Thinking Skills and Creativity 47 (2023) 101244

Contents lists available at ScienceDirect

Thinking Skills and Creativity

journal homepage: www.elsevier.com/locate/tsc

The effect of the flipped classroom model on gifted students' self-regulation skills and academic achievement☆

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ARTICLE INFO

Keywords:
Academic achievement
Flipped classroom
Gifted students
Mixed research methods
Self-regulation

ABSTRACT

This research examines the effect of the flipped classroom model on gifted students' achievement and self-regulation skills using the embedded design, a mixed research method. For this aim, the research has been carried out with 70 gifted students (35 in the experimental group and 35 in the control group) studying in the Recognizing Individual Skills 1 program at a Science and Art Center. A 6-week implementation has been carried out taking into account the lesson plans developed by the flipped classroom model for the experimental group and the existing Recognizing Individual Skills Program 1 curriculum for the control group. MANOVA has been used to analyze the quantitative data, inductive content analysis was used to analyze the qualitative data. A statistically significant difference has been found between the experimental and control groups in favor of the experimental group in terms of academic achievement and self-regulation skill scores during the quantitative data analysis. However, while we were able to generalize to the accessible population the results found in terms of academic achievement, we could not generalize the results to the population in terms of self-regulation. As a result of the qualitative data analysis, students stated the model to be effective for learning and flexible in terms of content and time, to assure that they come prepared for the course, and to increase their self-regulation skills. In this context, the flipped classroom model is recommended for use in the subject of science for gifted students

1. Introduction

Blended learning can be defined as a combination of face-to-face and technology-supported education (Graham, 2006). Blended learning combines the effective aspects of face-to-face learning (e.g., motivation, sociability, and interaction) with the advantages of online learning (e.g., flexibility; Williams et al., 2008). In this context, students have the opportunity to organize their learning situations by their needs (Twigg, 2003). Therefore, blended learning provides opportunities for developing students by prioritizing their requirements (Thorne, 2003). Rotation, flex, enriched virtual, flipped classroom, and self-blended models have been classified within blended learning (Staker & Horn, 2012). Flipped Classroom Model (FCM) has a structure that allows school learning to be moved out of the classroom, blending online learning with face-to-face learning in the traditional classroom environment (Lankford, 2013). This model is a blended learning model in which activities that will ensure students' active participation are moved into classrooms, and

☆ This research was produced from the doctoral dissertation of the first author.

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https://doi.org/10.1016/j.tsc.2023.101244
Received 24 April 2022; Received in revised form 17 January 2023; Accepted 31 January 2023
Available online 2 February 2023

narrations and discussions in the classroom environment are moved to out-of-class environments using an online technological infrastructure (Bergmann & Sams, 2014). Therefore, FCM has two basic components: in-class and out-of-class activities (Bishop & Verleger, 2013).

As shown in Fig. 1, while knowledge-based learning in FCM is carried out outside of the classroom with online tools, the time within the classroom is left to the process of configuring information through high-level individual and group activities (Hamdan et al., 2014). In other words, the process of accessing the steps of remembering and understanding in Bloom's taxonomy (Bloom et al., & 1956) is carried out in the home environment, and access to other higher levels is provided in the classroom environment (Zainuddin & Halili, 2016). In this way, the aim is to achieve meaningful learning by providing students with learning environments where they can develop their knowledge and skills in class (Schneider & Blikstein, 2015). Undoubtedly, for this process to be carried out correctly, significant changes must occur within the learning culture (McGrath et al., 2017).

In FCM, students have control over the learning process (Du, 2018), and having students see this as an opportunity to develop their learning skills is important. Students have learning responsibilities in their learning environments within the scope of out-of-class activities. Meanwhile, teachers have to fulfill certain responsibilities to achieve the efficiency desired by FCM. In this context, Mehring (2018) stated that students and teachers should fulfill their responsibilities in FCM and this process should be structured carefully. Teachers should have technological knowledge on preparing appropriate content (Herreid & Schiller, 2013) and help students with time management and learning responsibilities (Evseeva & Solozhenko, 2015). Therefore, FCM has four dimensions: intentional content, learning culture, flexible environment, and professional educator (Flipped Learning Network [FLN], 2014; Hamdan et al., 2014). FCM has many advantages (Goodwin & Miller, 2013; Roach, 2014).

When examining the literature, FCM has been stated to increase student success (Fulton, 2012), offers opportunities for cooperative learning (Chen et al., 2014), enable skills such as problem-solving and critical thinking (Kong, 2015), and offer a flexible learning environment in terms of time and content (Wanner & Palmer, 2015). One of the most important advantages of FCM is that it does not place time or space restrictions on students (Davies et al., 2013). In this way, students can organize their learning according to their speed. This model can have high-level activities held during in-class hours (Bergmann & Sams, 2014). FCM has students come to school by examining the narration part of the course at home and face high-level learning by including individual and collaborative learning during course hours (Milman, 2012). However, the use of FCM does not provide equal advantages for all students (Yoon et al., 2021). For example, when the teacher does not give instant feedback to students in extracurricular practices, students may have misconceptions (Johnson & Renner, 2012; Moravec et al., 2010). Turan and Göktaş (2015) concluded that students stated the disadvantages of FCM as lack of technical equipment, time-consuming, and watching videos before the lesson. In addition, Thoms (2012) stated that students have problems focusing on homework while doing homework in the classroom. Enfield (2013), on the other hand, stated that teachers spend a long time developing their lecture videos. Although FCM has advantages and disadvantages (Bergman & Sams, 2014; Milman, 2012), the use of FCM is considered important for educating gifted students. Considering the advantages of FCM, it would be appropriate to use FCM in the education of gifted students (Al Harbi, 2017; Siegle, 2014).

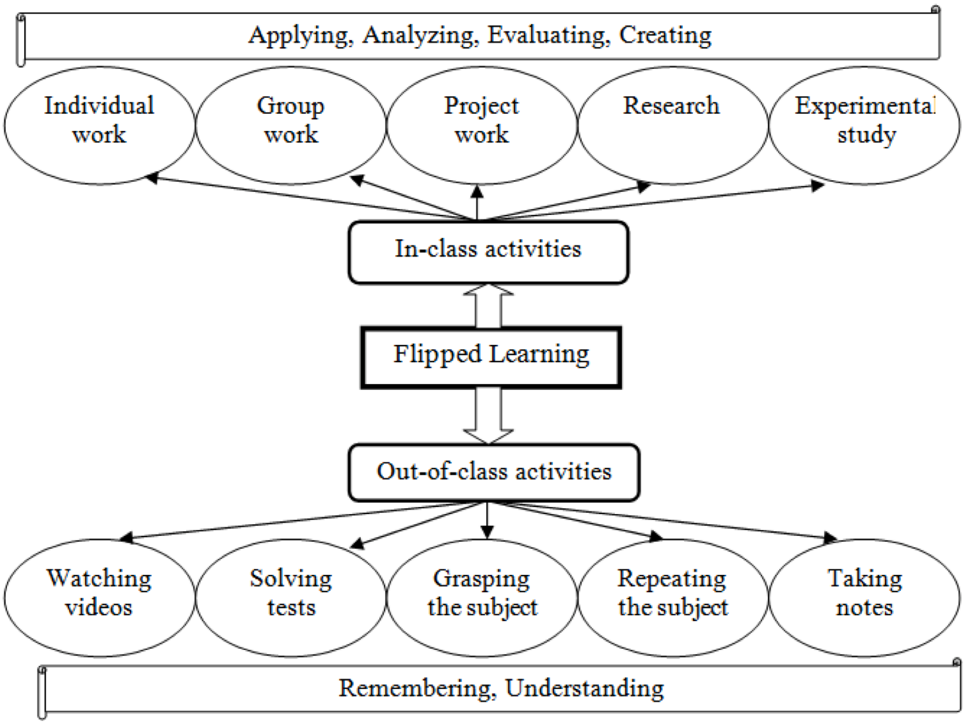

Fig. 1. Activities and components of the flipped classroom model.

