

Effect of Flipped Classroom Model Supported Science Teaching on Learning Responsibility and Perceived Self-Regulation Skills *

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Abstract

The study aims to investigate the effect of Flipped Classroom Model (FCM) supported science teaching on sixth-grade students' learning responsibility and perceived self-regulation skills. A mixed design was adopted to reveal the effects of FCM supported science teaching. The participants consisted of 39 students in total. The research used the Responsibility for Learning Scale (RLS) and Perceived Self-Regulation Scale (PSS) as quantitative data collection tools. An interview form was used as a qualitative data tool. Quantitative data obtained in the study were analyzed with comparative statistical tests. Qualitative data were analyzed with content analysis. Research results found that FCM-supported science teaching effectively improved sixth-grade students' ability to take responsibility for learning and perceived self-regulation. In addition, the FCM supported science teaching increased students' responsibilities, improved self-confidence, made knowledge permanent, and made learning fun. Thus, the FCM can be considered as a useful tool if there is a need to improve regulation and taking responsibility skills.

Keywords: Science teaching, flipped classroom model, taking responsibility, self-regulation skill.

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Tersyüz Edilmiş Sınıf Modeli Destekli Fen Öğretiminin Öğrenme Sorumluluğu ve Algılanan Öz Düzenleme Becerileri Üzerindeki Etkisi *

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Öz

Çalışmanın amacı, Ters Yüz Sınıf Modeli (TYSM) destekli fen öğretiminin altıncı sınıf öğrencilerinin öğrenme sorumluluğu ve algılanan öz düzenleme becerileri üzerindeki etkisini incelemektir. TYSM destekli fen öğretiminin etkilerini ortaya koymak için karma desen benimsenmiştir. Çalışmanın katılımcıları toplam 39 öğrenciden oluşmaktadır. Araştırmada nicel veri toplama araçları olarak Öğrenme Sorumluluğu Ölçeği ve Algılanan Öz Düzenleme Ölçeği kullanılmıştır. Nitel veri aracı olarak görüşme formu kullanılmıştır. Çalışmada elde edilen nicel veriler karşılaştırmalı istatistik testler ile analiz edilmiştir. Nitel veriler ise içerik analizi ile analiz edilmiştir. Araştırma sonuçlarına göre TYSM destekli fen öğretimi, altıncı sınıf öğrencilerinin öğrenme sorumluluğu alma becerilerini ve algılanan öz düzenlemelerini etkili bir şekilde geliştirmiştir. Ayrıca TYSM destekli fen öğretimi, öğrencilerin sorumluluklarını artırmış, öz güvenlerini geliştirmiş, bilgiyi kalıcı hale getirmiş ve öğrenmeyi eğlenceli hale getirmiştir. Bu nedenle TSYM, düzenleme ve sorumluluk alma becerilerinin geliştirilmesine ihtiyaç duyulduğunda yararlı bir araç olarak düşünülebilir.

Anahtar Sözcükler: Fen öğretimi, ters-yüz sınıf modeli, sorumluluk alma, öz-düzenleme becerisi.

* Bu makale, "Eğitim Bilişim Ağı (EBA) destekli ters yüz sınıf modeline yönelik bir uygulama: Ses ve özellikleri ünitesi" adlı tezden elde edilen veriler kullanılarak hazırlanmıştır.

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Introduction

The Flipped Classroom Model (FCM) is a teaching model that allows more efficient use of time in the classroom by ensuring that course preparations are made outside of school (Strayer, 2012). According to this model, unlike traditional teaching, teachers record their lessons and present these recordings to students on a platform where they can be accessed. Students watch these videos before attending class and have the opportunity to make learning more effective by interacting with their peers and teachers in the classroom. Today's new generation, Generation Z, can easily access information and value information from multiple sources. Therefore, there is a need for learning environments where learning does not only occur within the school's boundaries but also where students can learn according to their learning styles and speed. However, the number of studies about implementing the FCM for science courses is limited in the national and international literature (Nacaroğlu & Bektaş, 2023). The FCM has the potential to improve students' abilities to self-regulate and take responsibility for learning in learning environments (Fauzi & Widjajanti, 2018; Shyr & Chen, 2018).

