Research Article

Evaluation of cooperative learning in science education: A mixed-meta method study

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ARTICLE INFO	ABSTRACT
	The aim of this study is to reveal the effect of cooperative learning method in science education on academic achievement with mixed-meta method. For this purpose, various national and international databases were searched, and among 81 articles and 37 theses covering the period between 2001 and 2022, 46 articles and 31 theses that included pre-test-post-test data and included the statistical information required for experimental or quasi-experimental analysis were preferred for meta-analysis. The effect size of 77 studies included in the analysis was found to be g = 1.070 and it was seen that the cooperative learning method in science education had a positive and large effect on academic achievement. On the other hand, as a result of the meta-thematic analysis, it was determined that the cooperative learning method increased academic achievement due to the meaningful and permanent realisation of learning. In addition, thanks to the activities in which the student plays a central role, it is understood that it develops positive attitudes towards the science course depending on the results such as making the course enjoyable and fun, making it popular and interesting; it is effective in gaining 21st century skills such as creativity, communication and cooperation, productivity and entrepreneurship. It is thought that examining the effects of cooperative learning method in science education with mixed-meta method will contribute to the literature by providing comprehensive results on the subject. **Keywords:** cooperative learning method, mixed-meta method, meta-analysis, meta-thematic analysis, academic achievement, attitude

INTRODUCTION

Science education, being a critical component of educational curricula worldwide, has been the focus of numerous studies exploring various instructional methods. Cooperative learning, in particular, has been extensively researched across different international contexts. For instance, Mendo-Lázaro et al. (2022) highlighted the positive impact of cooperative learning on student achievement in Spain, while Muawanah (2023) demonstrated similar benefits in Indonesian classrooms. In Europe, studies have provided evidence of the method's effectiveness in fostering academic achievement and improving social skills among students

(Herrmann, 2013). These international studies underscore the global relevance and applicability of cooperative learning methods in enhancing science education. Science course is one of the integral parts of these changes and progresses. Science applications are deeply involved in our daily lives, and it is known that these applications affect both economic and industrial development. Today, the development and progress of science and technology is related to the adoption of scientific knowledge, skills and attitudes as a lifestyle (Yılmaz & Karaçöp, 2018).

Science education affects students' language development and increases their interaction with people and objects around them. Students who develop language develop skills such as reasoning and problem solving. The individual who develops in this way becomes aware of his/her own learning control and provides progress in the level of academic success by facilitating learning not only in science but also in other courses (Avgın & Uygun, 2021). For this reason, all societies, including developed and developing countries, have endeavoured to indicate the importance of science, to provide students with these features of science courses, and to raise the level of science education. In order to meet these needs, it is necessary to abandon the traditional teaching methods that teachers commonly use and in which teachers are active and students are passive, and instead, studies based on the research of methods and techniques in which students are active in the process should be planned and current curricula should be arranged according to this need (Yılmaz & Karaçöp, 2018). For this reason, different teaching methods and techniques should be preferred in teaching practices in order to realise learning at permanent and higher levels in today's education system.

One of the main objectives of the science course is to raise science literate individuals (MoNE, 2018). One of the characteristics of science literate individuals is to use scientific method steps in solving the problems they encounter. Individuals are curious about the problems they encounter in daily life, think about this problem and try to solve these problems by questioning. In this direction, they find more rational and innovative solutions (Bağcı-Kılıç et al., 2008). For this reason, individuals need to produce original information in order to realise permanent learning in individuals (Yıldız, 2020). Therefore, active learning approaches are given importance in daily life.

Since the introduction of the constructivist approach, the teaching process with different methods and techniques has increased the quality of education by making more sense of information in the minds of students. The cooperative learning method, which enables students to actively participate in the education process with the effect of learning environments and developed curricula, has become increasingly important. When the literature on the cooperative learning method is reviewed, different names such as cooperative model, cooperative learning, and cooperative learning appear in Turkish sources (Bayrakçeken et al., 2013). Cooperative learning method is an approach in which students are responsible for each other's learning by forming heterogeneous groups to achieve a common goal, provide self-confidence to each other, gain skills such as problem solving, effective communication and critical thinking, and participate more actively in the classroom (Doymuş et al., 2004). According to this method, individuals take responsibility for learning from each other by forming complex groups towards a common goal, communicate effectively with each other and help each other learn, and their successes are rewarded as a group (Açıkgöz, 2008).

International studies have consistently demonstrated the benefits of cooperative learning in science education. In Pakistan, Parveen and Batool (2012) found that cooperative learning significantly improved students' achievement in general science. In Kazakhstan, Kaymak et al. (2021) reported that cooperative learning not only boosted academic performance but also enhanced social interactions among students. Additionally, Gillies and Boyle (2010) in Australia observed that cooperative learning facilitated better understanding and retention of scientific concepts. In the cooperative learning, students reach the goals and achievements they want to achieve in the learning process not directly by the teacher but by learning from each other (Savaş, 2011). In the education process, some conditions must be met in order for the lessons to be processed in accordance with the cooperative learning model. Among these conditions, positive dependency is the most important feature of the cooperative learning method, and it is realised when each student in the group realises his/her share of responsibility and fulfils his/her own duty. The important thing is that each member of the group feels belonging to the group and believes that everyone has a duty to achieve the goal. Individual responsibility: what is important here is the obligation of each individual to learn his/her part and the parts of other individuals (Efe et al., 2008). Formation of groups and group spirit; the co-operative learning model is implemented through group work. While forming these groups, the groups should

be heterogeneous in terms of gender, economic status, success, interest, desire and abilities (Koç, 2014). The role of the teacher; the teacher who applies this method has responsibilities such as dividing the students into groups, adjusting the student ranks, planning the lesson, guiding the students, showing the activities to be done to the students, and evaluating the process (Şahin & İnce, 2016). The use of social skills refers to individuals getting to know each other and interacting with each other (Kırbaş, 2010). Face-to-face interaction refers to students completing the task together, encouraging each other under all circumstances and providing facilities to each other (Açıkgöz, 2008). Rewards are given to students to increase their success and motivation. In this way, a sense of competition develops among heterogeneous student groups and a group spirit is formed in students (Er, 2012). In addition, the co-operative method has a comprehensive application area. In this method, application examples can be found at all levels from primary school to university (Bozdoğan et al., 2006).

