Instead of provision of content related with the subject at the beginning of the year, how did your preparation of content affect your learning status?"

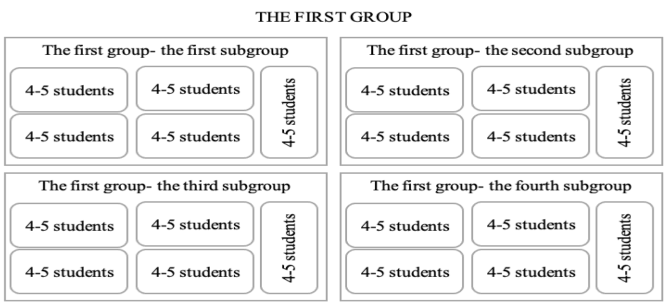
"In which stages did you have difficulty during this year?"

Data Collection

The General Chemistry Laboratory III course, which was designed according to the FL and TL approaches runs for 13 weeks. The students were divided into 4 subgroups as the number of students participating in the course conducted with both the FL and the TL approaches (Figure 1) Each subgroup participated in learning activities for 2 hours a week, 26 hours in total. In addition, the students in the subgroups formed study groups during the time they were in the laboratory, and the number of students in these groups varied between 4-5 (Figure 2).

Figure 2

Sample Group Distribution



Both teaching practices in lab sessions carried out with the FL and TL approaches were carried out by two science education experts. In both practices, information was given about the course process in the first week and their expectations regarding tasks in lab sessions from students were expressed. The process, which is based on directed route learning, and which is carried out as fully structured in the TL approach, has been transformed into a process where students search for information, actively learn and discuss with their friends with the FL approach (See Table 2 for sample lesson design). Sample lesson plans on TL and FL approaches are presented in appendix.

Table 2

One-Week Sample Content of General Chemistry Laboratory III Course

Pre-laboratory process	Laboratory process
Week 5. Introduction to cation analysis *Research into what cation analysis is and why this analysis is needed.* *Determining an analysis follow-up schedule for a cation.*	▪ With the large class discussion, students come up with common explanations of cation analysis. ▪ Working groups determine which materials were used during the analysis and procure the appropriate materials from the laboratory. ▪ Working groups work collaboratively to complete the analysis and take note of the result. ▪ Working groups analysing different items share their results with other groups.

Table 2 shows the topic and content given to the students for one specific lesson and how the classroom activities related to this topic are organised. Large and small group discussions, collaborative work and problem solving frequently took place in the laboratory process carried out with the FL approach. With the change in the teaching method, the lecturers also took care to guide students in the process of accessing information, interpreting it and reaching conclusions.

Analysis of Data

For the analysis of the written exam questions, answer keys were prepared separately by two science education experts and a common answer key was created by comparing them. The repeaters were removed from the first and second groups, and the non-parametric Wilcoxon signed rank test was used to determine the effect of teaching on the scores of these students. The scores of the students in the first and second groups were analysed with the independent *t*-test.

Semi-structured interviews conducted in order to examine the views of the repeaters regarding the change in teaching method were subjected to content analysis by the two researchers and the harmony between coders was calculated as 90.5%. Common codes are organised under categories describing the relationship of the data and they are presented with their frequencies.,

Findings

Findings Obtained in Relation to the First Research Question

The first research question of the study is based on whether the academic achievement of science teaching second-year students differs according to the TL and the FL approaches. The achievement scores of the students in the midterm and final exams were analysed using the *t*-test as shown in Table 3.

Table 3

Independent t-test Analysis of Success Scores of Science Teaching Students in Written Exams

Written exams	Groups	n	$\underline{x}$	Sd	df	t	p
Mid-term exam	First group (TL)	81	58.04	17.86	165	4.091	0.00
	Second group (FL)	85	69.74	18.84			
Final exam	First group (TL)	81	64.01	14.14	164	4.525	0.00
	Second group (FL)	85	75.32	17.77			

In Table 3, it is seen that there is a significant difference in favour of second group which includes repeaters who had laboratory lessons both in mid-term exam scores [$t_{(164)}$=4.091; p<0.05] and also in the final exam scores [$t_{(164)}$=4.525; p<.05]. The average academic achievement score of the second group students which includes repeaters who participated in the laboratory applications carried out with the FL approach is higher than the first group, who took the course with the TL approach, in both written exams. The Cohen d value for the final exam was calculated as 0.704, which shows that the FL approach had a medium effect on students' academic achievement.

Findings Obtained in Relation to the Second Research Question

Regarding the repeaters having lessons as per TL and FL approaches, data obtained with Wilcoxon signed-rank test analysis applied to the scores students obtained in the written exams in relation to the second research question, examining the impact of the teaching method on their academic success, are presented in Table 4.

