

# Traditional, Cooperative, Constructivist, and Computer-Assisted Mathematics Teaching: A Meta-Analytic Comparison Regarding Student Success

**Gokhan Bas**
Nigde Omer Halisdemir University, Turkey

**Zafer S. Kivilcim**
Ministry of National Education, Turkey

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# Traditional, Cooperative, Constructivist, and Computer-Assisted Mathematics Teaching: A Meta-Analytic Comparison Regarding Student Success

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## Abstract

The purpose of this research was to perform a meta-analysis to draw conclusions about the effectiveness of traditional, cooperative, constructivist, and computer-assisted teaching, and also to compare the effectiveness of these four approaches over the last twenty years. So, the present research adopted meta-analysis technique. In order to identify relevant empirical studies on the effect of cooperative, constructivist, and computer-assisted teaching on student success, a systematic literature view was carried out over three-month's time, using several databases. Based on this extensive review, the studies ($N$ = 34) evaluating the effect of cooperative, constructivist, and computer-assisted teaching on student success in mathematics were included in the research. In the research, the procedure effectiveness technique was adopted for the analyses of the data obtained from the empirical studies involved in the meta-analysis. The results of the research indicated that cooperative, constructivist, and computer-assisted mathematics teaching were more effective in the improvement of academic success of students, rather than the traditional one, indicating that all these three approaches of teaching were effective than the traditional one to improve the student success in mathematics course. Thus, it may be suggested that student-centered teaching should be used in mathematics, rather than the traditional one.

## Introduction

Mathematics is one of the courses which students are having serious problems in Turkey (Dursun & Dede, 2004; Savaş, Taş, & Duru, 2010), so that families are making considerable investments to make their children succeed particularly in mathematics (Yolcu, 2011). However, despite the investments, students are seen to have failed in mathematics in both national high stakes assessments as well as international student assessments. For example, in the High School Entrance Examination (HEE), one of the latest national high stakes assessments held in Turkey, 8th graders had an average of 6.99 in 20 questions in mathematics (Milli Eğitim Bakanlığı [MEB], 2018). In another national high stakes assessment, the Higher Education Institutions Examination (HIE), it was determined that 12th graders had an average of 5.99 in 40 mathematics questions in Basic Proficiency Test, and an average of 4.35 in 40 questions in Field Proficiency test of Mathematics (Ölçme, Seçme ve Yerleştirme Merkezi [ÖSYM], 2018).

Moreover, it was revealed that mathematical success of 15-year old Turkish students at the Programme of International Student Assessment (PISA) was far behind the average (Organisation for Economic Cooperation and Development [OECD], 2004, 2007, 2010, 2013, 2016). As can be seen, Turkish students fail to demonstrate the desired performance in mathematics in national high stakes assessments as well as international assessments (Savaş, Taş, & Duru, 2010); therefore, mathematics is perceived as difficult and boring by many students (Brown, Brown, & Bibby, 2008). While there may be many reasons why students are failing in mathematics (Anthony, 2000) and why mathematics is perceived as difficult and boring by many students (Macnap & Payne, 2003), teaching approaches used in mathematics in particular are considered to be effective on these reasons (Akinsola & Olowojaiye, 2008).

For a long time, traditional teaching was the predominant approach used in mathematics (Anthony, 2000). For many teachers, traditional teaching was very attractive, since it was easy to implement to a large group of students in the classroom (Alsup, 2004). However, the failure of the traditional teaching in providing the desired student success in mathematics has directed the teachers to use different approaches of teaching (Stigler & Hiebert, 2004). Since mathematics teaching requires active participation of students (Reynolds & Muijs, 1999), the use of student-centered teaching approaches has become inevitable (Hiebert & Grouws, 2007). In this sense, recent meta-analytic studies have demonstrated that student-centered teaching approaches are more effective in improving academic success of students in mathematics, rather than the traditional one (Çelik, 2013; Uyar & Doğanay, 2018).