It has been supported in various scientific studies that the effects of cooperative learning method on the learning process in many areas such as making learning permanent, developing social skills, associating information in a meaningful way, creating high-level cognitive strategies, providing active participation in the lesson, developing self-esteem, critical thinking are positive. It is still a matter of curiosity with which teaching method and technique the science course, which includes subjects covering various intelligence areas, should be presented (Batdı et al., 2021).

Purpose of the Research

The main purpose of this research is to investigate and analyse the previous studies on the use of cooperative learning method applications in detail. The fact that such studies are included in the literature is important in terms of revealing the current situation and obtaining more comprehensive results. It is thought that the data obtained as a result of these studies will eliminate the missing points in the literature and may shed light on the relevant researchers in future studies. In line with the aim of the research, the effect of cooperative learning method in science education on learners' academic achievement was examined in a holistic perspective through a mixed method including meta-analysis and meta-thematic analysis. In this respect, in the direction of the main purpose of the research, answers to the following questions were sought:

1. What is the effect level of cooperative learning on academic achievement in the studies within the scope of meta-analysis?
2. According to the views of the participants, what are the effects of the use of cooperative learning method
   a. on academic achievement and attitude,
   b. on the 21st century skills,
   c. on personal development, and
   d. and what are the negative aspects and suggestions?

METHOD

In this study, mixed-meta method was used to determine the effect of cooperative learning method on students' academic achievement in science education. Mixed-meta method is a method based on document analysis in which both meta-analysis and meta-thematic analysis are used together (Batdi, 2021). In this method, quantitative data (meta-analysis) were analysed with CMA statistical program and MetaWin program, and qualitative data (meta-thematic) were analysed with programs such as Nvivo/Maxqda. In this way, it is aimed to present more detailed findings for the literature. Below, the analysis procedures preferred in the mixed-meta method are explained in detail.

Data Collection in Meta-Analysis Process

Meta-analysis is expressed as a statistical technique used to combine the findings of previous studies on certain subjects (Camnalbur & Erdoğan, 2008). The studies conducted between 2001 and 2022 and scanned with Turkish and English keywords from various databases such as Ulakbim, YÖK National Thesis Centre, DergiPark, and Google Scholar were examined and 46 articles and 31 theses (9 doctoral theses and 22

master's theses) with experimental or quasi-experimental characteristics with pre-test-post-test data were included. While selecting these studies, the inclusion criteria including the sample number (N), arithmetic mean (X) and standard error (SE) values of the experimental and control groups were taken into consideration.

Data Collection in the Meta-Thematic Analysis Process

Meta-thematic analysis method is the process of examining the data with qualitative content and combining all the qualitative findings collected with codes and themes by passing the findings with verbal and textual content through the analysis process (Batdı, 2019). In this study, qualitative studies including students' and teachers' opinions and ideas were analysed to determine the effect of cooperative learning method in science education on academic achievement, its effect on students' attitude towards the course, its effect on students' personal development, its effect on 21st century skills, negative aspects of cooperative learning method and suggestions. In this study, the findings obtained within the scope of meta-thematic analysis were obtained from raw data in this way. Therefore, in line with the purpose of the study, it was aimed to reach the studies in which participant opinions about the effect of cooperative learning method on achievement in science education with 13 studies (9 theses and 4 articles) in which themes and codes were used and quotations were included were preferred for meta-thematic analysis.

Data Analysis

For the meta-analysis study, effect size was calculated using CMA and MetaWin programmes and graphical operations were performed. Lipsey and Wilson (2001) expressed the effect size as a unitless measure. The effect size indicates the direction and magnitude of the effect of an experiment. Determination of effect size for meta-analysis study is analysed according to REM (random effects model) or FEM (fixed effects model) (Ried, 2006). Since SEM predicts only one effect size in meta-analysis studies, this assumption is not realistic for all cases (Erez et al.,1996; cited in Batdı, 2021). At this point, Schmidt et al. (2009) stated that SEM is limited. As a result, the use of REM was preferred for the current study. REM effect size is distributed and is not interpreted according to a single value. The effect size can take positive or negative values due to this distribution (Israel & Richter, 2011; as cited in Bakioğlu & Göktaş, 2018).

In this study, the Hedges g value obtained by meta-analysis from programmes such as CMA and MetaWin was interpreted by preferring the level classification of Thalheimer and Cook (2002). Accordingly, the relevant effect size value was interpreted as: $-0.15 \leq g < 0.15$ at insignificant level, $0.15 \leq g < 0.40$ at small level, $0.40 \leq g < 0.75$ at medium level, $0.75 \leq g < 1.10$ at large level, $1.10 \leq g < 1.45$ at very large level, $1.45 \leq g$ at excellent level (Thalheimer & Cook, 2002).

In another dimension of the study, qualitative research were scanned and meta-thematic analysis process was carried out. For this purpose, the above-mentioned databases on the subject were scanned and the qualitative data were analysed by content analysis method. Document analysis involves the content analysis of materials containing information about the phenomenon or phenomena intended to be investigated (Yıldırım & Şimşek, 2008, p. 187). Content analysis, on the other hand, is a systematic technique that is summarised in the form of coding based on certain criteria and small contents of some words in the text divided into sections. Assumptions are made about the messages in the text by determining the presence and meaning of words or concepts in the text and their relationships with each other (Büyüköztürk et al., 2020). In the meta-thematic section, different themes and codes were revealed as a result of the analysis of the studies included in the research. Codes were collected in five different themes as the effect of cooperative learning method on academic achievement, effect on attitude, effect on personal development, effect on 21st century skills, negative aspects and suggestions, and various codes belonging to these themes were created. While coding the studies preferred for the analysis, the letter "T" was used for theses and "M" for articles, and a ranking was created from past to present by taking into account the number of the theses and the date of publication. In the ranking of the studies published in the same year, the alphabetical order of the surnames of the authors was arranged according to the alphabetical order. The coding were formed in the order of the letter represented for the study, the number of the study and the page number of the study from which the coding was taken (e.g., T1-p73, M2-p365). In the coding, the points we took as quotations were directly included without changing them. In the context of the research, Cohen kappa (agreement value) coefficient