The cluster of capabilities to control thoughts, feelings, and behaviors can be considered self-regulation (Baumeister & Vohs, 2004). An individual has self-regulation skills as much as actively participates in the learning environment behaviorally, motivationally, and metacognitively (Cheng, 2011). Self-regulated learning environments are needed to raise individuals with good self-regulation skills. Self-regulated learning is primarily about being aware of one's capacity, knowing oneself well by creating appropriate learning environments, determining one's goals, and realizing one's learning using various methods and techniques. Studies show a relationship between students' academic success and self-regulation skills (Nacaroğlu & Bektaş, 2023). Self-regulated learning is essential today, from primary to higher education (Fauzi & Widjajanti, 2018), and this reveals how vital self-regulation skills are at all levels of education. Self-regulation skills are necessary for a student to have awareness, control, and regulation of their learning (Baumeister & Vohs, 2004). From this perspective, the FCM is critical in realizing the self-regulation skills of individuals because one of the focuses of this teaching model is improving individuals' self-regulation skills (Shyr & Chen, 2018).

Learning responsibility means that the students make their own decisions, determine the learning progress, monitor and analyze their learning outcomes, and take precautions regarding the results to improve the quality of their learning (Roper, 2007). Students have specific responsibilities in the learning environment. These responsibilities include coming to classes prepared, attending classes regularly, doing assigned homework, and cooperating with friends. Students can access, use, and produce information due to their responsibilities towards learning. It can be said that the FCM is one of the teaching models that focuses on the concept of learning responsibility. FCM is an implementable model for the development of skills that can be employed in the learning process, especially learning responsibility (Shyr & Chen, 2018). This model induces learning to individuality and provides each student with a process of structuring knowledge based on their pace and learning style. Thus, it is aimed at the student who takes responsibility for learning to gain awareness about his learning process. Therefore, revealing the effect of the FCM on sixth-grade students' learning responsibility will shed light on future studies.

Studies on the FCM in science education are limited in the national and international literature (Ates, 2024; Lo et al., 2018). International studies have focused primarily on foreign language and mathematics education (Fisher et al., 2024; McAlindon et al., 2023). However, studies are also found in engineering, medicine, and social sciences (Mason et al., 2013). National researches on the FCM are conducted in small numbers and primarily by university and graduate students. However, it was found that there were fewer studies at the secondary school level (Eser, 2021). In addition, it seems that studies on the FCM focus mainly on variables such as academic success, high-level skills, and student and teacher perceptions (Eser, 2021). When the skills targeted in the curriculum are looked at holistically, students are expected to acquire existing achievements and develop skills suitable for teaching (Yakar & Saracalaoğlu, 2017). Developing students' self-regulation and learning responsibility skills is essential in this context (Sasson & Yehuda, 2023). In recent years, self-regulation, which is necessary to take responsibility, has drawn attention at the center of studies on academic success (Nacaroğlu & Bektaş, 2023). Thus, the flipped classroom is an applicable model which provides some sort of control on their learning and gain skills for their learning processes (Talbert, 2017).

Purpose of the study

As a result, according to the literature evaluation, the findings obtained vary due to the differences in the implementation methods of the FCM (Ates, 2024; Fulton, 2012). In addition, it can be said that there are no studies examining the effects of the FCM on self-regulation skills and learning responsibility together (Ateş et al., 2024; Chin, 2023; Lo et al., 2018). It has been determined that studies on the FCM are primarily conducted with university and high school students, and there are very few studies conducted with secondary school students (Shyr & Chen, 2018). Therefore, this study investigates the effect of FCM supported science teaching on sixth-grade students' ability to take responsibility for learning, their perceived self-regulation skills, and their opinions about flipped learning activities. In the context of this purpose, the following questions were sought to be answered.