1.1. Literature review

1.1.1. The use of FCM in the education of gifted students

At the beginning of the 20th century, the concept of superior intelligence was defined as achieving high scores on academic tests. Since the 21st century, the concept of giftedness has been introduced instead of the concept of superior intelligence with the emergence of terms such as problem-solving, leadership skill, and creativity (Sternberg et al., 2010). Subotnik et al. (2011) have described gifted students as "individuals who have been professionally identified by competent persons and who have the high-level capacity in any field of performance." Renzulli (1978), on the other hand, used the "three rings" model while describing the characteristics of gifted individuals. Renzulli took interaction, above-average ability, sense of duty, and creativity skills as criteria for shaping the behavior of gifted individuals. Gifted students differ from their peers in many ways. How then should these students be educated? This question emerges as a very important question that the authors seek to answer (Galitskaya et al., 2022). Subotnik et al. (2011) emphasize that gifted students need a different education from the education given in normal classrooms. In support of this emphasis, VanTassel--Baska and Stambaugh (2006) stated that education should develop the talents and research skills of gifted students. In addition, Robinson et al. (2014) stated that appropriate learning environments and strategies are needed to provide gifted students with skills such as problem-solving, creative thinking, dialectical thinking, and reflective research.

Different strategies such as acceleration, subject acceleration, integrated curriculum, enrichment, differentiated education, and grouping are used for educating gifted students (Clark, 1988). As one of these strategies, differentiated education is based on changing the content, product, process, and environment to students' characteristics. Implementing the strategies used in the education of gifted students is not always possible informal education (Wallace, 2009). Therefore, the use of different educational models in the education of gifted students is very important in terms of revealing their abilities (Galitskaya et al., 2022). Gifted students need educational programs and models that support their potential (Feldhusen, 1997). Callard-Szulgit (2010) suggested that gifted students have different characteristics. Therefore, their learning activities should be differentiated. Similarly, Tannenbaum (2000) stated that differentiated and continuous education should be given to meet the educational needs of gifted students. Soysal (2022), on the other hand, stated that there is a mandatory need to create in-class and out-of-class learning environments by integrating technology into the education of gifted students. In this context, the use of the FCM in the education of gifted students is considered appropriate (Al Harbi, 2017).

1.1.2. Flipped classrooms and academic achievement

A recent increase has occurred in studies examining the impact FCM has on students' academic achievement at different levels of education (Tutal & Yazar, 2021). Some of these studies reported FCM to be effective in academic achievement (Aydin et al., 2021; Chien & Hsieh, 2018; Ebrahim & Naji, 2021; Halasa et al., 2020; Kashada et al., 2017; Lee et al., 2015; Lin, 2021; Onyema et al., 2021; Salimi & Yousefzadeh, 2015; Winter, 2018; Zhang, 2018), while others reported the opposite (e.g., Dixon & Wendt, 2021; Love et al., 2014; Saunders, 2014; Smallhorn, 2017; Sun & Wu, 2016). Wright and Park (2022) stated that there were inconsistent findings on the effect of FCM on students' learning. Kashada et al. (2017) examined the effect FCM has on students' academic achievement and concluded FCM to have a positive effect on student achievement. Chien and Hsieh (2018), Lee et al. (2015), Onyema et al. (2021), and Aydin et al. (2021) concluded that FCM has an impact on academic achievement. Similarly, Zheng et al. (2020) examined the effect FCM has on academic achievement. Peterson (2016) emphasized the importance of FCM in the education of students with different developmental characteristics. Alamri (2019) stated that more studies should be conducted to reveal the effect of FCM on academic achievement. On the other hand, Fraga and Harmon (2014) reported that FCM was not effective in academic achievement. They suggested that there may be many factors that will affect the FCM process and that more studies on FCM are needed. In line with this need, the effect of FCM on the academic achievement of gifted students was investigated in this study.

Al Harbi (2017) and Siegle (2014) suggested that FCM can be an effective model for increasing the success of gifted students. Turkey and Abu-Omar (2022) stated that it is important to use integrated and e-learning environments such as FCM in the education of gifted students and that more studies should be done on the effectiveness of FCM. The fact that gifted students have been stated to become less motivated and have lower success when they are not provided with appropriate learning conditions (Cross, 1997; Lee et al., 2019). In this context, FCM's use in educating gifted students becomes more meaningful (Lee et al., 2019). Therefore, the current research has used FCM in educating gifted students in an attempt to reveal the effect FCM has on their academic achievement. In addition, the current study is a preliminary study examining the effect of FCM on the academic achievement and self-regulation skills of gifted students in Turkey. We think that the present study will contribute to the development of gifted students' learning programs in Turkey. VanTassel-Baska and Brown (2021) stated that the development of a learning program for gifted students has always been a problem and should not be ignored. They also stated that enriched learning programs should be expanded in the education of these students. Similarly, Callahan and Azano, 2021 stated that there are few program options in the education of gifted students and that alternative learning programs should be used. In addition, Cheung et al. (2020) stated that gifted students are at risk when their educational needs are not met. They also drew attention to the importance of learning environments that would support these students' in-class and out-of-class learning. Therefore, we think that the present study will be a resource for experts who prepare programs for gifted students in Turkey.

1.1.3. Flipped classrooms and self-regulation skills

Self-regulation allows individuals to relate to their environment and control their behavior; it is defined as the processes that students use to mobilize their emotions and behaviors in line with their goals (Zimmerman & Kitsantas, 2014). Self-regulation has a multifaceted structure such as self-evaluation, behavioral monitoring, and self-reaction (Bandura, 1986). Self-evaluation emphasizes the individual's ability to take responsibility for planning, implementing, and evaluating their learning (Mistar, 2011). Behavioral monitoring is the monitoring and recording of an individual's behaviors and directing their behavior (Gangestad & Snyder, 2000). Self-reaction, on the other hand, states that the individual's satisfaction with learning can be a source of motivation for subsequent learning efforts (Sari, 2019). Pintrich (2000) emphasized self-regulation theory to enable students to constantly improve and strive in terms of content, behavior, cognition, and motivation. Self-regulation is the ability of learners to control and manage their motivation while performing the learning task (Bodrova & Leong, 2005). Self-regulated learning is the process of regulating the emotions, thoughts, and behaviors of learners to achieve their goals (Zimmerman, 2000).

1.1.4. Self-Regulated learning

Self-regulated learning can be defined as individuals defending their learning by observing and evaluating themselves (Bandura, 1986). In self-regulated learning, the processes of setting goals that will help learners control their learning environments, and choosing and following strategies that will enable them to reach their goals are important (Schunk & Zimmerman, 2013). Self-regulated learning theories that focus on explaining learning success provide explanations through different models for how this skill is achieved (Zimmerman & Schunk, 2001). Self-regulated learning models ensure that students can take responsibility for their learning, determine and plan their learning goals, and gain the ability to control and evaluate their behavior in line with these goals (Ruohotie, 2002). The self-regulated learning model consists of cognition, metacognition, and motivation components. This model focuses on remembering information, planning the process, and beliefs and attitudes that affect cognition and metacognition (Schraw et al., 2006). It is very important to direct and evaluate the attitudes and behaviors of learners in the self-regulated learning process (Boekaerts, 1996). The self-regulated learning model, which includes the metacognition component, focuses on students' determination of learning strategies and is process-based. This model explains that the learner constructs his academic achievement within the framework of cognition, motivation, environment, and individual components and that the student's achievement depends on the choice of strategy (Borkowski, 1992). Self-regulated learners take the responsibility of learning by making use of metacognitive strategies while determining their learning styles (Perry & VandeKamp, 2000). This process positively affects students' learning performance and achievement (Pintrich & De Groot, 1990). Therefore, it is important to implement practices that will support children's self-regulated learning from an early age (Dörr & Perels, 2019; McClelland & Tominey, 2011). Self-regulated learning skills involve the important skills that gifted students as well as all students must acquire and develop (Stoeger et al., 2014). Gifted students also need educational support that enhances their self-regulation skills (Housand & Reis, 2008). In this context, today's learning models have attached importance to self-regulation skills (Wolters, 2010). As such, self-regulated learning is important in FCM.