One of these student-centered teaching approaches–cooperative teaching (Davidson, 1990)–has been used to increase both interactions amongst students and their academic success in mathematics in diverse countries (Capar & Tarım, 2015; Hossain & Tarmizi, 2013; Kolawole, 2008; Zakaria, Chin, & Daud, 2010; Whicker, Bol, & Nunnery, 1997). Cooperative teaching was also used in mathematics for a period of time in Turkey (Erçelebi, 1995; Yıldız, 1998). In particular, it can be claimed that this approach gradually was fallen from the eye in time, due to the inadequacy of teachers in using cooperative teaching (Türkmen, 2016; Yağcı, Kaptı, & Beyaztaş, 2012), the overcrowded classrooms (Bilgin, 2004), and the dominance of the national high stakes assessments held in the Turkish Education System (Baş & Kıvılcım, 2019). Thus, teachers preferred to use the traditional teaching once again owing to its ease of implementation in the classroom (Akpınar & Gezer, 2010).

However, the failure of the Turkish students in mathematics in national as well as in international assessments has led educators and the policy makers to different quests (Akşit, 2007). As a result, the Ministry of National Education (MoNE) adopted the constructivist teaching in curriculum in 2005 (Eğitim Reformu Girişimi [ERG], 2005), in which it took an important step to make teachers implement constructivism in classroom mathematics teaching (Şahin, 2010). Over the years, teachers have encountered many problems during the implementation of the constructivist teaching in the classroom (Adıgüzel, 2009; Bukova-Güzel & Alkan, 2005; Karacaoğlu & Acar, 2010). While the constructivist teaching in the Turkish Education System has fallen from the eye over time (Ayaz & Şekerci, 2015), the educators and the policy makers have gone back to different quests in the context of teaching approaches once again.

Investigation of many educational systems across the world, particularly the ones in Eastern Asia (Türel, Akgün, Aydın, & Yaratan, 2020), has led to the belief that information and communication technology (ICT) is an important factor explaining student success in mathematics (Bulut, 2007). For this reason, the MoNE has launched a computer-assisted education project–Movement of Increasing Opportunities and Improving Technology (FATIH)–in order to increase the effectiveness in learning and teaching in 2011 (Durnalı, Orakcı, & Aktan, 2019). The FATIH Project, expected to be completed in four years, would be spent approximately 750 million dollars (Dündar & Akçayır, 2014). When the project has been completed, all high schools as well as primary and middle schools will be distributed with interactive whiteboards, and also both students and teachers will be supplied with tablet computers (MEB, 2013).

Teaching approaches extending from the traditional to the computer-assisted, each one representing four different teaching traditions, have been used in mathematics in the Turkish Education System at certain periods. While these four approaches have been employed to increase the effectiveness of mathematics teaching, their main purpose has been to increase student success. Significant budgets have been devoted to the educational reform acts initiated in 2005 and 2011, in particular. However, due to the fact that the reform acts have been initiated to be implemented very quickly without sustaining the necessary infrastructure in the education system, the results of these reforms have not been fully achieved.

These reforms, which can be defined as paradigm shift in the context of teaching approaches, have created serious debates amongst educators, and have brought the question of which of the teaching approach is more effective. For this reason, it has been decided to compare the effectiveness of the traditional, cooperative, constructivist, and computer-assisted teaching, which represent four different teaching traditions in nature, on student success in mathematics. Thus, it is aimed to determine the effective approach used in teaching mathematics in the Turkish Education System. The result of the research is expected to shed light on future educational reform initiatives in the context of mathematics teaching. At the same time, it is aimed to provide a perspective for policy makers to use the future education investments correctly in the teaching of mathematics.

So, the purpose of this research is to perform a meta-analysis to draw conclusions about the effectiveness of traditional, cooperative, constructivist, and computer-assisted teaching, and also to compare the effectiveness of these four approaches over the last twenty years. In line with the purpose of the present meta-analysis, the following research questions are addressed:

- RQ1. Is there a significant difference between the effect sizes of studies conducted with traditional and cooperative teaching?
- RQ2. Is there a significant difference between the effect sizes of studies conducted with traditional and constructivist teaching?
- RQ3. Is there a significant difference between the effect sizes of studies conducted with traditional and computer-assisted teaching?
- RQ4. Is there a significant difference amongst the effect sizes of studies conducted with cooperative,

constructivist, and computer-assisted teaching?