- 1) Does FCM have an effect on 6th grade students' responsibility for learning skills?
- 2) Does FCM have an effect on 6th grade students' perceived self-regulation skills?
- 3) What are the opinions of 6th grade students regarding FCM practices?

Method

Research Design

Creswell's explanatory sequential mixed design approach was adopted in the study (Creswell & Creswell, 2023). This design was preferred because it enabled the collection and analysis of quantitative data first and then the analysis of qualitative data. In this way, the event or situation was evaluated from different perspectives in the light of qualitative and quantitative data and was used to collect richer and more detailed data, and it was assumed that each data type complemented the other during the analysis (Baki & Gökçek, 2012). The quantitative dimension of the research was designed as quasi-experimental research to reveal the effect of FCM learning activities on learning responsibility and perceived self-regulation within the scope of sound and properties in the science course. Then, qualitative data were obtained with an interview form in the data collection process in order to add depth to the research due to the nature of the research design.

Participants

An easily convenient sampling was chosen for this research because one of the researchers conducted the study with 6th-grade students, provided convenience for the activities, and was the most appropriate sampling method regarding technical facilities and time (Patton, 2005). The participants were 39 students studying in the 2021-2022 academic year. This research included two classes, one as an experimental group (N=20) and one as a control group (N=19). While determining the students who participated in the qualitative part of the research, the RLS and PSS scores of the participants who participated in the quantitative part were calculated separately for each student and categorized under low, medium, and high group. Thus, students at different levels in terms of the variables of interest in scope of this study were included in the interviews. Among the students falling into these categories, six students were interviewed, two students each. The interviewed students were coded as SL1, SL2, SM1, SM2, SH1 and SH2, taking into account the low, medium and high categories.

Data Collection Tools

Responsibility for Learning Scale (RLS)

RLS is a five-point Likert-type scale consisting of 35 items. The expressions in the scale were scored as "Not at all suitable for me = 1", "Not suitable for me = 2", "Somewhat suitable for me = 3", "Suitable for me = 4", and "Extremely suitable for me = 5". The Cronbach Alpha reliability coefficient was 0.94 (Yakar & Saracalaoğlu, 2017). In this study, the researchers recalculated the reliability of RLS. The scale was administered to 350 students in a public middle school in Van. At the end of this administration, the Cronbach Alpha value of the scale was determined as 0.91.

Perceived Self-Regulation Scale (PSS)

PSS was developed by Arslan and Gelisli (2015). PSS consists of 16 items and two subdimensions: openness and seeking. It was created in a 5-point Likert type, appropriate to the middle school student level. The expressions in the scale were scored as "never = 1", "rarely = 2", "occasionally = 3", "often

= 4", "always = 5". Cronbach Alpha internal consistency reliability coefficients were found to be 0.84 for the openness factor, 0.82 for the seeking factor, and 0.90 for the entire scale. In this study, the reliability values of this scale used by the researcher were recalculated. In this context, it was administered to 200 middle school students. The Cronbach Alpha value was recalculated for the openness sub-dimension, and this value was found to be 0.82, 0.81 for the seeking sub-dimension, and 0.83 for the scale (Büyüköztürk et al., 2012).

Semi-structured Interview Form

The opinions of the students about FCM supported science teaching were obtained through an interview form. The form included questions about the FCM experiences. The questions prepared by the researcher were to be clear, understandable, and accessible directions. While preparing the interview questions, the opinions were considered by two faculty members who were experts on science education and had articles about qualitative research, considering the purpose of the research and the students' situations. In line with experts' opinions, it was decided to remove two questions from the interview form. In addition, it was suggested that changes be made to the wording of two questions. The final version of the form is in Appendix 1.

Implementations

The implementations were carried out in three stages. In the first stage, RLS and PSS were applied as pretest two weeks before the courses started in the experimental and control groups. In the second stage, the subject of sound and properties was covered in the science course for five weeks (4 hours per week) in both groups. While the experimental group students experienced a learning process based on FCM activities, the other group experienced a learning experience in the 5E model. Learning experiences were enriched with the Education Information Network (EIN). EIN is an online platform that teachers and students can access through their accounts, providing access to information regardless of location and time and providing social learning and sharing opportunities (MoNE, 2018). In this study, with the instructions given to the students, they were allowed to enter the EIN system before the lesson and watch the lesson videos. The one-week part of the implementations performed in the study groups is explained in Appendix 2. In the third stage, RLS and PSS were applied as posttests two weeks after the end of the implementations in the experimental and control groups. In addition, interviews were conducted with six students participated from the experimental group.