FCM allows students to take responsibility for learning and organize their studies according to their learning speed. In other words, students' self-regulated learning skills must be improved during the FCM process, as FCM allows students to take responsibility for their learning and organize their studies according to their learning speed (Fulton, 2012). Rodríguez et al. (2019) investigated whether FCM supports creativity and critical thinking skills. They concluded that the students developed different skills (e.g., generating original ideas, developing different perspectives, and producing effective arguments) after the research. Tsai et al. (2020) stated that students organize their learning by presenting critical and creative ideas during the FCM process. They also stated that FCM increased the interaction between teacher-student and their peers and that students actively participated in the learning process. Therefore, it is necessary to consider critical thinking and creativity skills to develop students' self-regulated learning skills (Akcaoğlu et al., 2022). Similarly, Chen et al. (2014) stated self-regulated learning skills to be very important during the FCM process. Moreover, self-regulation skills allow students to set goals for their learning based on their experiences and the contextual characteristics of the learning environment (Pintrich, 2000) and are seen as an important element in increasing FCM's effectiveness. In addition, van Alten et al. (2020) suggested that students should have self-regulation skills to apply FCM. Similarly, Jung et al. (2022) stated that students in the FCM process require a high level of self-regulation to complete individual and collaborative learning tasks. On the other hand, Liaw and Huang (2013) suggested that FCM can be a conceptual model for investigating students' self-regulation skills. Similarly, Sletten (2015) stated that FCM can be used to develop students' self-regulation skills since self-regulation allows students to regulate their learning. In the current study, the first author organized learning environments for students to take responsibility for learning in the classroom and in extracurricular practices. He enabled students to participate in activities by creating cooperative learning environments in the course. Outside of the classroom, he created an environment to organize learning by doing individual studies. In addition, the first author prepared worksheets to reinforce learning during extracurricular times. Finally, he had students assess their learning during both in-class and extracurricular times. Therefore, we think that FCM increases students' self-regulation skills with these efforts. Studies investigating the effect of FCM on self-regulation skills are increasing in the literature (e.g., Elakovich, 2018; Lai & Hwang, 2016; Sun et al., 2018). Although there has been an increase in studies in recent years, little is known about the effect of FCM on self-regulation skills (Rasheed et al., 2020). Alamry (2017) argued that FCM and self-regulation should be investigated further. Even more, Al-Abdullatif (2020), who used the quantitative research method in his study, suggested using the mixed research method to reveal the effect of FCM on self-regulation skills more deeply. Therefore, the current research examines the effect FCM used in the subject of science has on the self-regulation skills of gifted students by taking into account Pintrich's (2000) self-regulation theory.

1.1.5. Problem statement

In this study, we investigated whether FCM affects the academic achievement and self-regulated learning skills of gifted students. We thought it was important to offer enriched learning environments that include extracurricular self-regulated learning processes to gifted students (Cheung et al., 2020). In this context, we thought that it would be appropriate to use FCM in the self-regulated learning process of gifted students (Al Harbi, 2017; Siegle, 2014). The present study can be a resource for experts who prepare curricula for gifted students and teachers who teach these students. In addition, the literature suggests conducting studies that examine the effect of

FCM on academic achievement (e.g., Alamri, 2019) and self-regulation skills (e.g., Alamry, 2017). In this context, we sought answers to the following research questions:

(1) What effect does FCM have on gifted students' academic achievement and self-regulation skills in the Matter and Transformation Unit (MTU) in Malatya's Science and Art Center (SAC): RIS 1 program?
(2) What are the opinions of gifted students in the experimental group about the contribution of FCM-based activities?

2. Method

2.1. Research design

The research uses the embedded design, a mixed research method. The embedded design is based on the inclusion of a qualitative design in a quantitative design, the collection of the second data set to support the primary data set, and the integration of all data (Creswell & Plano-Clark, 2018). In other words, the embedded design covers the interpretation of the data obtained from the primary data set by supporting it with the secondary data set (Creswell et al., 2003). In this study, quantitative data was used as the primary data set and qualitative data was used as the secondary data set. We tried to integrate quantitative data by supporting it with qualitative data. The quantitative part of the research examines the effect FCM has on gifted students' achievements and self-regulated learning skills in the RIS 1 program in comparison with the current RIS 1 science teaching program using a quasi-experimental design. The qualitative part examines the students' opinions about FCM using the phenomenological design. Quantitative results have been supported with qualitative data as a secondary data source.

2.2. Participants

The accessible population of the research consists of gifted students studying in the RIS 1 program in all SACs located in Malatya. SACs are independent private educational institutions that have been opened to make gifted students aware of their abilities, develop their capacities, and use these capacities at the highest level (MoNE, 2017). To enroll in SAC, 1st, 2nd, and 3rd graders must pass a two-step exam (Güneş, 2018). In the first stage, the classroom guidance counselors recommend the students they consider as gifted. A diagnostic test is performed on these students. Students who are successful in this diagnostic test are evaluated individually. Intelligence tests are used in individual assessments. Students who are successful in this evaluation are accepted to SAC. Students who pass these exams participate in educational activities in SAC on weekdays or weekends without disrupting their formal education. These activities are carried out taking the Compliance Education Program (CEP), Support Education Program (SEP), Recognizing Individual Skills Program (RISP), Developing Special Skills Program (DSSP), and Project Production and Management Program (PPMP) into account (Genç, 2014).

CEP is the first program within SAC. CEP introduces the mission, vision, and basic values of SAC to newly enrolled students. Following this program, SEP enables students to gain the basic skills of communication, collaboration, group work, learning to learn, solving problems, and scientific research. Students who complete SEP are enrolled in RISP. RISP 1 and RISP 2 are planned over two academic years. This program allows students to understand the contents of disciplines such as science, mathematics, and Turkish. As the next program, DSSP provides students with advanced knowledge, skills, behaviors, and production, taking into account interdisciplinary relations. Meanwhile, PPMP has students individually or as a group carries out project studies in a discipline in line with their interests, wishes, and abilities under the guidance of teacher advisors (MoNE, 2019). The current research is conducted with students studying in the RIS 1 program. This program aims to make students aware of their abilities, determine the areas where they will want to do serious work in the future, and make them aware of their attitudes and skills toward these areas. The authors chose to work with students in the RIS 1 program because the students in the RIS 1 program took the science courses and were the most appropriate group to answer the research question. The authors did not choose SEP students because of their young age. In addition, they did not include DSSP and PPMP students because they preferred more specific courses (physics, chemistry, biology, literature, and history).

The sample of the research consists of 70 gifted students (35 in the experimental group and 35 in the control group) enrolled in the SAC: RIS 1 program in Malatya. These students are in the 4th and 5th grades and their ages range between 9 and 11 years old. The sample of the research was selected from the accessible population by taking into account the rule of at least 10% of the total applicable population and the random sampling approach of simple sampling (Creswell, 2012). No statistically significant difference exists between the groups' achievement pre-test scores. Therefore, since there was no significant difference between the groups in terms of pre-tests, the researchers did not intend to control the pre-tests as a covariate. (Tabachnick & Fidell, 2013). The researchers identified the control group as the class that scored higher on the achievement test ($\bar{x} = 9.85$), and the experimental group as the class that scored lower on the achievement test ($\bar{x} = 9.68$). Seven students from the experimental group constitute the study group. Since there was no statistically significant difference between the achievement pre-tests, the researchers first considered choosing any class as the control or experimental group. However, if they took the class with a higher score than the experimental group, they might not be able to fully observe the effect of the independent variable on the dependent variables. Therefore, they determined the class with the higher score was the control group. In addition, the authors agreed that there would be no ceiling effect due to the very small mean difference between the two groups.