Table 4

Wilcoxon Signed-Rank Test Analysis of Success Scores Which the Repeaters Obtained in Exams

Type of Exam	FL–TL	n	Average rank	Rank sum	z	p
Mid-term exam	Negative rank	2	1.50	3.00	3.109	0.002
	Positive rank	12	8.50	102.00		
	Equal	0				
Final exam	Negative rank	2	4.00	4.00	3.046	0.002
	Positive rank	12	7.77	101.00		
	Equal	0				

According to Table 4, both mid-term exam (z=3.109; p<.05) and final exam (z=3.046; p<.05) scores of the repeaters taking the General Chemistry Laboratory III course differ significantly from other groups. Considering the rank sum of the difference scores for both types of exams, it is seen that the observed difference belongs to the positive ranks, meaning the group taught according to the FL approach. Similarly, the academic averages of the repeaters' achievement scores increased in the FL approach compared to the TL understanding (Table 5).

Table 5

Comparison of Score Averages of the Repeaters

Teaching approach	Mid-term exam		Final exam	
	$\bar{x}$	Sd	$\bar{x}$	Sd
Traditional Learning	30.14	14.14	32.35	16.43
Flipped Learning	61.78	24.61	69.85	23.73

Note. N:14

The average of scores obtained by the repeaters both in the mid-term and final exams in the General Chemistry Laboratory III course is higher under the FL approach.

Findings Obtained in Relation to the Third Research Question

The data obtained from the third research question, which examines the views of the repeaters about the FL approach, are revealed under three different headings, namely the comparison of the two approaches, the views on the FL approach, and the negativities experienced in teaching with the FL approach. The data obtained from the opinions of the students about the FL and the TL approaches are presented in Table 6.

Table 6

Opinions of the Repeaters About the FL and the TL Approaches

Teaching method	Code	f	Quotations from student conversations
FL	Increased permanence of learning	5	S2 – This method keeps the student more active, enables active participation in the lesson… It is more effective for us to solve problems and conduct experiments in the classroom. S5 - Of course, since we learned by doing, it made it more permanent, we learned to use all the materials, so it became more permanent. S8 - You come to each table separately in this term. I repeat it when you ask a question, so it is remembered.
	Active learning	4	
	Giving continuous feedback	4	
	Effective pre-preparation	3	
	Guidance in the process	3	
TL	Difficult understanding of the lesson	3	S4 – In the experiment we conducted last year, we had tables and it was very complicated, the process was difficult. S6 - Last year we were coming without studying. We were solving the questions at home. S2 - I could not relate the content of the lesson to subject. S7 - The course material was very complicated. S9 - There was a complexity while doing experiments in the lesson ... We learned most things partially.

When Table 6 is examined, it can be seen that teaching with FL approach increases permanence of learning, encourages active learning, students receive feed-back constantly, students come to class prepared and guided by teacher during sessions. Regarding the TL approach, the repeaters stated that the lesson was difficult to understand and that the lesson material used made learning difficult. There were also students who stated that they had difficulties in the laboratory since the experiments were multi-staged and there had been no pre-lab preparation. Data obtained from opinions of the repeaters in relation to the FL approach are presented in Table 7.

Table 7

Opinions of the Repeaters in Relation to FL Approach

Theme	Category	Code	f	Quotations from student conversations
Lesson content	Positive	Doing research	5	S1 – It is better for us to investigate. When you give the content, we think that it is prepared and we come and directly listen to the lesson… But now during the lesson we only solve problems and have discussions. Hence, we come prepared. S5 – I am doing research… I have shortcomings. But when you give information about the contents at the end of the lesson, I only work on my shortcomings. This also saved time. S9 - I had done my research but I did not want to attend the class. Now you have done so much research and so, why wouldn't you want to enter the lesson?
		Being prepared in the lesson	3	
		Other (time saving, motivation, etc.)	2	
	Negative	Choosing correct information	1	S8 – It was difficult to study first and then come to class. I'm looking on the internet, struggling to choose which information is right.
Interaction in the class	Interaction of student and lecturer	Positive impact on interaction	7	S2 - It is a great advantage that you conduct the lesson with two people. Everybody can be asked questions as much as possible. In this way, we can communicate more easily. S5 - You do a lot of repetitions, come to the groups and talk to us again. I think this makes the student - teacher relationship more intimate. My interest is growing. S6 -… I think there was no difference with the previous year.
		No difference	2	
	Student role	Active participation	8	S7 – You were keeping the student active. It was very good for me. S8 - We did most of the experiments that were previously performed as demonstration experiments, we were more active.