## Theoretical Framework

### Traditional Mathematics Teaching

For years, mathematics was thought to be taught in the traditional way, and this approach was used by teachers in schools for many years. Traditional teaching, which had a predominant influence on mathematics education in the early-to-mid 20th century (Alsup & Sprigler, 2003), involves mainly direct instruction where students are passive recipients of knowledge (Lightner, 1999). Direct teaching can be an effective way to gain certain knowledge and well-defined skills to the student; however, it displays unsuccessful results in gaining high-level thinking and problem solving skills (Przychodzin, Marchand-Martella, Martella, & Azim, 2004).

In traditional teaching, mathematical knowledge is broken down into small units of study, and the teacher has the responsibility to distribute it to students in a given relatively short period of time (Anthony, 2000). In this approach, knowledge is seen as absorption from the teacher to the student. In this respect, the teacher's task is to present the information units to the students in a packaged form, on the contrary the student's task is to take the information conveyed to him or her as it is and store it in the mind (Alsup, 2004). The teacher provides a step-by-step demonstration of each mathematical problem and makes the students practice the procedure of mathematical problem solving in the classroom (Smith, 1996). In traditional education, mathematics is learnt not to be used in the solution of daily life problems, but to be used in examinations–especially in high stakes exams.

In traditional mathematics teaching, many relations, rules and symbols that are not based on any reason are taught to students; thus students are expected to repeat and memorize this kind of information (Alsup & Sprigler, 2003). In such a teaching, there is no meaningful learning for the students, because they are only directed to solve the problems in examinations, not to use mathematics in their daily lives (Alsup, 2004). Traditional teaching offers mathematics to students in a way that is disconnected from daily life. Students have to memorize mathematical knowledge in a way that is disconnected from daily life and repeat the knowledge they obtain in the exams (Schwerdt & Wuppermann, 2011). This process encourages memorization and accelerates forgetting; so it is important to upload information to the student, instead of making him or her produce and use information (Boaler, 2002). As a result, students become unable to solve the problem that was not shown to them, and they have difficulty in associating mathematics with daily life problems. The mathematical knowledge acquired in this way is forgotten in a relatively short period of time.

### Cooperative Mathematics Teaching

Cooperative learning is not a new approach that emerged in the field of education; its roots are relatively old (Deutsch, 1949). Cooperative learning is an approach where students form small mixed groups in the classroom, help each other learn for a common purpose, and group success is rewarded in different ways (Johnson & Johnson, 1999). Cooperative learning activates students' participation in the classroom, saves them from memorization, and contributes to their cognitive and social development in mathematics, rather than the traditional approach (Johnson & Johnson, 1990). Cooperative learning is an approach where students ask questions, discuss their ideas, learn to listen to the opinions of others, offer constructive criticisms and summarize what they have learnt (Jolliffe, 2007). Cooperative learning emerges an effective approach in mathematical communication, problem solving, logical thinking, and making mathematical connections (Davidson, 1990).

Learning mathematics is not passive, but involves an active process. Students learn mathematics by helping each other and discussing their thoughts with others, not only by listening as in traditional classrooms (Johnson & Johnson, 1991). It is a must to work together within groups in cooperative learning; therefore, students help each other and learn together in this process (Slavin, 1995. In cooperative learning process, students make explanations such as rearranging the problem, explaining and defining step-by-step how to solve the problem to convey their thoughts to their peers in groups (Johnson & Johnson, 1990). So, group interaction in cooperative learning helps all members learn concepts and problem solving strategies in mathematics (Kramarski & Mevarech, 2003).

Mathematics is very suitable for group work, because each student can explain the solution to mathematics problems as well as discuss different solutions (Johnson & Johnson, 1990). Students gain the skills of working on the problem, understanding the problem, discussing and generating solutions, thanks to cooperative learning (McGlinn, 1991). Students working in groups deal with challenging problems; so they can develop beyond their individual capabilities when dealing with them (Davidson, 1990). Since group success is emphasized in cooperative learning, students in the groups have to both understand and explain the mathematical problem (Johnson & Johnson, 1991). Therefore, cooperative learning in mathematics teaching plays an active role in helping students acquire mathematical thinking skills (Johnson & Johnson, 1990).