Qualitative research is based on the interpretative/naturalistic paradigm and the qualitative researcher is not concerned with generalizing to the population (Creswell, 2012). For this reason, the researchers preferred to interview people who could answer the second research question in depth. For this purpose, we identified seven participants using a maximum diversity sample. Students participated in the interview voluntarily. Four of these students are boys and three are girls. They had low (S6 and S7), medium (S3, S4, and S5), high (S1 and S2) achievement, and self-regulation post-test scores. The maximum variation sampling approach has been preferred for determining the study group (Creswell, 2012).

2.3. Data collection process

The research was carried out during the 2019–2020 academic year. The necessary permissions were obtained for the pilot study and main research. Permission was obtained from the Ministry of National Education, (Document Number: 27250534-605.01-E.9420342). In addition, the research was found ethically appropriate as a result of the evaluation of the Erciyes University Social and Human Sciences Ethics Committee (Decision No: 88). In addition, a consent form was prepared and permission was obtained from the parents to study with their children. The courses were taught to the experimental group using FCM and to the control group by considering the science curriculum of the RIS 1 program. In both groups, the same teachers performed treatment. The authors educated the teacher on the implementation of FCM. The lessons conducted with the experimental group are summarized in Table 1.

As can be seen in Table 1, the lessons in the experimental group were taught as FCM-based in-class and out-of-class practices. Lesson videos and activities within the scope of the out-of-class activities were delivered to students using online tools (i.e., Ed puzzle and WhatsApp). After watching the video and doing the activities that were sent, the students came to the lesson and did high-level individual and group work in class. In addition, the students were allowed to fill in the Pre-Class Self-Assessment Form (PCSAF) and the In-Class Self-Assessment Form (ICSAF) developed by the researchers. The students filled out these forms every week during the treatment. By completing these forms, students were able to evaluate their learning and development regarding self-regulation skills during the activities. There are eight questions in both forms. With these questions, the authors aimed to determine how students use the strategies of elaboration, time regulation, organization, critical thinking, effort regulation, help-seeking, metacognitive self-regulation, and repetition. For example, at PCSAF, "When did you watch the lecture video?" "What did you pay attention to when determining this time?" questions are included. With this question, the authors wanted to reveal what the students used as a pre-class time regulation strategy. Also, at ICSAF, the authors asked, “What kind of studies have you carried out in your learning process throughout the course, individually and as a group?” Thus, they revealed what kind of effort regulation strategies students use during the lesson.

The control group taught the courses considering the current RIS 1 science curriculum. In this context, the teacher explained the

Table 1
Activities for the experimental group.

	Out-of-class activities	In-class activities
First week	-Uploading the video and worksheet named Elements and the Periodic System to Ed puzzle -Contacting parents and delivering the contents to students -Obtaining feedback from parents about students’ work -Interviews with the students at the specified time	-Newsletter event (Group work) -Mind map drawing on the subject (Individual) -Doing the atomic and molecular elements with play dough (Group work) -Group and period activity (Group work) -Creating puzzles of elements using a puzzle maker (Group work)
Second week	-Uploading the video and worksheet named Elements and Usage Areas to Ed puzzle -Contacting parents and delivering the contents to students -Obtaining feedback from parents about students’ work -Interviews with the students at the specified time	-Experimental study according to whether the elements transmit electricity or not (Group work) -Determination of the first 20 elements by using periodic table application (Group work) -Concept map drawing reflecting the features and usage areas of the elements (Individual) -Performing elements honeycomb activity (Individual) -Preparation of the elements card (Group work)
Third week	-Uploading the video and worksheet named Physical and Chemical Change to Ed puzzle -Contacting parents and delivering the contents to students -Obtaining feedback from parents about students’ work -Interviews with the students at the specified time	-Performing an event called “Ayşe’s Day” (Individual) -Eight experimental studies with physical and chemical changes (Group study) -Making worksheets with physical and chemical changes occurring in daily life (Individual)
Fourth week	-Uploading the video and working paper called Chemical Reactions to Ed puzzle -Contacting parents and delivering the contents to students -Obtaining feedback from parents about students’ work -Interviews with the students at the specified time	-Making a photo printing activity (Group work) -Water electrolysis experiment (Group work)
Fifth week	-Uploading the video and worksheet named Acids and Bases to Ed puzzle -Contacting parents and delivering the contents to students -Obtaining feedback from parents about students’ work -Interviews with the students at the specified time	-Determination of acid and base substances in daily life (Group study) -Using litmus paper in the determination of substances (Group work) -Determination of electrical conductivity of acids and bases (Group work) -Performing Rebus activity on acids and bases (Individual)
Sixth week	-Uploading the video and worksheet named Natural Indicators to Ed puzzle -Contacting parents and delivering the contents to students -Obtaining feedback from parents about students’ work -Interviews with the students at the specified time	-Making pH matching activity paper (Group work) -Making natural indicators from red cabbage and onion (Group work -Calculation of pH values of substances using a pH meter (Group study) -Investigation of acid and base status of substances by using methyl orange and phenolphthalein indicators (Group study)

elements and periodic system in the first week, and the classification of elements and their usage areas in the second week. Similarly, the teacher discussed the subject of physical and chemical change in the third week and chemical reactions in the fourth week. In the last two weeks, the teacher has clarified the acids and bases, and the concept of pH and natural markers, respectively. The activities related to these subjects were the same in the experimental and control groups and were carried out by FCM in the experimental group and by the current RIS 1 curriculum in the control group. After the studies were completed, the Matter and Transformation Unit Achievement Test (MTUAT) and Self-regulation Scale (SRS) were applied to the experimental and control groups as a post-test. After the post-tests, semi-structured interviews were conducted with seven students from the experimental group. The data collection process is summarized in Fig. 2.

2.4. Data collection tools

2.4.1. Matter and transformation unit achievement test (MTUAT)

To create the MTUAT, MTU's objectives were written out concerning Haladyna's (1997) taxonomy, which includes understanding, problem-solving, and critical thinking skills. Six questions were formed for the dimension of understanding, 24 for problem-solving, and five questions for critical thinking. Two experts in science education and a science teacher examined the draft form of the academic achievement test consisting of 35 multiple-choice questions, after which the form was administered to 115 gifted students who had successfully passed the RIS 1 program. To increase the content validity of the achievement test, item difficulty and discrimination