Table 1. Meta-analysis results

Test type	Models	n	G	Lower	Upper	Q	p	I²
				95% confidence interval		Heterogeneity		
Success	FEM	77	0.970	0.912	1.028	478.621	0.000	84.121
	REM	77	1.070	0.921	1.219			

The overall effect sizes of the studies according to moderator analyses

Md	Groups	N	g	Lower	Upper	Z-value	p-value	Q-value	df	p-value
		Effect size and 95% confidence interval				Test of null		Heterogeneity		
Student levels	Junior high	51	1.009	0.849	1.170	12.336	0.000			
	High	8	1.931	1.201	2.660	5.184	0.000			
	University	17	0.897	0.551	1.244	5.075	0.000			
	Tot. Betw. Overall	76	1.026	0.883	1.168	14.083	0.000	6.468	2	0.039
Interdisciplinary	Science	59	0.991	0.835	1.146	12.496	0.000			
	Physics	11	1.609	0.907	2.311	4.492	0.000			
	Chemistry	2	0.914	0.521	1.307	4.555	0.000			
	Biology	5	1.096	0.611	1.580	4.432	0.000			
	Tot. Betw. Overall	77	1.013	0.877	1.149	14.612	0.000	3.200	3	0.362
Durations of imp.	1-4	33	1.276	1.019	1.533	9.715	0.000			
	5-6	19	0.947	0.639	1.255	6.029	0.000			
	7-8	10	0.891	0.579	1.204	5.593	0.000			
	9-+	15	0.930	0.639	1.220	6.275	0.000			
	Tot. Betw. Overall	77	1.035	0.890	1.179	14.014	0.000	4.998	3	0.172
Class sizes	Small	23	1.589	1.138	2.037	6.924	0.000			
	Medium	47	0.829	0.689	0.969	11.608	0.000			
	Large	7	1.301	0.919	1.682	6.682	0.000			
	Tot. Betw. Overall	77	0.940	0.814	1.066	14.612	0.000	13.825	2	0.001

was used to determine the agreement value between the data coders, and it was determined that these values were at a good/very good level.

FINDINGS AND INTERPRETATION

In this part of the study, the findings obtained as a result of quantitative (meta-analysis) and qualitative (meta-thematic) analyses on the effect of cooperative learning method on achievement in science education are presented and interpreted.

Quantitative Findings

The confidence intervals, average effect size and homogeneous distribution value according to the effect model, regarding the effect of the studies preferred for meta-analysis on the use of cooperative learning method in educational environments on academic achievement are shown in **Table 1**. In the table, the SE value of the studies preferred for meta-analysis according to REM was found as 0.076 and the upper limit of the 95% confidence interval was calculated as 1.219 and the lower limit as 0.921. The effect size value was found as g = 1.070. Effect size values were interpreted according to the classification level proposed by Thalheimer and Cook (2002) and a large effect size ($0.75 \leq g < 1.10$) was found in the study. When this value is interpreted, we can say that co-operative learning method in science education has a positive and large effect on academic achievement.

According to **Table 1**, when the heterogeneity test type value obtained is examined, it is seen that the effect sizes of academic achievement (Q = 478.621; p < .05) are heterogeneously distributed. However, the I2 value (84.121%) indicates that the 84% variance observed is due to the actual variance between the studies. 25% and I2 value shows low heterogeneity, while 50% shows medium heterogeneity and 75% and above shows high heterogeneity (Cooper et al., 2009). In the current study, since the I2 result shows heterogeneity, it can be said that moderator analysis of the test should be performed (Borenstein et al., 2009). For this reason, teaching level, interdisciplinary, application process and sample size were selected as moderator analyses. According to the moderator analysis results, it can be said that there is a significant difference according to the level of education (QB = 6.468; p < .05) and sample size (QB = 13.825; p < .05), while there is no significant difference according to interdisciplinary (QB = 3.200; p<.05) and implementation process (QB =
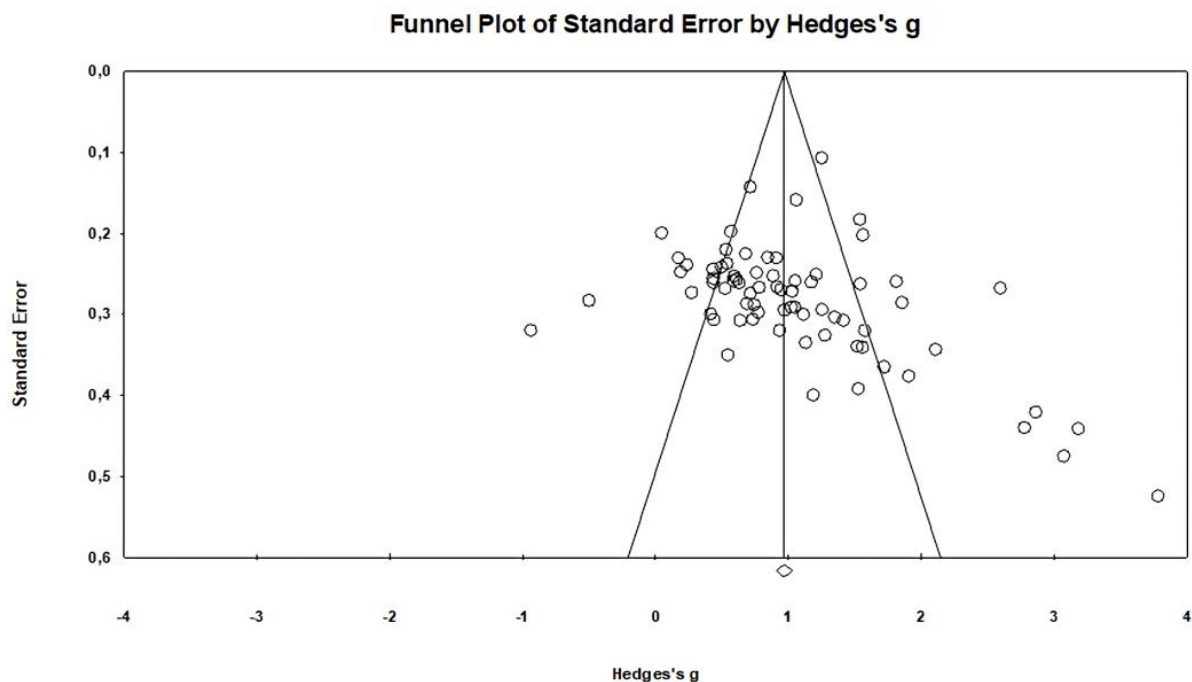
Figure 1. Funnel scatter plot for publication bias (Source: Authors)