## Constructivist Mathematics Teaching

Although its roots are older, constructivism is grounded in the research of Piaget, Vygotsky, and Bruner as well as the educational philosophy of Dewey (Phillips & Soltis, 2004). Constructivism is basically an epistemological view of how knowledge is acquired, rather than a learning theory (Fosnot & Perry, 1996). However, constructivism was initially an epistemological view of how knowledge was acquired; later it has become an approach that explores how individuals construct their knowledge (Perkins, 1999). In this respect, the nature of knowledge and learning constitute the basic basis of constructivism (Brooks & Brooks, 1999). For this reason, constructivism is not a theory about teaching, but it is a theory about knowledge and learning (Driscoll, 2000), and its core is the learner's structuring and putting knowledge into practice (Perkins, 1999).

According to constructivism, new information is built on what has already been learnt, however, information is not stored stacked on top of each other; the information is ensured to create meaningful relationships (Brooks & Brooks, 1999). According to the constructivists, knowledge cannot be seen independently of the learner, it is on a case-by-case basis, and the meanings belonging to the learner cannot be transferred to others (Phillips, 2000).

Indeed, constructivism emphasizes the student's contribution to meaning and learning through both individual and social activity (Bruning, Schraw, Norby, & Ronning, 2004). Constructivism advocates the structuring of knowledge by the learner; so the learner is not a passive recipient of the external stimuli, but he or she is the active creator of knowledge (Jonassen & Rohrer-Murphy, 1999).

Learning in constructivism is seen more as a process of creating meaning, and meaning is created by the student, not directly by teaching (Biggs, 1996). In this respect, students do not take the information as it is, but reconstruct their own knowledge. They learn new knowledge by adapting it to their subjective situations, together with the knowledge they have (Fosnot & Perry, 1996). For this reason, learning in constructivism refers to a process in which the information is internalized by the students, not a process in which he or she receives the information passively (Olssen, 1996). Active participation of the learner is very important (Marlowe & Page, 2005); therefore, constructivism proposes to provide environments where learners can interact with each other and enhance learning experiences (Gagnon & Collay, 2001).

Teaching mathematics has undergone a radical change under the influence of constructivism. Previously, teaching mathematics was seen as the transfer of mathematical relations, rules and symbols to students. In traditional mathematics classes, teaching and learning is based on the transfer of knowledge and its acquisition. In these classes, students have to passively adopt mathematical structures discovered by others (Alsup & Sprigler, 2003). However, this approach in teaching directed students to memorize information, but failed to improve their high-level thinking skills.

With constructivism, mathematics has begun to be seen as a process of questioning, thinking, and problem-solving, rather than memorizing algorithms and using them to find the correct answer (Simon & Schifter, 1991). Thus, students have begun to learn how to construct a mathematical theory and evaluate its mathematical validity, as well as the discovery of numbers, operations and data (Schrifter & Fosnot, 1993). Constructivism is based on the active participation of students in the process of making mathematics, and it aims to enable students to form their own thoughts from their interactions with their environment, concrete objects, and their peers (Brooks & Brooks, 1999). Constructivism associates mathematics with daily life (Fosnot & Perry, 1996); therefore, it encourages students to use mathematics in daily life problems.

**Computer-Assisted Mathematics Teaching**

With the emphasis on ICT, a radical shift has occurred on the understanding of teaching and the learning over the past two decades. In line with this shift, computer-assisted teaching has gained a widespread use across the world, particularly in mathematics to provide more enjoyable and effective learning opportunities for students. Emerged from the behaviorist psychology in the 1960s, computers were used on a narrow range of applications (Zhao & Cziko, 2001), with mainly included presentation, calculation, and so on. In traditional classrooms, mathematical concepts are being taught to students by using abstract explanations and formulas, mainly with direct teaching (Boaler, 2002). Since students are being exposed to subject matters in traditional classrooms, they have problems overcoming the abstract explanations and a series of formulas delivered, which in turn makes students not understand mathematics and use it in their daily lives (Lessani, Yun, & Bakar, 2017). Whereas with the emerge of computers in schools, the nature of mathematics teaching has changed considerably; computers have started to be used as a way to pursue higher order thinking skills of students, rather than help them memorize mathematical knowledge (Breunlin, 1999).

Computers help in improving the knowledge of mathematics (Ramani & Patadia, 2012), as they provide a number of ways for student learning including tutorials, hypermedia, simulations, and educational games (Alessi & Trollip, 2001). Computers in teaching play an important role in explaining mathematical knowledge and concepts with the aid of certain software, and they can serve as a way to improve learning outcomes of students (De Witte, Haelermans, & Rogge, 2015). Computer-assisted teaching in mathematics provides different learning experiences according to the readiness level of the students (Ramani & Patadia, 2012), and it has a potential to address all students having diversity of learning (Wittwer & Senkbeil, 2008). Computers can make the teaching of mathematics individualized; thus, each student can pursue his or her learning with their own level and pace (Ruthven & Hennessy, 2002).