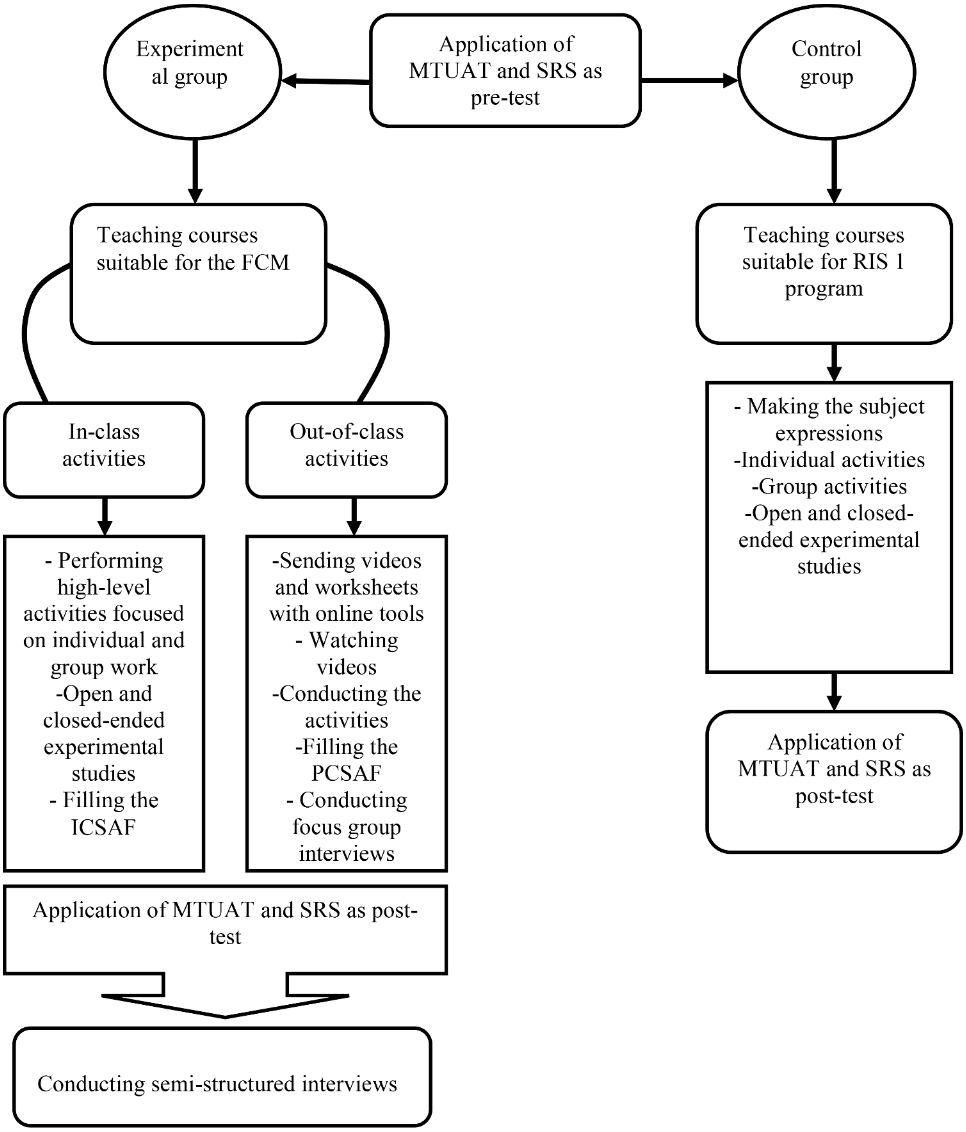

Fig. 2. Data collection process.

indices were also checked. The average item difficulty index of the test was calculated as 0.68. The discrimination indices for the two questions were less than 0.20 (Agarwal, 1986). An independent sample *t*-test was also conducted to test the questions' discriminatory power. The significance value of one of the questions with a discrimination index of less than 0.20 was found to be 0.08.

The reliability test results were also examined in this context to decide whether this question should remain in the test. The reliability coefficient value was determined to increase when this question is removed from the test. As a result of this finding, the decision was made to exclude this question from the test. As a result of the analysis, an achievement test with 34 questions has been developed. Researchers set the value of each question as 1. Therefore, students can get the highest 34 points on the test. the KR-20 reliability coefficient value has been calculated as 0.87. An example question for the test is given below.

Example question: Ali learned in his science class that the first 20 elements can be classified as metals and non-metals. He is considering creating a code system on his tablet, using atomic number cards for elements with atomic numbers of 3 and multiples of 3. For this purpose, he wrote the letter "X" for metal elements and "Y" for non-metal elements in his code system. In this case, what coding system did Ali create on his tablet?

A) XYYYXX
B) XYYXYY
C) YXXYYX
D) XYYXXX

2.4.2. *Self-regulation scale (SRS)*

The study also uses the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich et al. (1991). The research uses the items from the self-regulation strategies section of the MSLQ. After adapting the scale to the science lesson, two experts in science education checked it, and the draft scale was administered to a total of 482 students. During the development of the scale, the administration of the scale to normal students instead of gifted students can be considered a limitation of the study. However, because the items in the scale were too many compared to the questions in the achievement test, the researchers needed a large number of samples for the validity and reliability study. Therefore, the researchers could not apply the draft scale to the gifted students consisting of 115 students. Cronbach's alpha of reliability was calculated as 0.90. After this process, exploratory factor analysis (EFA) was conducted first to ensure the construct validity of the scale. In this context, the KMO value was found to be 0.88. Because this KMO value is greater than 0.60, factor analyses were conducted (Tabachnick & Fidell, 2013). As a result of the repeated factor analysis, overlapping items were removed from the scale, and factor analysis was again repeated for the remaining 25 items. These 25 items were determined to be grouped under five factors explaining 50.63% of the total variance. All items were found to have acceptable loading values for the factor in which they were entered. The five factors are repetition, effort regulation, elaboration, metacognitive self-regulation, and critical thinking. After performing the EFA, confirmatory factor analysis (CFA) was conducted on the same sample with the help of the program LISREL to verify the factor structure of the scale. When examining the literature, discussions are found regarding how to conduct exploratory and confirmatory factor analyses on the same sample. Worthington and Whittaker (2006) stated that, when performing EFA and CFA on the same sample, the structure of the data set can be revealed experimentally. Similarly, Van Prooijen and Van Der Kloot (2001) stated that CFA should be conducted on the same sample. Therefore, this research has performed both EFA and CFA on the same data set. As a result of the analyses, the observed fit indices were found to be within the desired value range ($\chi 2 / df = 2.52$, AGFI = 0.91, GFI = 0.92, CFI = 0.94, NFI = 0.91, RMSEA = 0.05). As a result, the five-dimensional structure of the SRS seen in the EFA has been confirmed by the CFA, and the decision was made to use this form of the scale in the research. Since it is a five-point Likert-type scale, the lowest score that the participants will get is 25 and the highest score is 125. Sample items for each factor in the scale are given in Table 2.

2.4.3. *Semi-structured interviews*

Semi-structured interviews have been used to determine the opinions of the experimental group participants regarding the FCM activities. The interview form has 10 questions. While preparing the interview questions, assistance was received from a science educator who has conducted studies on FCM and is an expert in qualitative research. While creating the interview form, researchers included questions to reveal how the FCM affects academic achievement and self-regulation skills. In addition, questions were prepared that allow students to evaluate the process in terms of both in-class and out-of-class practices. The questions in the interview form are as follows:

Table 2
Sample items related to SRS.

Factors	Sample Items
Repetition	When I'm studying science, I repeat important information over and over again.
Effort-regulation	I usually read something on the topic before I come to class.
Elaboration	When I study science, I review my notes and make a list of important concepts.
Metacognitive self-regulation	When I'm studying science, I set goals to direct my studies.
Critical thinking	I try to constantly review my ideas about what I learned in science class.

1 Could you compare the FCM-based learning you used in the Matter and Transformation Unit (MTU) with the previous learning methods? What differences do you think there are?
2 What kind of activities were included in the FCM process? Give examples. Which activity/activities did you enjoy the most? Why?
3 Please explain FCM's contributions to the process of learning MTU.
4 Do you think FCM has positive aspects in the process of learning MTU? Why?
 Probe: Evaluate for extracurricular applications.
 Probe: Evaluate in terms of in-class applications.
5 Do you think there are negative aspects of using FCM in the learning process of MTU? Why?
 Probe: Please evaluate for extracurricular applications.
 Probe: Please evaluate in terms of in-class applications.
6 Did you encounter any difficulties using FCM during the learning process of MTU? Please explain.
 Probe: Please evaluate for extracurricular applications.
 Probe: Please evaluate in terms of in-class applications.
7 Do you think your learning is permanent at the end of the FCM-based learning process? Why?
8 Do you think your self-regulation skills have increased at the end of the FCM process?
 Probe: Have you used repetition strategies (underlining chapters, reading aloud, etc.)? Please explain.
 Probe: Have you made connections between your previous learning and what you have just learned? How? Please explain.
 Probe: Have you done such activities as grouping, schematizing, extracting the main ideas from the text, and drawing diagrams? Please explain.
 Probe: Did you question what you learned? Explain with examples.
 Probe: Do you think you use your time effectively? Please explain.
 Probe: How did you get help from whom? Please explain.
9 Would you like to use FCM in your science lessons in the future? Why?
10 Would you like to use FCM in other lessons as well? Explain?