Data Analysis

Quantitative data obtained through the RLS and PSS were transferred to the computer to make statistical operations available. Then, the data obtained from the RLS were subjected to the test of normality before being used to compare the groups before and after the implementation. In this context, the results of the Shapiro-Wilks test ($W=0.954$, $p<0.05$), which is preferred for samples smaller than 50 people, showed that the data obtained from the RLS did not have a normal distribution. Similarly, the data obtained through the PSS were subjected to the Shapiro-Wilks test ($W=0.953$, $p<0.05$) which indicated that the data did not have a normal distribution. So, nonparametric tests were adopted in comparisons based on the data obtained from the PSS (Mayers, 2013).

Content analysis was used to analyze the semi-structured interviews. The primary purpose of content analysis is to simplify and interpret the data obtained by the person conducting the research and present it to the readers in an understandable form (Yıldırım & Şimşek, 2013). The student's answers to the interview questions were transcribed into plain text without any changes. Data reduction was made on the raw data transferred to plain text. In the first stage, codes were determined by two researchers. Then, the agreement rate of the codes determined by two different researchers was determined. To calculate the compatibility of agreement rates, the reliability formula developed by Miles & Huberman (1994) was preferred [$\text{Reliability} = (\text{Consensus/Disagreement}) \times 100$]. Thus, the reliability coefficient of the agreement rate between the coders was 84%. This value indicates that the coding for qualitative studies is reliable (Miles & Huberman, 1994). The codes that emerged from these analyses are given in tables.

Findings

Findings about Responsibility for Learning

In order to reveal if there are any effects of FCM supported science teaching on 6th-grade students' responsibility skills for learning, RLS was administered to the groups. Findings regarding 6th-grade students' learning responsibility skills of flipped classroom-supported science teaching are provided in Table 1.

Table 1. *Comparison of responsibility for learning scale scores*

Test	Group	N	Mean Rank	Sum of Ranks	U	Z	p
Pretest	Experimental	19	19.37	368,00	178.000	-0.338	0.736
	Control	20	20.60	412,00			
Posttest	Experimental	19	28.66	544,50	25.500	-4.625	0.000
	Control	20	11.78	235,50			

When Table 1 was examined, RLS scores were close to each other regarding groups before the implementation. Therefore, no statistically significant difference was found between the RLS pre-test scores of the groups [$Z=-0.338$, $p>.05$]. However, a statistically significant difference was found between the RLS posttest scores of the groups [$Z=-4.625$, $p<.001$]. In addition, the mean rank score of the control group was 11.78 while it was 28.66 for the experimental group. So, this significant difference is in favor of the experimental group regarding the mean rank scores.

Findings about Perceived Self-Regulation

In order to compare the groups about Perceived Self-Regulation before the application, the data obtained from the PSS, which was applied as a pre-test, was examined. The findings resulting from this pre-test are given in Table 2.

Table 2. *Comparison of perceived self-regulation scores before the implementation*

Scale	Group	N	Mean Rank	Sum of Ranks	U	Z	p
Openness	Experimental	19	19.47	370.00	180.000	0.282	0.778
	Control	20	20.50	410.00			
Seeking	Experimental	19	20.37	387.00	183.000	-0.197	0.844
	Control	20	19.65	393.00			
Total	Experimental	19	20.05	381.00	189.000	-0.028	0.978
	Control	20	19.95	399.00			

In Table 2, there is no statistically significant difference between the groups in terms of Perceived Self-Regulation before the application ($Z=0.282$, $p>.05$). In other words, before the implementation, the students in the groups were identical in terms of Perceived Self-Regulation. The PSS was administered as a post-test to determine whether there was a difference between identical groups after the implementation. The findings resulting from the analysis of this post-test are given in Table 3.