Computer-assisted teaching provides learning environments that engage students in creative tasks and problem solving (Kapa, 1999). Computers provide important advantages for students to think deeply about mathematics, to facilitate generalization, to empower them to solve difficult problems, and to establish links between real mathematical models (Ruthven, Hennessy, & Brindley, 2004). Thanks to computers, students learn to prove and apply on their own, rather than listen and memorize results previously found by others (Cuoco & Goldenberg, 1996), Also, computer-assisted teaching can provide an opportunity for individualized assessment for each student; therefore, students can receive immediate feedback, and then accommodate their learning accordingly (Nguyen, Hsieh, & Allen, 2006).

## Methodology

### Research Design

In the present research, meta-analysis techniques were used (Glass, McGaw, & Smith, 1981; Lipsey & Wilson, 2001). A meta-analysis is a statistical technique for combining the data obtained from independent studies to draw a general conclusion (Hunter & Schmidt, 2004). In other words, a meta-analysis a statistical procedures application used for the purpose of combining, synthesizing, and interpreting the data obtained from independent empirical studies (Wolf, 1986). A typical meta-analysis follows some key steps such as determining the research problem, reviewing of the relevant literature, coding all possible studies, analyzing the studies with suitable statistical techniques, and interpreting the results of the research (Durlak, 2005).

### Data Sources

In order to identify relevant empirical studies on the effect of cooperative, constructivist, and computer-assisted teaching on student success, a systematic literature view was carried out over three-month’s time, using several databases such as Web of Science, ERIC, PsycINFO, Science Direct, ULAKBIM, and the National Theses

Centre of the Turkish Higher Education Council (HEC) of Turkey, EBSCOhost, as well as web-based repositories as Google Scholar. In the search of the empirical studies, different combination of keywords (i.e. cooperative learning, cooperative teaching, cooperative learning/teaching on student success/achievement; constructivist learning, constructivist teaching, constructivist learning/teaching on student success/achievement; computer-assisted learning, computer-assisted teaching, computer-assisted learning/teaching on student success/achievement) were used, so that over 300 potential studies were obtained as a result of the literature review (see Figure 1).