The first author conducted the interviews individually with each student. Interviews lasted approximately 30 min.

2.5. Data analysis

First of all, the data were tested for normal distribution. MANOVA was used to analyze the first research question. Before performing MANOVA, a check was made to determine whether the MANOVA assumptions were met. The minimum sample size was calculated in this context. Multivariate outliers were identified by examining the Mahalanobis distance. The assumptions of multicollinearity and singularity, homogeneity of variance-covariance matrices, and equality of variances were additionally checked. All assumptions were met and MANOVA was conducted (see the results). Content analysis was used to analyze the qualitative data. The authors first read the data separately and determined the codes. Then they came together and reached a consensus on the codes. For example, the first author noted that the positive aspects of FCM should include the code of being fun. The second author argued that this code is an emotional feature and will not directly contribute to academic success. In this context, the first author was persuaded and the relevant code was not included in the aforementioned category. The process continued in this way, and the code and category formation ended with the authors reaching a consensus. In the literature, it is stated that due to the hermeneutic nature of qualitative research, it is more appropriate to conduct the analysis process with consensus rather than numbers, and such a process will keep the internal reliability (consistency) higher (Author, 2021; Bogdan & Biklen, 2007; Creswell, 2012; Marshall & Rossman, 2006; Patton, 2002). For this reason, the authors did not report the inter-coder reliability coefficient based on positivism, which is the paradigm of quantitative research (Fraenkel & Wallen, 1996). In other words, the researchers increased the internal reliability by reaching a consensus on the codes and categories. Lastly, we gathered the codes under three categories in consensus (Creswell, 2012). As a result, we analyzed the data using inductive content analysis.

2.6. Effect size and power of the research

To determine the minimum sample size that should be included in the research, the procedures recommended by Cohen (1988) were carried out. The authors have set the effect size (f^2) as a medium of 0.15 to determine the required sample size and calculated power at the beginning of the study, Cohen et al. (2003) stated that the formula $n = (L / f^2) + k_a + k_b + 1$ should be used to calculate the sample size of a study. We calculated ka (number of covariates) and kb (number of fixed factors) to determine L values. The fixed factor is the teaching method and it has two levels (n) which are experimental and control groups. Thus, kb = n-1 = 2–1 = 1. Then, the L value was found as 7.85 for $\alpha = 0.05$, power = 0.80, and kb = 1. Likewise, the number of covariates (ka) is zero. We have found the required sample size as 54 using the formula of Cohen et al. (2003) ($n = L/f^2 + ka + kb + 1 = 7.85/0.15 + 2 + 1 + 1 = 54$). Similarly, the required sample number was calculated using the GPower 3.1.9.4. program. In this program, the authors determined that the required sample size should be 56. The number of participants in this research was 70, exceeding the minimum sample size. Also, the initial power (1-β) of the research was determined as 0.80 and the actual power was calculated as 0.81 from the GPower. The authors set the initial effect size to be 0.15. The generalizability of the research to the accessible population in terms of external validity was addressed by comparing this value with the observed power of the research obtained as a result of MANOVA.

3. Results

3.1. Findings regarding the first research question

When examining Table 3, we interpreted the kurtosis and skewness values to vary between -1 and +1. Therefore, the achievement and self-regulation pre-test and post-test scores from the control and experimental groups of students are normally distributed (Morgan et al., 2004). The reason why the great difference between the pre-test and post-test achievement scores is that gifted students have not learned the concepts and topics in the unit in advance. MANOVA has been conducted to determine whether a significant difference exists between the experimental and control groups in terms of achievement and self-regulation scores. To meet the assumption of the equality of variances, the variance scores of both dependent variables should be equal between both groups (Pallant, 2016). The assumption of the equality of variances for the achievement (MTUAT) post-test scores was not violated (0.13 > 0.05). However, this assumption was violated for the self-regulation (SRS) post-test scores (0.02 < 0.05). For this reason, a more conservative alpha level of 0.01 was used to interpret the SRS post-test scores of the groups in the research (Tabachnick & Fidel, 2013). As seen in Table 4, a statistically significant difference exists between the experimental and control groups in terms of the combined dependent variables ($F(2, 67) = 33.45$; $p < .05$; Pillai's trace = 0.50; partial eta squared = 0.50).

When examining Table 5, we found a significant difference to be present between the groups for both the achievement and self-regulation post-test scores ($F_{achievement}$ (1, 68) = 65.49, $p < .05$, partial eta squared = 0.49; $F_{self\text{-}regulation}$ (1, 68) = 9.68, $p < .01$, partial eta squared = 0.12).

Table 6 shows the pairwise comparison, which involves the difference between the groups. The difference is in favor of the experimental group. Therefore, the FCM is seen to have affected the gifted students' achievement and self-regulation skills.

As a result of the analysis, the observed power for the achievement test (MTUAT) was found to be 1.00 and the observed power for the SRS was found to be 0.86 (see Table 4). When looking at the effect-size values in Table 5, they are seen to have been calculated as 0.49 for MTUAT and 0.12 for SRS. In the beginning, the authors set the initial effect size to be 0.15. Based on these findings, the teaching method can be said to explain 49% of the variance in the total scores from the achievement test and 12% of the variance in the total scores from SRS. Therefore, the significant difference between the groups is generalizable to the accessible population in terms of MTUAT. However, the difference between groups in terms of the SRS is not generalizable to the accessible population.

3.2. Findings regarding the second research question

3.2.1. FCM's positive aspects

Instead of giving the percentage of participants in a code, the authors showed which code they belonged to. The reason for this is that qualitative research focuses on people's perspectives, not numbers (Creswell, 2012). As can be seen in Fig. 3, all participants stated the FCM to have enabled effective learning. Since the opinions of most of the participants were similar to each other, the authors presented direct quotations from some of the participants. In this context, S6 said, *"I did not understand acids and bases before. I learned better when I worked with this model."* Four participants were found to state that FCM provides a lot of opportunities for repetition. For instance, S1 said, *"I had time to do more repetition with the flipped classroom."* Three participants were found to state that FCM has saved time regarding learning. For example, S4 said, *"We work in the flipped classroom first… When we come here, we do a lot of activities directly. It is more efficient."* Two participants stated that FCM courses have more flexible content. In this context, S3 said, *"It contributed to my out-of-class activities for me. We carried the learning out of class."*

3.2.2. FCM's negative aspects

As can be seen in Fig. 4, participants S1 and S7 stated FCM to have negative aspects in terms of not giving instant feedback and not

Table 3
Descriptive statistics findings from the groups' pre-test and pos-test results.

Pre-test	Group	Mean	Median	Mode	S.D.	Skewness	Kurtosis
Achievement	Experimental	9.69	9.00	9.00	3.04	0.46	-0.43
	Control	9.86	9.00	8.00	3.62	0.52	-0.41
	Total	9.77	9.00	8.00	3.32	0.28	-0.38
Self-regulation	Experimental	81.28	82.00	82.00	10.77	-0.08	0.13
	Control	83.40	82.00	80.00	12.21	0.26	0.74
	Total	82.34	82.00	80.00	11.48	0.15	0.51
Post-test	**Group**	**Mean**	**Median**	**Mode**	**S.D.**	**Skewness**	**Kurtosis**
Achievement	Experimental	24.94	26.00	26.00	3.31	-0.86	0.77
	Control	19.42	20.00	19.00	2.29	-0.65	-0.51
	Total	22.18	22.00	19.00	3.96	0.08	-0.58
Self-regulation	Experimental	92.17	91.00	88.00	6.98	0.48	-0.68
	Control	84.82	84.00	77.00	12.08	0.13	0.77
	Total	88.50	88.50	82.00	10.47	-0.31	0.11

Table 4
MANOVA results.