Looking at Table 7, the views of the repeaters about the FL approach are gathered under the themes of course content and classroom interaction. Under the theme of course content, students exhibited more positive than negative opinions. The codes of research and being prepared for the lesson of the repeaters were the most positively expressed codes. In the theme of classroom interaction, the student-teacher interaction and student role categories came to light. While there were 7 repeaters who stated that the FL approach contributed positively to the student-teacher interaction, there were 2 students who stated that the approach did not make a difference. Under the student role category, most of the students stated that the FL approach enabled active participation. Difficulties experienced by the repeaters during the General Chemistry Laboratory III course carried out with the FL approach are presented in Table 8.

Table 8

Opinions of the Repeaters About Difficulties They Experienced During Laboratory Practices Carried Out with FL Approach

<table>
<tr><th>Category</th><th>Code</th><th>f</th><th>Quotations from student conversations</th></tr>
<tr><td>Pre-lab</td><td>Not being able to find/ select information</td><td>2</td><td>S1 –While we search on the internet, sometimes we cannot reach a conclusion.</td></tr>
<tr><td rowspan="2">Experiment</td><td>Processing of experiments</td><td>2</td><td rowspan="2">S2 – I had difficulty doing the experiments due to my discomfort.
S7 - I have difficulty in the experiment phase. I can't keep it in my mind. Stages in the experiment need to be written on the board.</td></tr>
<tr><td>Personal problems</td><td>1</td></tr>
<tr><td>Discussion</td><td>Deficiency of pre-lab information</td><td>2</td><td>S3 – I also had difficulty in class discussions when I came without doing research. I tried to learn from the answers given by other groups to the questions.
S5 - If I did not study, if I did not know, the discussion phase was difficult for me. I couldn't follow because I couldn't attend.</td></tr>
</table>

Opinions of the repeaters about the difficulties they were confronted with in laboratory lessons carried out with the FL approach are shown under the categories of pre-preparation, experiment and discussion in Table 8. When the table is examined in general, the frequencies of students who stated that they had difficulties do not exceed 2. Difficulties experienced by students can generally be stated as not being able to choose the correct information or access the right information during the preparation stage and not following the process in the lesson as a result of coming unprepared with regard to the subject. 3 students (S4, S6 and S9) stated that they did not have any problems during the preparation and lesson process.

Discussion

The study was carried out to determine the effect of the adoption of the FL approach in the General Chemistry Laboratory III course on science teaching students' academic achievement. While it is claimed in the literature that the FL approach is effective for theoretical lessons (Göğebakan et al., 2016; Hibbard et al, 2016; Ponikwer & Patel, 2018), it was also found to yield positive results in relation to General Chemistry Laboratory III course. In addition, the academic scores of the repeaters who took the course with both approaches, obtained from the mid-term and final exams as a result of the FL approach are significantly different from the scores they obtained from the course conducted with the TL understanding. Especially, when the success score averages of the repeaters are examined, a significant increase is seen in favour of the FL approach. The literature states that the FL approach has a positive effect on the academic success of learners at various educational levels (Barral et al 2018; Botomaty et al, 2019; Davies et al, 2013; Hamdan et al, 2013; Hibbard et al, 2016; Kuroki & Mori, 2021; Tomas et al, 2019; Wilson, 2013). FL increased learners' motivation by developing a positive attitude (Hibbard et al., 2016). Thus, it is thought that the academic success of the students whose motivation is increased is also positively affected.

Although course repetition will not create important differences in the academic success of students whose academic success level is low and that failure is generally related with personal reasons (McGrath, 2006; Sezer, 2008), the teaching method preferred by the instructor is as important as individual factors regarding learning. In this laboratory course carried out with the FL approach, while students were given the opportunity to learn individually, they also found the opportunity to structure this information socially with their friends. As stated by the repeaters, the increasing teacher-student interaction with the FL approach helped to ensure active participation in the lesson. In this way, the students abandoned the passive listener role in the TL approach and became active learners (Davies et al, 2013). Besides, as students mentioned difficulties such as difficulty in understanding the lesson and the fact that the process is complex in the TL approach, this shows that even though the proof-based structure of traditional approach contributes to teaching the laboratory skills, it will not be always sufficient for understanding theoretical information (Kurt et al, 2002; Tekin, 2008). In the practices carried out with the FL approach, students' readiness for the lesson by having subject information reduces their cognitive load and facilitates structuring of information learned during the lesson process (Bae et al., 2021; Hamdan et al, 2013; Widyasari et al., 2022).

Even though the pre-lab preparation stage, constitutes an important component of the FL approach, some students stated that they had problems in having access to information. When both the cognitive levels and class levels of the science teaching program 2nd year students making up the study group are considered, the requirement for them to obtain information from appropriate sources instead of standard texts may have caused this situation (Ash, 2012). Students coming to class with a lack of pre-lab information experienced problems (Table 8). Students attending the lesson without being prepared is one of the points preventing the FL approach from being successful (Bergmann & Sams, 2012). The literature was stated to be used quizzes before the lesson for them to come to class prepared to promote students' willingness (Howell, 2021; Ryan & Reid, 2016; Serry, 2015).