4.998; p < .05). When the results of the analyses are evaluated, it can be said that the related practices had a positive effect in all groups during the training process.

On the other hand, in order to ensure reliability in meta-analysis studies, publication bias was examined and the funnel scatter plot in **Figure 1** was used to indicate whether there was a bias in favour of the studies showing significant differences between the studies preferred for the research.

When we look at **Figure 1**, the effect size of the 77 studies preferred for the study is symmetrically distributed on both sides of the vertical line and is close to the combined effect size. Therefore, it can be said that the distribution is in a reliable range. In meta-analysis studies, the effect size levels of the studies included in the analysis depend on the distribution being between both lines (Rosenberg et al., 2000). Publication bias is another method by which reliability is determined in meta-analysis studies. During the literature review, the fact that only studies with significant differences are selected for meta-analysis indicates publication bias. In this context, it is necessary to eliminate or minimise this situation. In this calculation, the fail-safe number (FSN) is obtained. The value of 2069 obtained for the effect of cooperative learning method on achievement for the study is the FSN that will minimise or eliminate the publication bias encountered in the meta-analysis study process (Rosenthal, 1979). It can be stated that the significant effect causing bias may be zero if the number of error protection studies found is included in the analysis. When the FSN value is compared with the number of studies included in the analysis, it is seen that the FSN value is a high number. In this context, the relevant value necessitates an unreachable number of studies. The fact that it is not possible to reach this number of studies can be interpreted as that publication bias does not affect the significant effect size (Cheung & Slavin, 2016). This result shows that meta-analysis studies are reliable.

Qualitative Findings

In this section, codes and themes are presented from the data in the study as a result of meta-thematic analysis within the scope of the qualitative dimension of the research. Four themes were created under the names of the effect of cooperative learning method in science education on academic achievement and attitude, effect on personal development, effect on 21st century skills and negative aspects. Under the theme of negative aspects, two sub-themes were created as negative aspects and suggestions. Models prepared from the generated themes and codes are included in this section. In addition, the models were tried to be supported with quotations from the studies from which the codes were extracted. In **Figure 2**, the model created about the effect of cooperative learning method on academic achievement and attitude is presented.
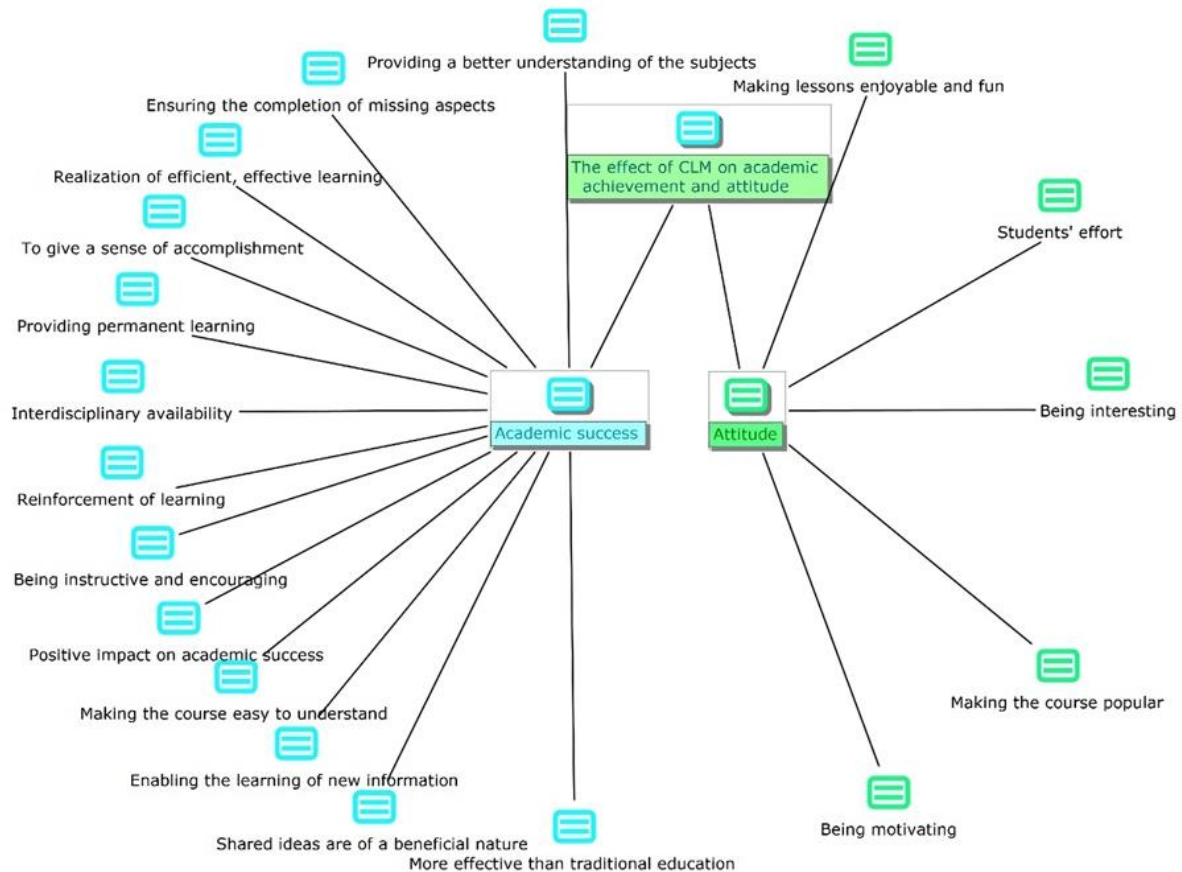
Figure 2. Model for the effect of cooperative learning method on academic achievement and attitude (Source: Authors)