	Pillai's trace	F	Hypothesis sd	Error sd	p	Partial eta squared	Observed power
Group	.50	33.45	2.00	67.00	.00	0.50	1.00

Table 5
Comparative results of the two groups in terms of the dependent variables.

	Dependent variables	Df	Mean square	F	p	Partial eta squared	Observed power
Group	MTUAT	2	532.12	65.49	.000	.49	1.00
	SRS	2	943.55	9.68	.003	.12	.86

Table 6
Post-test score means the groups in terms of dependent variables.

Dependent variables	Group	μ	S. error	95% Confidence interval	
				Lower limit	Upper limit
Achievement	Experimental	24.94	.48	23.98	25.90
	Control	19.42	.48	18.46	20.39
Self-regulation	Experimental	92.17	1.66	88.84	95.50
	Control	84.82	1.66	81.50	88.15

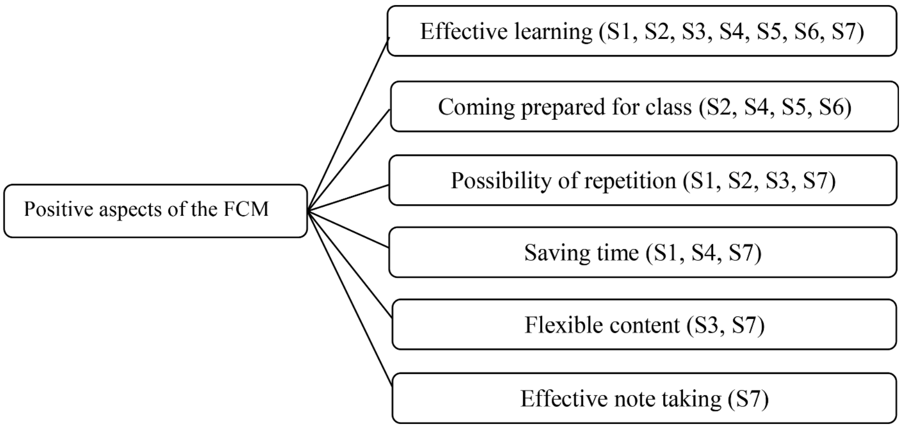

Fig. 3. Codes related to FCM's positive aspects.

accessing information. S7 expressed, *"I think there are a few problems with out-of-class activities. For example, since there is no face-to-face contact, I cannot ask a question."* Likewise, S1 expressed, *"Sometimes I cannot find what I am looking for outside of class."*

3.2.3. FCM's contribution to self-regulation skills

As can be seen in Fig. 5, all participants stated FCM to have increased their self-regulation skills. In this context, six participants stated using repetition strategies in the in-class and out-of-class activities such as reading the text aloud and underlining the text. For example, S2 said, *"I used them in the out-of-class activities, although not as much in class. I took note of most of the important concepts and read them. I underlined what I read."* Six participants stated using time effectively during the activities. In this context, S3 said, *"I think I*

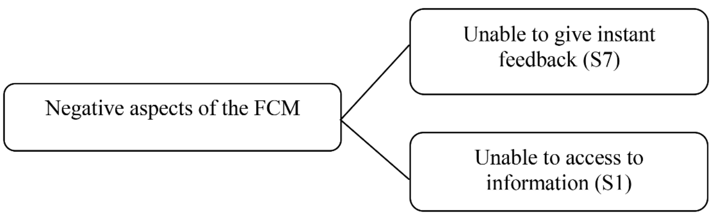

Fig. 4. Codes related to FCM's negative aspects.

used my time efficiently in the in-class activities. So, I think I used it effectively." Six participants stated receiving help during the in-class and out-of-class activities. For instance, S6 said, *"I got help from my mother. For example, my mother asked me questions, and I also answered;"* S2 said, *"I generally got help from my teacher, during the activities, or I got help from the friends in my group."*

When examining the students' opinions in terms of the dimension of elaboration, six participants stated using elaboration strategies during the activities. In this context, S7 said, *"Sometimes my father asked me what I had learned. So, I would briefly summarize the video;"* S2 said, *"Yes, for example, I made a* pH *drawing. I'm working on the periodic table."* Finally, S3, one of the three participants who learned by using critical thinking strategies in the learning process, said, *"I researched the subject. I wanted to be completely sure about it by using some resources or by asking my family."*

4. Discussion, conclusion, and recommendations

This research has concluded the flipped classroom method (FCM) is more effective in increasing the academic achievement of gifted students studying in the RIS 1 program compared to the current RIS 1 science curriculum. This result is also supported by the qualitative findings.

The results from this research in terms of academic achievement resemble those from some studies in the literature. For example, the literature has emphasized FCM increases academic achievement (e.g., Adonu et al., 2021; Baepler et al., 2014; Baranovic, 2013; Chien & Hsieh, 2018; Elian & Hamaidi, 2018; Förster et al., 2022; Lee et al., 2015; Lin, 2021; Masadeh, 2021; Onyema et al., 2021; Talan & Gulsecen, 2019; Touchton, 2015; Ugwuanyi, 2022; Van Wyk, 2019), to be effective at eliminating incomplete and erroneous learning (Berrett, 2012), and to enable meaningful learning (Sharpe, 2016). Therefore, this study is important because it shows teachers that FCM can be used for teachers who want to increase their students' academic achievement and want them to learn meaningfully.

Ugwuanyi (2022) emphasized that FCM improves students' academic achievements and it is important for teachers to adopt FCM. In the current study, the authors educated the teacher in the control and experiment groups before the treatment. This makes it easier for the teacher to adopt FCM. Förster et al. (2022) stated that students should be motivated to prepare promptly for courses conducted with FCM. In this study, the teacher with a doctorate and the first author made a great effort to increase the motivation of the experimental group of students. However, some studies found FCM to not affect academic achievement (e.g., Davies et al., 2013; Saunders, 2014; Stratton et al., 2020; Thomas & Philpot, 2012). There may be many reasons why there are conflicting results on the effect of FCM on academic achievement in the literature. In this context, Talan and Gulsecen (2019) stated that many factors such as the activities carried out during the lesson, the way teachers apply the model, and the attitudes of students towards the model may be effective in the conflicting results in terms of academic success. Lee et al. (2021) stated that FCM will not increase academic achievement and its effects cannot be generalized if extracurricular and in-class practices are not planned properly. Therefore, this study is important because it constructs in-class and extra-curricular practices in a planned way, and it will provide advantages to researchers and teachers in the use of these practices. In the current study, the authors can summarize the possible reasons for finding a significant difference in favor of the experimental group in terms of academic achievement as follows.