Some students stated that in addition to their not taking responsibility for their own learning and their experiencing problems while planning their learning process, their attendance in the class with no pre-lab preparation had a negative impact on their learning process. The fact can be interpreted such that they have awareness regarding factors affecting their own learning. Despite some of the negative opinions, students had more positive opinions in relation to laboratory lessons carried out with the FL approach (Table 7). Both the increase in their academic success and their motivation towards learning (Bajurny, 2014; Hibbard et al, 2016) can be seen as the fact that most of the students undertook responsibility for their own learning process.

In sum, when looking back to research questions 1 and 2 how the teaching approaches affect students' academic achievement, as a conclusion carrying out the General Chemistry Laboratory III course with the FL approach gave more effective results both the second group and repeaters, when compared with the TL approach. Hence, the independent t-test, Wilcoxon signed-rank test and Cohen d values support the effect of the FL approach on the academic achievement of second grade students in science teaching.

Considering the repeaters' views investigated by the third research problem, the FL approach increased students' motivation towards the lesson, encouraged them to take responsibility for their own learning, and enabled active and meaningful learning before the lesson as well as during the lesson. In this context, the FL approach gives effective results in practice-based courses such as laboratory courses.

Conclusion and Recommendations

The General Chemistry Laboratory III course with the FL approach has a positive impact on students' academic achievement. In this vein, it is recommended for the FL approach to be used in different topics related with chemistry and in physics and biology laboratory classes Considering that the teaching process is also effective in repeaters, the FL approach can be preferred to increase the academic success of these students. By increasing repeaters' learning motivation, opportunities for meaningful learning can be provided. In addition, the lesson plans used in this study can be adapted to different subjects by the instructors.

The FL approach supported repeaters taking responsibility for their own learning and study independently and increased their motivation to learn. In situations where students prepare the content, examination of the impact of the FL approach on their learning motivation and self-efficacy will be helpful in obtaining important results. In accordance with this, it is recommended for more research to be done on the impact of the adoption of the FL approach on affective characteristics of students. However, in long term planned interventions, it is seen that it is difficult to ensure that the motivation of students during the pre-lab preparation stage will be just as it was at the beginning of the process. It is important to make students understand that the pre-lab preparation stage is one of the most important components of this approach and that pre-lab information has an important effect in the structuring of new information. In order for students to come to the lesson prepared, the short tests can be an alternative as well as it is recommended for students' intrinsic motivation to be improved by giving examples about why pre-lab preparation is important and how it will be useful both in the lesson.

In the study, when the problems which students are faced with during pre-lab preparation stage are considered, especially in cases where content is created by students, the situation where detailed explanations are made by lesson instructors and more clear outlines are given in relation to subject limits will contribute to practice of research in accordance with the purpose In order to prevent the problems encountered, that course instructors give keywords / concepts related to each subject, and that concepts that students are likely to encounter but that are not within the scope of the subject are defined are recommended.

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Appendix

Sample Lesson Plans on TL and FL Approaches

TL Approach

A detailed explanation of what cation analysis is and how it works is given to the students.
The process steps of the cation analysis are explained in detail and what the students should do at each step is stated.
It is specified to the groups which cations they will receive as a result of the analysis (For example, the first group will obtain lead, the second group will obtain silver as a result of the analysis).
Laboratory tools and solutions to be used in the analysis are distributed to the groups.
Experiments are conducted by groups.
Those who detect the silver cation as a result of the analysis explain the analysis steps to those who detect the lead cation, or vice versa.

FL Approach

Pre-laboratory process
Students search what cation analysis is and why it is needed.
Students design analysis process for lead, silver, and mercury cations.

Lab process
Students share their knowledge on cation analysis and a large class discussion takes place.
The analysis steps are distributed to the students. However, unlike the TL approach, it is not specified which cation they will obtain as a result of the analysis.
Students are given only the main sample ready. Other solutions and laboratory tools needed are determined by the students and made ready for analysis.
The groups work collaboratively on the main sample to determine which cation their sample contains.
(The dispersed samples contain a single cation. Groups divide the main sample into two. The necessary analysis steps to obtain the silver cation in one of the parts and the necessary processes to obtain the lead cation in the other part are applied by the students. For example, if a sample of a group contains lead, it will obtain a white precipitate as a result of the analysis. In the other sample, on which process steps are carried out to obtain the silver cation, no precipitate is formed. On the other hand, yellow precipitate formation occurs in groups containing silver cations. As a result of the steps carried out to obtain the lead cation, a precipitate does not form.)
Groups share their results first within the group and then with other groups.