In the themes related to the effect of the cooperative learning method on academic achievement and attitude, various codes were formed as *"enabling the learning of new information", "enabling the completion of missing aspects", "providing permanent learning", "reinforcing learning"* and *"the shared ideas being beneficial"*. The expressions that are thought to be the source of these codes (T3-p69) are as follows: "We encountered different opinions about the subjects we had knowledge about before, we learnt new information... ", *"In an area where one of us was deficient or not good, another friend in the group was helping him/her, helping him/her to overcome his/her deficiencies. This provided us with the opportunity to reinforce our learning."* In addition, the code of *"giving a sense of achievement"* was supported by the sentence quoted from the study coded T7-p58 as follows: *"When applying this method, especially students with low achievement level are given simple tasks such as spokesperson and they are made to come to the forefront, and they are given a sense of achievement"*. In addition, the code of *"making the lesson enjoyable and fun"* within the scope of the theme of the effect of cooperative learning method on attitude was shown with the source taken from the study coded T1-p73 and stated as *"The majority of the students reported that cooperative learning is informative, easy, useful, fun, instructive, encouraging, enjoyable, and creative"*. It can be said that cooperative learning method in science education is effective in terms of increasing academic achievement, making the lesson easy and enjoyable and developing positive attitudes on students.

Another theme created within the scope of meta-thematic analysis dimension is the effect of cooperative learning method on 21st century skills in science course. The codes created within the scope of this theme are shown in **Figure 3**.

In the theme about the effect of cooperative learning method on 21st century skills, codes were created as *"revealing different views"* and *"enabling ideas to be shared freely"*, *"creating awareness by enabling deficiencies to be seen"* and *"creating effective in-class discussions"*. The statements that are thought to be the source of these codes are from the study coded T3-p69: *"We encountered different opinions about the subjects we had knowledge*
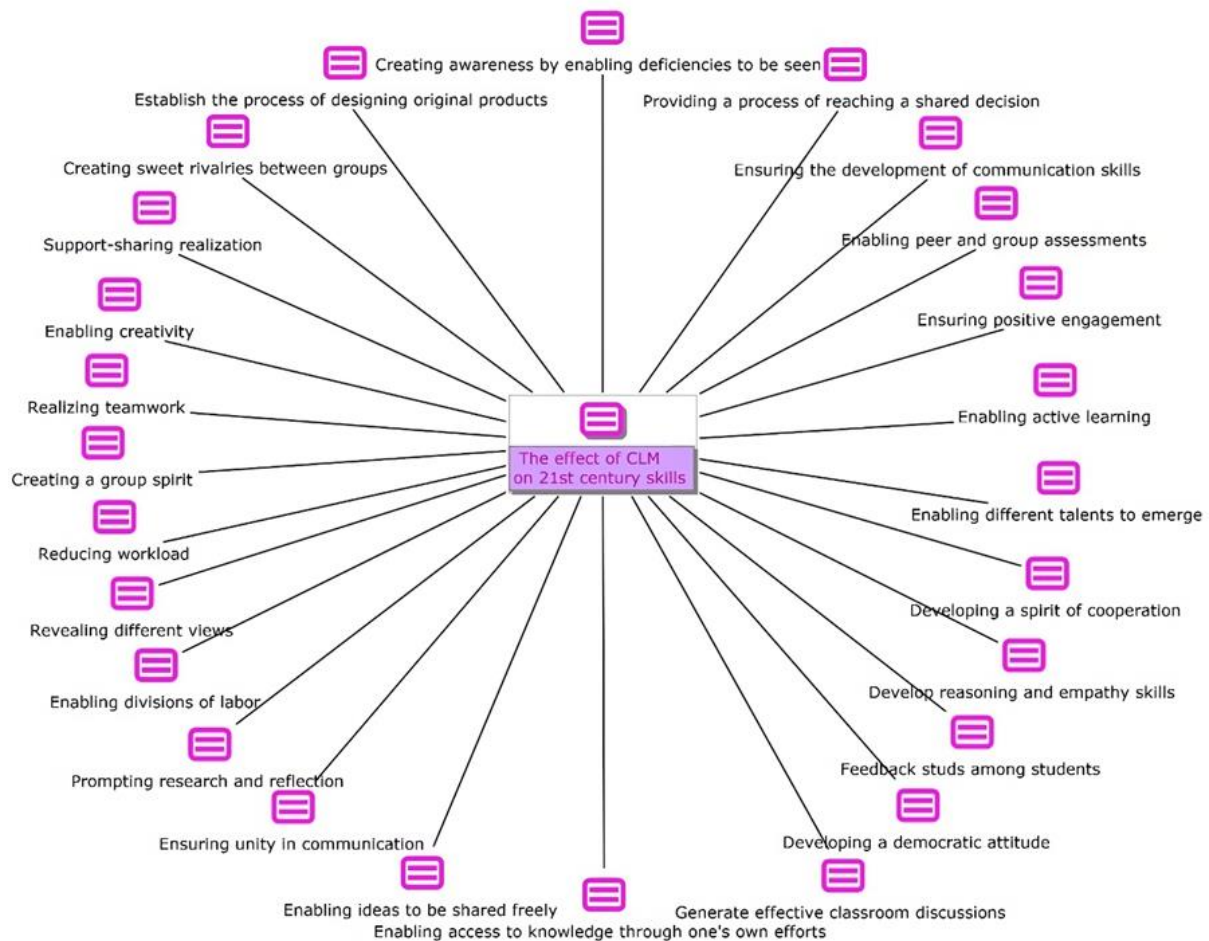
Figure 3. Model for the effect of cooperative learning method on 21st century skills (Source: Authors)