Table 3. *Comparison of perceived self-regulation scores after the implementation*

Scale	Group	N	Mean Rank	Sum of Ranks	U	Z	p
Openness	Experimental	19	25.11	477.00	93.000	-2.737	0.006
	Control	20	15.15	303.00			
Seeking	Experimental	19	21.16	402.00	168.000	-0.622	0.534
	Control	20	18.90	378.00			
Total	Experimental	19	23.79	452.00	118.000	-2.028	0.043
	Control	20	16.40	328.00			

As seen in the table, total scores obtained from the PSS after the implementation indicate a statistically significant difference ($Z=-2.028$, $p<.05$). Considering the total scores obtained from the scale after the implementation, it was found that the mean rank of the control group was 16.40, while it was 23.79 for the experimental group. A similar situation was also valid for the openness sub-dimension

of the scale ($Z=-2.737$, $p<0.05$). Again, considering the openness sub-dimension after the application, it was found that the mean rank score of the control group was 15.15, while it was 25.11. However, no statistically significant difference was found in the seeking sub-dimension ($Z=-0.922$, $p>0.05$). After the implementation, the statistically significant differences detected in the total and openness sub-dimensions of the PSS were for the good of the experimental group. Thus, FCM supported science teaching practices caused a more significant increase in the Perceived Self-Regulation of the experimental group students than those in the control group.

Findings about Opinions of Students

The codes obtained from the student responses to the question “What are your thoughts about FCM supported science teaching practices?” are given in Table 4.

Table 4. Findings regarding student thoughts about FCM

Codes	SL1	SL2	SM1	SM2	SH1	SH2	f
a. Effective learning	+	+	+	+	+	+	6
b. Readiness	+	+	+	+	+	+	6
c. Interaction with technology	+	+	+	+	+	+	6
d. Positive contribution to lessons	+	+	+	+	+	+	6
e. Academic success	+	+	+	-	+	+	5
f. Active participation	-	+	+	+	+	-	4
g. Gaining self-confidence	+	+	+	-	+	-	4
h. Reinforcement of topics	+	+	+	+	+	+	6
i. Being eye-catching	+	+	+	+	+	+	6
j. Visual richness	+	+	-	+	+	-	4
k. Social learning	+	+	+	+	-	-	4
l. Instant feedback and correction	+	+	+	-	-	-	3

In table 4, students mentioned the codes such as effective learning (f=6), readiness (f=6), interaction with technology (f=6), positive contribution to lessons (f=6), academic success (f=5), active participation (f=4), and gaining self-confidence (f=4). In addition, students used the codes of reinforcement of the lesson (f=6), being eye-catching (f=6), visual richness (f=4), social learning (f=4), instant feedback and correction (f=3). Some excerpts from students’ opinions on this subject are given below.

SM1: “*With the FCM, my communication with our teacher and classmates improved since our interaction was intense both before (b) and during the lesson. It increased my success in science classes (e), and I started participating more in class (f). Since we spent more time on experiments, what I learned became more permanent (a)...*”

SM2: “*Our teacher divided us into groups and gave us tasks and responsibilities (f). I liked the fun classroom environment. When I learned this way by discussing and consulting with my friends (d), I realized that I understood the subject better (e) and became happier...*”

SH2: “*With this application in science class, I realized that I could learn a subject independently (a). My self-belief and confidence have increased for my other courses as well (g). Nowadays, technology is used in everything. In this course, our interaction with technology increased (c). First, we learned the subject at home with the help of technological devices, and we reinforced the subject (h) with interactive videos at school...*”

The codes obtained from the answers to the question “What do you think is the contribution of FCM supported science teaching to the ability to take responsibility for learning?” by the students are presented in Table 5.