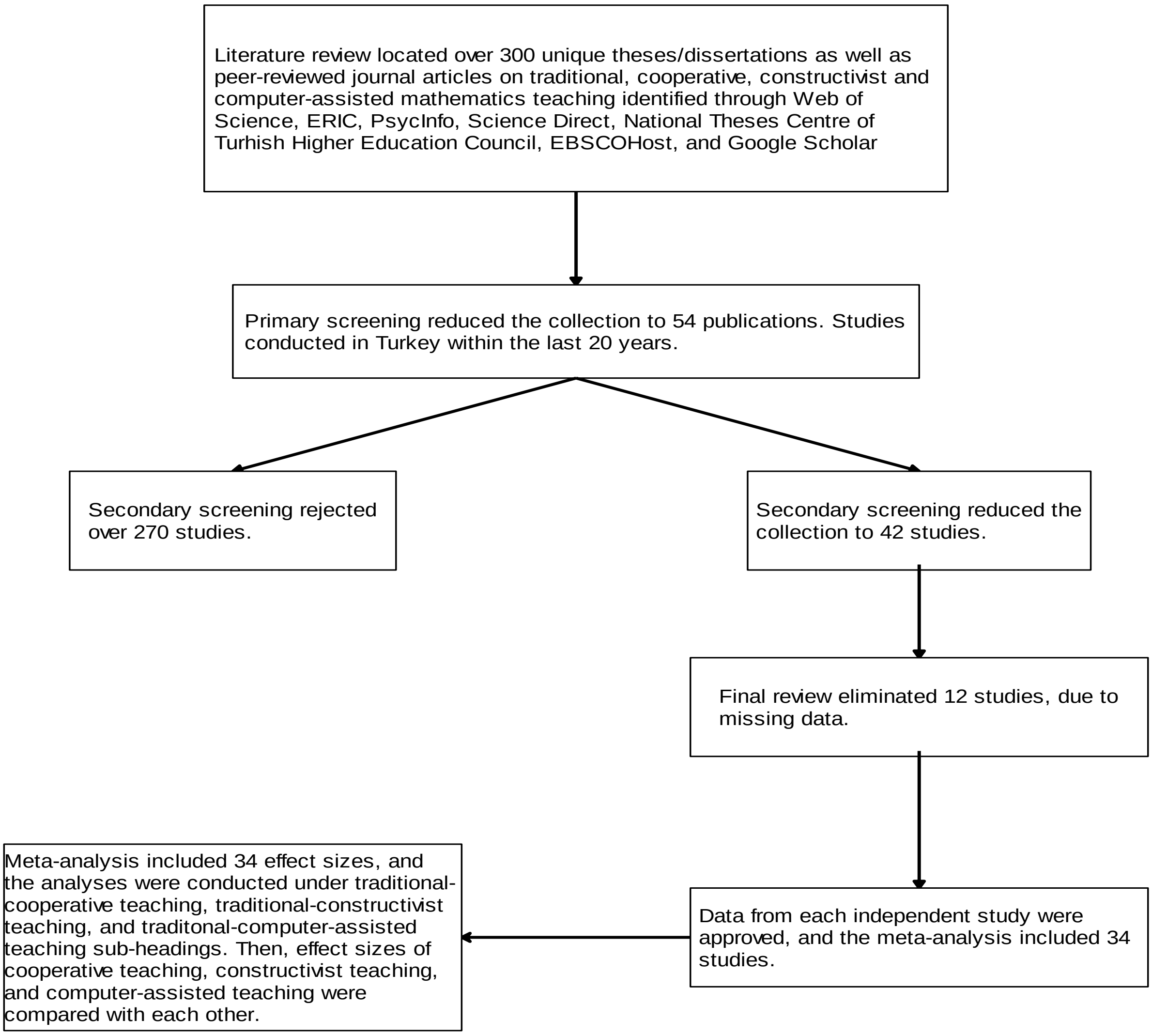


Figure 1. Summary of data collection process in the meta-analysis

### Criteria for Inclusion

In the present meta-analysis, a number of inclusion criteria were used. Firstly, the studies evaluating the effect of cooperative, constructivist, and computer-assisted teaching on student success in mathematics course were included in the research. While the studies involving studies from primary education to university level of education were taken into account, the studies comparing students taught experimental groups using cooperative, constructivist, and computer-assisted teaching to those in control groups using the traditional teaching were included in the research.

Besides, the studies that conducted pre- and post-tests in order to determine the effectiveness of cooperative, constructivist, and computer-assisted teaching. Also, the empirical studies took place in the Turkish context, reporting both in the Turkish or the English languages were taken into consideration. Lastly, the studies taking place for the period of 1998 to the present, including exactly a decade of recent research on cooperative, constructivist, and computer-assisted teaching in mathematics course.

**Coding Procedure**

Based on the purpose of the research, a coding procedure was generated to identify the study features (Card, 2012). For this reason, a coding form using MS Excel 2010 was created to identify the features of the empirical studies included in the meta-analysis. Firstly, all the studies reached in the literature review suitable for the inclusion criteria of the research were examined. As a result of this review, 30 studies were deemed suitable for the inclusion in the research, after excluding the duplicate studies and the studies not involving the requisite data. Then, all the studies meeting the criteria for inclusion of the present meta-analysis were coded in the Excel form created previously. Finally, after reviewing the reference lists of the studies, four additional empirical studies were identified and the coding form was completed for totally 34 studies for the meta-analysis.

Consequently, the present research was carried out on the basis of 5 journal articles and 29 master's theses/doctoral dissertations. In order to ensure the reliability of the data of the research, it is suggested that at least two researchers should make codifications of the data obtained independently (Miles, Huberman, & Saldana, 2013). Therefore, the data obtained from the empirical studies included in the meta-analysis were coded by two researchers independently, reaching a Cohen's (1960) Kappa coefficient of 0.99 meaning that a high level of agreement between the researchers was sustained (Landis & Koch, 1977).