about before, we learnt new information, we all had a say and we were always active. We shared our opinions freely, which helped me to be more successful." and *"... with the discussions at the end of the experiments, we exchanged ideas, we saw each other's deficiencies, we tried to complete them, which helped me learn the subjects better..."* In addition to this, the code of *"providing creativity"* was taken from the study coded T1-p73 as *"The majority of the students stated that co-operative learning was informative, easy, useful, instructive, encouraging, enjoyable and creative."* In addition, statements such as "enabling peer and group evaluations", "providing feedback among students", "enabling the development of communication skills", "enabling teamwork" and "enabling access to information with their own efforts" emerged from the study coded T5-p97. It is thought that various features such as creating effective discussions in the classroom, enabling co-operation and division of labour, creating a group spirit, creativity and product design that the cooperative learning method provides to the individual can also be within the scope of 21st century skills.

Another theme revealed in the meta-thematic dimension of the research is the effect of cooperative learning method on students' personal development. The codes created in this context are presented in **Figure 4**. In this context, expressions such as *"developing a sense of trust", "ensuring the development of thinking horizons", "providing the development of problem-solving skills"* and *"contributing to research"* have emerged. In addition, codes such as *"respecting the ideas of others", "not allowing gender discrimination"* and *"pushing personal interests to the background"* were formed from the study coded T5-p97. The statements referring to these codes were taken from the study coded T1-p73:

> "Since each student in the group knew his/her own task, all students in the class participated in the study. Students provided more permanent and efficient learning with their own efforts. These activities, together with teamwork, made great contributions to students in many areas such as helping each other and getting help from each other, improving friendship relations and
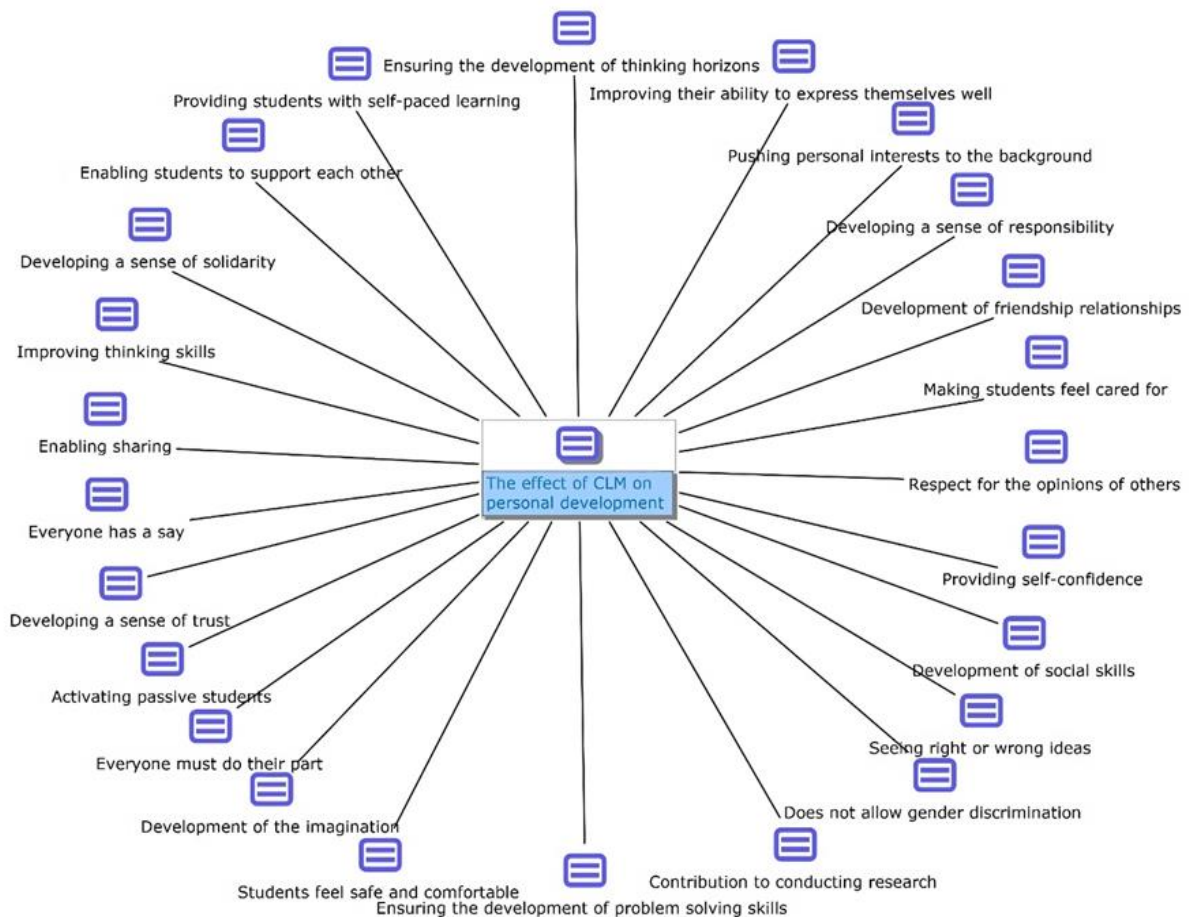
Figure 4. Model for the effect of collaborative learning method on personal development (Source: Authors)

> communication, motivation, concentration, respecting the opinions of others, self-confidence, empathic approach and problem solving."

are the statements stated in the form.