Table 5. Findings about the contribution of FCM to learning responsibility skills

Codes	SL1	SL2	SM1	SM2	SH1	SH2	f
a. Taking responsibility for learning	+	+	+	+	+	+	6
b. Information not readily available	+	+	+	+	+	+	6
c. Positive attitude toward homework	+	+	+	+	+	+	6
d. Ability to accomplish one’s task	+	+	+	+	+	-	5
e. Confidence in the face of problems	+	-	+	-	+	+	4
f. Self-confidence boosting	+	+	+	-	+	-	4
g. The desire to explore comes to the fore	-	+	-	+	-	+	3

In Table 5, the students mainly stated that they took responsibility for learning (f=6) and that the information was not presented ready-made (f=6). They also stated that they developed a positive attitude towards homework (f = 6), their ability to perform their tasks (f = 5), their self-confidence increased (f = 4), and their desire to explore became more prominent (f = 3). Excerpts from the data obtained from the interviews conducted with the students on this subject are presented below.

SL2: *“In this activity, since the information was not given directly by the teacher in the course, we had to take responsibility for accessing the information (b). I saw that I could learn the subject independently by taking responsibility (a). This increased my self-belief and self-confidence (f)...”*

SM2: *“When I fulfilled my responsibility by watching the course videos (a), I became more active in the lesson (g), which increased my self-confidence (f)...”*

SH1: *“I think it increased my responsibility skills (a). My participation increased when I prepared for the subject, and my prejudices against science class were destroyed. Since this motivated me more, I started doing my homework more with pleasure (c)...”*

The codes obtained from the responds to the “What are the problems you encountered during the process of science teaching practices supported by the FCM?” question are given in Table 6.

Table 6. Findings on the problems encountered during the implementation of the FCM

Codes	SL1	SL2	SM1	SM2	SH1	SH2	f
a. Internet access problem	+	+	+	+	+	+	6
b. Pause in videos	+	+	+	+	+	+	6
c. EIN login error	+	+	+	+	+	+	6
d. Getting kicked out of the system while watching videos	+	-	+	+	+	+	5
e. Inability to ask questions	+	-	+	+	+	-	4
f. Crowded family environment	-	-	+	--	+	+	3
g. Distractibility	-	-	-	+	-	+	2

When Table 6 is examined, students stated that they had internet access problems (f = 6), received an error warning when logging into EBA (f = 6), and experienced technical difficulties while watching the videos (f = 5). They also stated that they experienced problems such as not being able to ask questions during the lecture (f = 4), noise caused by the crowded family environment (f = 3), and distraction (f = 2). Student opinions on this theme are given below.

SL1: *“There was a pause in some videos (b) because our internet connection was not working (a), and when we entered again, the system would give an error and would not open (c). This was a waste of our time...”*

SM1: *“Even though I watched the videos completely, I constantly received an incomplete warning (d). That is why I had to log in to EIN constantly (e)...”*

SH1: *“I had trouble watching the videos because I had younger siblings at home and did not have a study room (f). Voice and noise were distracting me, and I could not focus (g)...”*

Codes created through the responses to the “What are your favorite features of FCM supported science teaching practices?” question by the experimental group students are given in Table 7.

Table 7. Findings regarding the favorite features of FCM

Codes	SL1	SL2	SM1	SM2	SH1	SH2	f
a. Learning at home	+	+	+	+	+	+	6
b. Events/Games on EIN	+	+	+	+	+	+	6
c. Ability to repeat	+	+	+	+	+	+	6
d. Ability to collaborate	+	+	+	+	+	+	6
e. Technology supported learning	-	+	+	+	+	+	5
f. Convenience of accessing information	+	+	+	+	+	-	5
g. Failure to learn in case of illness	+	-	+	+	-	+	4
h. Prevents loss of time	-	+	+	-	+	-	3
i. Increasing course engagement	+	+	-	-	-	+	3

For the enjoyable aspects of the FCM, the students answered that they were able to learn at home (f=6), enjoy the activities/games on EIN (f=6), and offer the opportunity to do it again (f=6). In addition, being able to cooperate with friends in the classroom environment (f=6), using technology effectively in the lesson (f=5), not disrupting learning in case of illness (f=4), preventing loss of time (f=3), increasing engagement in the course (f=3) It was observed that they responded with their codes. Student opinions on this theme are given below.