For FCM to be effective in the learning process, the content should be produced by the acquisitions and samples (Taylor, 2015). In this context, this research produced activities involving suitable in-class and out-of-class activities. In addition, having students follow the videos in out-of-class activities and perform the activities is important (Johnson, 2013). Not watching videos until the time of the class and not performing the given tasks may cause students to have problems throughout the course (Acedo, 2013). The current research ensured that the students had watched the videos by the time class came around and that they had fulfilled the assigned tasks with their parents' support. In-class activities should also be well organized. In this context, giving importance to group work and to increasing students' interactions during the course are recommended (Bösner et al., 2015). In the current research, group work that would allow students to interact with each other was included in the in-class activities. As a result of all these explanations, the learning activities carried out by considering the components of purposeful content, learning culture, flexibility in the learning environment and experienced educator (FLN, 2014) can be interpreted as comprising a statistically significant difference in favor of the experimental group in terms of academic achievement. Therefore, this study reveals the importance of group work during FCM practices and

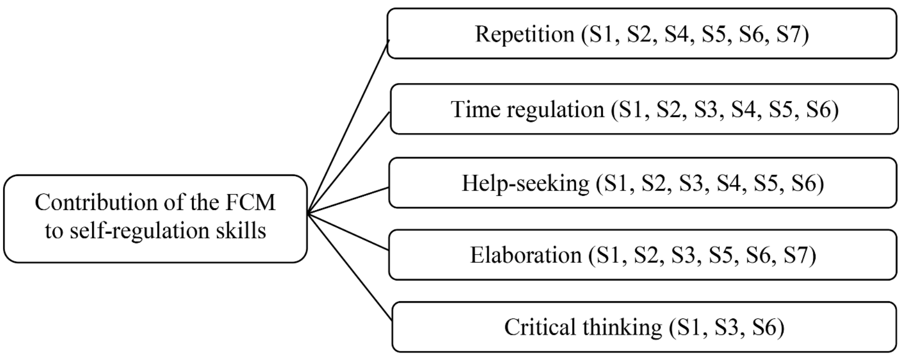

Fig. 5. Codes related to the category of FCM's contribution to self-regulation skills.

will raise awareness for teachers who enable their students to learn through group work.

According to the quantitative findings of the research, FCM has been concluded to be effective at developing gifted students' self-regulated learning skills. This result is also supported by the qualitative results and resembles results in the literature (e.g., Al Mulhim, 2021; Lai & Hwang, 2016; Liaw & Huang, 2013; Shyr & Chen, 2018). For example, Shyr and Chen (2018) stated FCM to be able to be effective in increasing students' self-regulated learning skills. Al Mulhim (2021) stated that FCM is effective in increasing self-regulated learning skills, and when using FCM, learning environments that are suitable for learning styles and meet learning needs should be created. For FCM to increase students' self-regulated learning skills, students should be allowed to set goals, participate in individual and group studies, and take responsibility for learning in the classroom and out-of-class practices (Broadbent, 2017; Peng, 2012). Possible reasons for the higher self-regulated learning skill scores of the experimental group students in the current study are summarized below.

To improve students' self-regulated learning skills in the FCM process, multiple options should be offered in the classroom and in extracurricular practices (Park & Kim, 2021). In the current research, students could be active in the in-class and out-of-class activities and organize their learning. In these activities, care was taken to ensure that students could do both individual and group work. Since self-regulated learning skill has a strong relationship with social interaction (Travers & Sheckley, 2000), we paid attention to the interaction of students with each other and their efforts in the activities during the implementation of FCM. Therefore, the researchers aimed to enable students' use of effort regulation strategies. In addition, activity papers were delivered to students in out-of-class activities. The researchers aimed to enable students' use of repetition and elaboration strategies. Forms were also prepared in which students evaluated their learning processes before and during the lesson; students were required to fill out these forms. The questions on these forms had been prepared by considering the sub-dimensions of self-regulation (i.e., repetition, effort-regulation, elaboration, metacognitive self-regulation, and critical thinking), and students were asked to evaluate their learning during the process. Open-ended experiments that would allow students to think critically and activities that would ensure active participation were carried out in the in-class activities. Therefore, the learning activities carried out by considering FCM's sub-components can be said to have improved students' self-regulation skills. As a result of the effect-size analysis, the difference between groups in terms of self-regulation was concluded to not be generalizable to the accessible population and to only be valid for the sample of the research. The literature has emphasized that gifted students have higher self-regulation skills compared to their peers (Ablard & Lipschultz, 1998). Conducting the study with gifted students in the current study may have caused this difference to remain only between the experimental and control groups. However, the experimental group of students did attempt to fulfill certain tasks weekly in both the out-of-class and in-class activities. Therefore, the workload of the experimental group of students increased. This increase may have caused their self-regulated learning skills to not increase at the desired level. Focus group interviews with the experimental group of students before the weekly lessons impacted the generalizability of the results to the population. Self-regulation includes the cognitive, affective, and behavioral processes through which individuals evaluate their own learning goals as well as what they exhibit to achieve these goals (Zimmerman & Kitsantas, 2014). Therefore, individual interviews are thought to perhaps be more effective for students in evaluating their learning properly. In addition, some of the students pointed out having difficulty in obtaining instant feedback in the out-of-class activities. The literature has emphasized that students who cannot fulfill the tasks given in out-of-class activities, even if they use more effort and time management strategies in the FCM courses, will be unable to adequately participate in the course (Milman, 2012). In this context, having the researcher and practitioner ensure that students receive instant feedback, especially in out-of-class activities, is important while conducting experimental studies to develop their self-regulation skills. Participants' repetition strategies included strategies such as reading the text aloud and underlining the text. These strategies allow attention to be directed to a text and the information in it to be selected. Actively keeping the information in one's short-term memory is also important (Pintrich, 2000). Therefore, students' use of repetition strategies can be interpreted as being effective in their learning. Likewise, six participants stated using time effectively in the in-class and out-of-class activities. The skill of time management is shown as another dimension of self-regulation skills (Pintrich, 2000). This skill can be evaluated as making a study plan as well as spending time efficiently while working. Therefore, providing students with the ability to manage their time is also important. An important result of this research is that students expressed using time effectively in FCM activities. Therefore, this study is important because it shows teachers the ways to use their students' time effectively.

Participants stated having benefited from different sources of information in both the out-of-class and in-class FCM activities. In line with this finding, FCM's inclusion of out-of-class activities can be interpreted as being effective in having students get help from different sources of information in addition to the teacher. FCM can also be said to be effective in having students gain help-seeking strategies. Regarding critical thinking, which is another important indicator of self-regulation, three participants stated that, when they learned a new topic or concept, they did not accept it immediately and used different strategies such as questioning its accuracy, asking someone who knows, and doing research. Therefore, FCM science courses can be concluded to have improved the self-regulation skills of gifted students.

4.1. Limitations and suggestions

The present study has some limitations. First, qualitative data were collected by interviewing seven volunteer students. Although the number is not important in qualitative studies (Creswell, 2012), researchers consider it is valuable to work with more students to explain quantitative findings in depth using qualitative data. Second, the present study covers six weeks. The effect of FCM on academic achievement and self-regulation skills can be examined by conducting longer studies (Lo & Hew, 2017). Third, qualitative data were collected using a single data collection tool. Different data collection tools can be used when collecting qualitative data.

The following important suggestions and recommendations have been made based on these research findings:

- The current research has determined FCM to increase gifted students' achievement and self-regulation skills. In this context, FCM is useful for educating gifted students.
- According to the effect size analysis, we concluded that the difference between the groups in terms of self-regulated learning skills cannot be generalized to the population. We thought that the increase in the workload of the gifted students in the experimental and control groups with extracurricular practices may cause this result. For this notion to be meaningful, future researchers could work with these two groups in addition to selecting a control group with no workload.
- The current research was conducted with gifted students studying in the RIS 1 program. In this context, studies examining FCM's effectiveness can be carried out with gifted students studying in different programs.
- The current research applied FCM to the Matter and Transformation Unit. Studies can be made to reveal the effect of the model by determining and applying it to different units.
- Having the model be evaluated by students, teachers, and parents is recommended.
- Having teachers use interactive classroom systems to provide students with instant feedback in out-of-class activities is recommended, as well as having students access different information sources while using FCM.

Declarations

Ethical statement

All procedures performed in the study were by the ethical standards of conducting a social science study.

Consent statement

Informed consent was obtained from all individual participants included in the research. All of the participants voluntarily participated in the research.

Declaration of Competing Interest

The authors declare no competing interests.

Data availability

Data will be made available on request.

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