The negative aspects of the cooperative learning method within the scope of the qualitative dimension of the research are presented in **Figure 5**. The two sub-themes created within the framework of the last theme titled negative aspects are the negative aspects of the cooperative learning method and suggestions. In this context, under the sub-theme of negative aspects of cooperative learning, codes such as *"being an unfamiliar method"* and *"taking too much time"* were taken from the study coded T2-p312, and statements such as *"occurrence of disagreements", "occurrence of grade anxiety"* and *"students' unwillingness to work together"* were quoted from the study coded M3-p54.

> "Since I usually got the highest score in the group, the others in the group did not have much reaction after the exam. Sometimes when I got a low score, the others in the group blamed me. This made me unhappy... When our teacher announced the first place, we improved ourselves even more if we were absent..."

On the other hand, under the sub-theme of suggestions, codes such as *"attention should be paid to the importance of opinions", "the situation of superiority among students should be taken into consideration", "attention should be paid to the situation of some students being in the background"* and *"different dissatisfactions should be taken into consideration"* were taken from the study coded T5-p97. The statement *"However, some students in some groups do not care about the opinions of those who are in a worse situation, try to impose their own opinions, those who know well come to the fore and the others remain in the background"* was taken into consideration in the creation of the relevant codes.
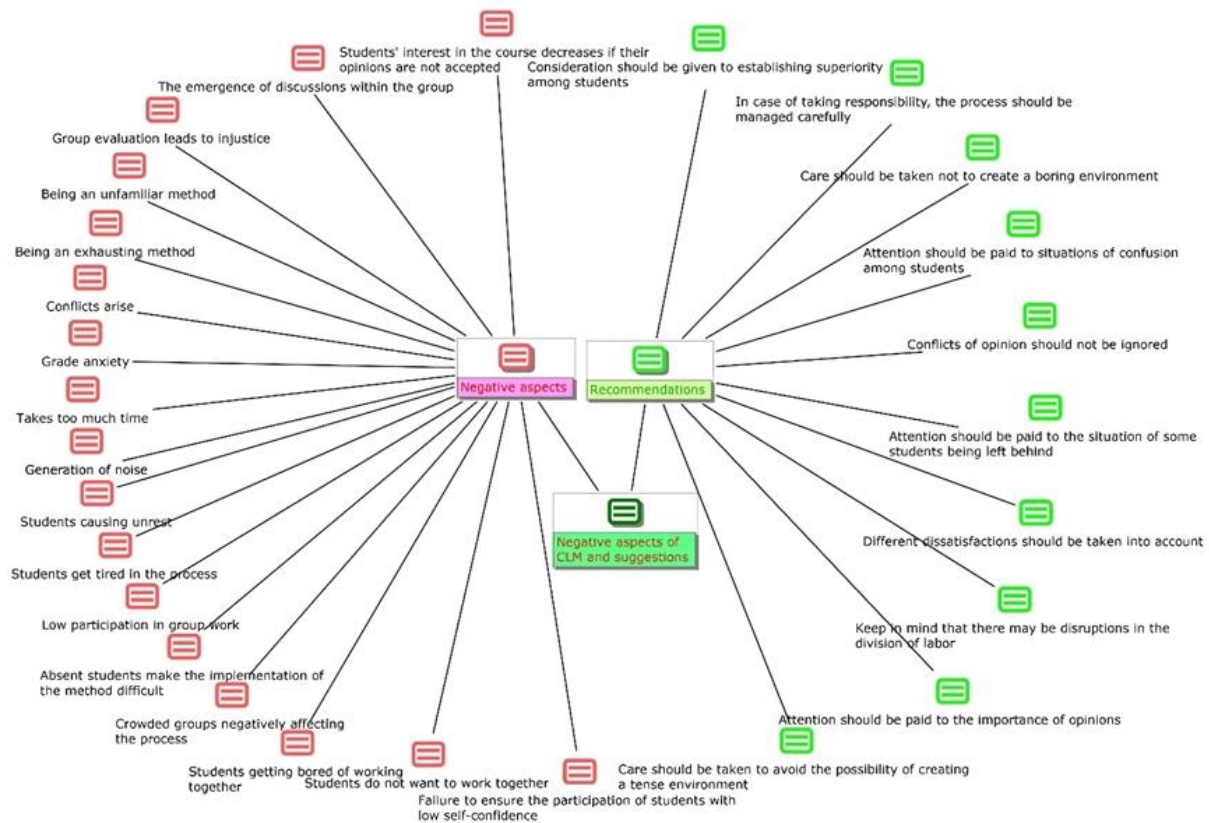
Figure 5. Negative aspects of cooperative learning method (Source: Authors)

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

This study, which was carried out within the framework of mixed-meta method, is a study based on document analysis. This study process consists of the analysis of qualitative (meta-thematic analysis) and quantitative (meta-analysis) data. In this context, the research was carried out with the data obtained from the studies accessed from the databases in order to determine the effect of cooperative learning method on academic achievement in science education. In this framework, firstly, the meta-analysis results of the studies on the effect of cooperative learning method on academic achievement in science education were analysed. Then, the meta-thematic data collected under the titles of the effect of cooperative learning method in science education on academic achievement, effect on attitude towards science course, effect on students' personality development, effect on 21st century skills, negative aspects and suggestions were interpreted. At this point, in parallel with the purpose of the research, 77 studies were preferred for meta-analysis and 13 studies were preferred for meta-thematic and taken into consideration. In addition, some suggestions were presented in line with the common results obtained from the research findings.