SL2: “I was studying and learning my subject at home. Since there was much noise in the school environment, I realized I understood better when I learned at home. I liked working at home this way (a)...”

SM1: “I liked EIN's events, interactive games, and animations (b). While watching the videos, we could understand the subject with short videos, which prevented loss of time (h) and did not get bored (j)...”

SH2: “We had become intimate with technology (e). Since my favorite thing is to work on computers and tablets, these homework videos given by my teacher attracted my attention, and I fulfilled my responsibilities without getting bored...”

Discussion, Conclusion, and Recommendations

When the responsibility for learning scores of the groups were compared, a statistically significant difference was detected in favor of the experimental group after the implementation. This finding pointed out that the FCM implemented in the experimental group was effective on sixth-grade students' responsibility skills for learning. The result reveals that the learning process designed with the FCM effectively increases the ability to take responsibility for learning. This situation results from the students' preparation before the lesson, watching the e-learning videos on time every week, and complying with the classroom rules during the lesson's implementation of the FCM. In a study, the most striking feature of the FCM is that the responsibility for learning lies with the students (Medone, 2019). In another study, although students' responsibility for learning was seen as an essential advantage in applying the FCM, it was observed that the increased number of responsibilities caused some difficulties in the implementation process (Faretta, 2016). In this context, it was concluded that implementing FCM in the learning environment improves students' responsibility skills for learning and contributes to their personal development (Liu et al., 2023).

The results also uncovers that the FCM supported by science teaching implemented in the experimental group effectively affects sixth-grade students perceived self-regulation skills. In the national and international literature, there are studies showing that the FCM improves self-regulation skills (Eser, 2021; Shyr & Chen, 2018). Contrarily, some studies revealed that the FCM has no effect on students' self-regulation skills (Elakovich, 2018; Yıldırım, 2022). In their study, Yoon et al. (2021) ensured that students became aware of what should be achieved by participating in the pre-lesson phase to enhance self-regulation. It was determined that providing support to students to improve their self-regulation skills during the online learning phase of the FCM provides them with higher self-regulation

skills (Yoon et al., 2021). Thus, students were provided with learning environments with course videos that they could review at their own pace and master the process before the lesson so that they could take responsibility for learning by using their self-regulation skills.

In study, students' opinions on their FCM based science education experiences were also tried to be determined. In this context, students stated that the FCM helped them to learn the subject effectively and come to class prepared. They also stated that the FCM increased their academic success and self-confidence. In addition, they underlined that the course was interesting, that they studied in a fun classroom environment, and that they cooperated with their friends. On the other hand, students mentioned some problems, such as experiencing internet problems, receiving an error warning when logging, experiencing problems while watching videos, and distractions caused by a crowded family environment. In parallel with our findings, the FCM supported science teaching provides a positive attitude towards the lesson, the lessons are fun of practical learning, and students love the practices (Chin, 2023; Yanardağ, 2021). So, in FCM supported teaching, students take more responsibility (Bursa & Cengelci Kose, 2020).

As a result, it has been revealed that flipped learning activities on sound and their properties increase perceived self-regulation with responsibility for learning and positively impact student opinions regarding flipped learning-based science activities. In addition, it was understood that students who had a learning experience by participating in flipped learning-based science learning activities mostly viewed the learning environments as beneficial and described them as fun and instructive. However, it has been observed that students sometimes have difficulties accessing learning materials over the internet due to infrastructure problems. For this reason, in cases where students' learning responsibility and self-regulation skills are desired to be developed, it is recommended to include more flipped learning-based science activities, considering subject compatibility and student expectations. In addition, for the success of FCM activities, it is recommended that homework assignments are well determined, assignments suitable for student characteristics are selected, homework follow-up is carried out through an online system, if possible, students are allowed to communicate with each other and auxiliary materials such as instructions and worksheets are provided. Moreover, EFN-based activities are included in the FCM activities implemented within the scope of the study and it is recommended that the effects of FCM activities developed using educational technologies such as Edpuzzle, kahoot, Google classroom etc. be investigated. Furthermore, in this study, the flipped classroom model was applied to sixth grade students in the Science course "Sound and Its Properties" unit, and it is recommended that further research be conducted to show that the model is applicable in different classes and courses, as it will contribute to the literature.