In the research, meta-analytical evaluations based on quantitative findings were carried out primarily. At this point, the aim of the meta-analysis study is to reveal the effect of using the cooperative learning method in the teaching environment on students' academic achievement. As a result of the analyses performed with the REM from the data of 77 studies preferred for the meta-analysis study; according to the result of the meta-analysis performed using 77 data; the effect size value $g = 1.070$ was found in the 95% confidence interval with an SE value of 0.076, an upper limit of 1.219 and a lower limit of 0.921. The interpretation of this value is significant, positive and large according to the effect level classification of Cohen et al. According to the results of the moderator analysis conducted within the scope of meta-analysis, a significant difference was observed in terms of teaching level ($Q_B = 6.468$; $p > .05$) and sample size ($Q_B = 13.825$; $p > .05$). On the other hand, no significant difference was found in terms of interdisciplinary ($Q_B = 3.200$; $p > .05$) and implementation process ($Q_B = 4.998$; $p > .05$). Considering the results of the analyses, it can be said that cooperative learning practices had a positive effect in all groups. In this context, Camnalbur and Bayraktar (2018) also obtained findings that the cooperative learning method has a positive effect on increasing academic achievement.

The findings of the present study showed that cooperative learning practices increased achievement in science education. This result is consistent with other studies in the literature (Aksoy et al, 2006; Alyar & Doymuş, 2015; Altınok & Açıkgöz, 2006; Atasoy & Gen, 2007; Bilgin & Geban, 2004; Bilgin & Karaduman, 2005; Bozdoğan et al., 2005; Çavdar & Doymuş, 2016; Çavdar et al., 2019; Doğan et al., 2009; Efe et al., 2015; Genç & Şahin, 2012; Gök & Sılay, 2008; Güngör & Özkan, 2015; Hevedanlı & Akbayın, 2006; Kavcar & Şengören, 2009; Kıncal et al., 2007; Nakiboğlu, 2001; Şenol, 2007; Taşdemir & Sarıkaya, 2005; Uygun & Avgın, 2021; Yılayaz et al., 2020). These quantitative studies were conducted to compare the achievements of the participants of the experimental group with the cooperative learning method and the participants of the control group with the traditional teaching method. As a result, according to the pre-test and post-test results, it was observed that there were significant differences in favour of the experimental group participants in terms of academic achievement.

The meta-analysis study conducted by İleri et al. (2022) examining the effect of cooperative learning method on student achievement is similar to the results of the present study. In this study, the findings of 104 studies were synthesised. As a result of the study, it was found that the cooperative learning method had a positive and strong effect (g = 1.048) on students' academic achievement. Similarly, the effect size value was found to be g = 1.070 in this study which includes the effectiveness of cooperative learning method in science education. Therefore, it can be stated that both effect sizes are positive and at a large level.

The findings of this study align with international research, demonstrating the positive impact of cooperative learning on academic achievement and personal development. Incorporating studies from different countries, such as Pakistan and Saudi Arabia, underscores the global relevance of cooperative learning. Future research should focus on cross-cultural comparisons to further explore how cooperative learning methods can be tailored to different educational settings. When the results of the analysis of the qualitative findings are analysed, it is observed that the cooperative learning method is generally very effective on the academic achievement of the learners. In this context, within the scope of the theme of the effect of cooperative learning method on academic achievement, it was observed that the cooperative learning method was more effective than traditional education, made the lessons a favourite lesson, helped students understand the subjects more easily and made the learned information more permanent. When the literature is examined, it is seen that there are studies that support the results obtained that the cooperative learning method increases academic achievement. In his study, Solmaz (2010) mentioned that depending on the use of cooperative learning method applications, students understood the subjects better in the process, they felt more active, and the lesson was made more fun. Similarly, Ergün (2006) emphasised that teaching with cooperative learning method is more successful than other traditional methods.

Again, when the research findings were analysed, it was seen that the students enjoyed the activities carried out with the cooperative learning method, did the activities fondly and followed the lesson with great enthusiasm. It shows that learning with this method increases motivation in direct learning, develops positive attitudes towards the course and changes students' personal development positively. Arslan (2016) mentioned in his study that the cooperative learning method has an effect on student attitude.

The rapid changes in the world, the innovations it brings with it and the fact that we are in the age of technology have led us to think that individuals may have new skills. These skills, which are referred to as 21st century skills in our age, contain a number of competences that will enable adaptation to the developing and renewing world. According to the analysis results of the study, most of the effects of the cooperative learning method on the students are in parallel with the 21st century skills that are thought to be gained to the learners. Some 21st century skills that learners should have been creativity and innovation, communication and co-operation, productivity and responsibility. These skills are seen in the codes obtained.

Determining the negative aspects of the cooperative learning method is another issue questioned in the research. As can be understood from the themes and sub-themes created in this regard, it is seen that some negative results may be encountered during the application phase of the cooperative learning method and there are issues to be considered. When the literature is examined, it is seen that there are studies that support the results obtained regarding the negative results of the cooperative learning method. Koç (2014) mentioned the difficulties in the implementation of the cooperative learning method in his study.

Based on the findings within the scope of the research, it can be said that the role of the students in the learning process, their performance in the evaluation process and the interest and attitude developed towards the course are affected in a good way and contribute to the increase in academic achievement scores with the cooperative learning method. In addition, it can be thought to be effective in the acquisition of 21st century skills. However, according to the results of the research, it is thought that there is a limitation in the acquisition of 21st century skills, in this context, it can be recommended to researchers to give importance to the activities that will ensure the acquisition and development of skills in the field of 21st century skills such as information literacy, media literacy, technology literacy, leadership, entrepreneurship and productivity (Batdı et al., 2021).

It can be said that the cooperative learning method activates the students in the process and enables them to learn by making sense of the information instead of taking it directly, which leads to more permanent learning. This situation can be said to break the prejudices of the students that science is a difficult and difficult to understand course and instead, it can be said that science is a fun, easy to understand, popular course that gives a sense of success. For this reason, it can be suggested that the use of the cooperative learning method may be appropriate not only at the primary education level but also at educational levels such as secondary and higher education.

As a result of the results of the current study with mixed-meta, it can be suggested that the cooperative learning method should be used more widely, effectively and planned considering its positive effects on affective, cognitive and social learning in the learning-teaching process. In addition, it can be suggested that researchers who conduct studies to examine research topics in more depth and in more detail should prefer the mixed-meta method.

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APPENDIX

Table A1. List of articles used in the analysis

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Table A1 (Continued). List of articles used in the analysis

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