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Appendixes

Appendix 1: Interview Questions

1. What are your thoughts about FCM practices?
2. What do you think the contributions of FCM supported science teaching are to the ability to take responsibility for learning?
3. What problems did you encounter during the FCM supported science teaching practices?
4. What did you enjoy most in the FCM supported science teaching practices?

Appendix 2: Implementation Stages in Groups

The experimental and control group implementations prepared within the scope of the “F.6.5.1.1. Predicts the environments in which sound can spread and tests its predictions” outcome (MoNE, 2018) are given in the tables below.

Experimental Group

Introduction	Before starting the implementation, the students were informed about the FCM. For the experimental group students, the course videos of the FCM they were required to watch outside the classroom were conducted through the EBA application. In this context, students with access to the internet and digital tools (computer, phone, tablet, etc.) can watch the course videos sent by the teacher using their own EBA accounts. Classroom arrangements were made for students who have limited internet access and they were allowed to watch course videos by logging into EBA via a smart board. Thus, the problem of students being unable to watch videos before class was eliminated.
Inquiry	A few questions were asked during the lesson to check whether the students watched the video. After considering the answers to the questions, the necessary materials were prepared to conduct experiments on the subject. The students were divided into four groups, each preparing their experimental setups. First, the students were asked to fill the experimental tub with water. They were then asked to place the ruler on the bathtub, fix it, and touch the ruler lightly. As a result of the experiment, it was observed that waves were formed as a result of the vibration coming from the ruler. With this experiment, it was deduced that sound is created as a result of vibration and spreads in waves.
Evaluation	At this stage, students were asked to think about the environments in which sound can spread, give an example for each state of matter, and write them in their notebooks. Necessary feedback was provided to the answers given by the students.

Control Group

Introduction	At this stage, the teacher conveyed some questions to students: “Does sound pass through walls?”, “Can Sea creatures hear sounds?”, “Would it be possible to hear conversations in space?”. Thus, an attempt was made to activate students’ prior knowledge regarding the subject.
Exploration	Before starting the activity, the teacher asked students, "Why don't we hear the explosion sounds in the sun?". After taking the students’ opinions, the audio recording made by NASA’s new generation spacecraft Perseverance on Mars was played to the students. After the audio recording was listened to by the students, the teacher asked questions to the students. These questions were “Although no sound can be heard in space, how did the Perseverance spacecraft manage to record the sound of Planet Mars?” and “How was this recorded sound sent to Earth?”. Students wrote the answers to these questions in their notebooks. Then students required to share their responses with the class. Finally, students gave examples of the transmission of sound.
Explanation	The teacher helps to structure basic concepts through teaching methods such as lecture, discussion, and question-answer. The activities proving that solids and liquids transmit sound, on page 165 of the textbook, were done by forming heterogeneous groups of 3-4 students, and the course ended by answering the questions under the activities together with the students. At the beginning of the second lesson, after the students understood that solid, liquid, and gaseous environments transmit sound, they were asked whether sound spreads in space and whether space is a material medium, and their answers were received. It was then stated that sound would not spread because space is not a material medium. Finally, the question “Does Sound spread in Space?” was asked on the smart board. The video of the experiment was shown to the students.
Elaboration	The activity on page 166 in the textbook was carried out so the teachers could relate the objectives that the students learned in the course to daily life.
Evaluation	At this stage, teacher asked questions to check the learnings about sound transition in the material medium. These questions are: “How does sound spread?”, “In which medium does sound spread the fastest?”, “Is a material medium necessary for sound to spread?”. Students’ answers to these questions were received. Feedback was given to the students’ answers by the teacher. The course process was implemented in the following weeks, as in the first week.