**Data Analysis**

In the research, the procedure effectiveness technique was adopted for the analyses of the data obtained from the empirical studies involved in the meta-analysis (Borenstein, Hedges, Higgins, & Rothstein, 2009). In the procedure effectiveness technique, standardized effect sizes, such as Cohen's *d* or Hedges's *g*, are used (Hartung, Knapp, & Sinha, 2008). The calculation of the effect sizes in meta-analysis is very important to obtain accurate findings (Lipsey & Wilson, 2001). In this research, for the calculations of the effect size, Hedge's *g* was used, and the significance level for the statistical analyses was adopted as 95% (Hedges & Olkin, 1985). Also, the classification suggested by Cohen (1992) was used for the interpretation of the effect sizes produced as a result of the meta-analysis. In this classification, effect sizes between 0.20 and 0.50 are small, effect sizes between 0.50–0.80 are medium, and effect sizes above 0.80 are higher (Cohen, 1992).

In the research, chi-square heterogeneity test of Cochran's *Q* was used to see whether there was heterogeneity amongst the studies included in the meta-analysis (Borenstein et al., 2009). A *p*-value lower than the accepted significance level as result of the heterogeneity test demonstrates that the findings should be considered to be heterogeneous in line with the hypothesis put forward, indicating that studies are gathered from more than one distribution (Lipsey & Wilson, 2001). The significant chi-square shows that the findings are homogeneous, suggesting that the effect sizes can be used for all studies (Shelby & Vaske, 2008). In the research, $I^2$ value was used as another criterion of heterogeneity; this value gives the ratio of the total variance for the effect size and unlike $Q$ statistic, it is not affected by the number of studies. The value being 25% indicates low, 50% moderate, and 75% high level of heterogeneity (Cooper, Hedges, & Valentine, 2009).

In meta-analysis research, there are two types of statistical models combining the findings as the fixed and the random effects models (Borenstein et al., 2009). In this research, both fixed-effects and random-effects models were used to interpret the findings (Lipsey & Wilson, 2001). In the fixed effects model, variance is considered to be a result of interrelated data (Shelby & Vaske, 2008). Concerning the fixed effects model, there is one effect size showing the same effect size for all studies (Hunter & Schmidt, 2004).

Conversely, the random effects model is considered to be appropriate when studies included are heterogeneous, and the fixed effects model is not appropriate as well (Lipsey & Wilson, 2001). When the data collected are not homogeneous and the fixed effects model is not appropriate, this model is adopted in meta-analysis (Hedges, 1983). Thus, while deciding on the statistical model to be adopted in the meta-analysis, whether the effect sizes demonstrate a homogeneous distribution or not should be tested (Ellis, 2010). In the analyses of the data, Comprehensive Meta-Analysis (CMA) v.2 was performed (Borenstein et al., 2009). CMA helped the researchers conduct all analyses, regarding the calculation of publication bias and effect sizes, as well as the creation of funnel and forest plots.

## Findings

In this part of the research, the findings in relation with the effectiveness of traditional, cooperative, constructivist, and computer-assisted teaching on academic success of students were given. Firstly, general characteristics of the studies included in the research were given, and then the preliminary findings regarding of the effect sizes of the studies were presented. Lastly, a comparison of the effect sizes of the studies adopting cooperative, constructivist, and computer-assisted teaching were given briefly.

### General Characteristics

When the general characteristics of the studies included in the research were examined, it was seen that 14.70 percent ($n$ = 5) were journal articles and 85.29 percent ($n$ = 29) were theses/dissertations. Of these studies included in the research, 61.76 percent ($n$ = 21) of them were conducted using cooperative teaching, 14.70 percent ($n$ = 5) of them were conducted using constructivist teaching, and 23.52 percent ($n$ = 8) of them were conducted using computer-assisted teaching (see Table 1).

Table 1. Characteristics of the Studies in the Meta-analysis

| Author(s)/Year | Publication Type | Teaching Approach |
|---|---|---|
| Yıldız, 2001 | Thesis/Dissertation | Cooperative Teaching |
| Ural, 2007 | Thesis/Dissertation | Cooperative Teaching |
| Özsarı, 2009 | Thesis/Dissertation | Cooperative Teaching |
| Koç, 2015 | Thesis/Dissertation | Cooperative Teaching |
| Kuzucuoğlu, 2006 | Thesis/Dissertation | Cooperative Teaching |
| Ünlü, 2008 | Thesis/Dissertation | Cooperative Teaching |
| Marangoz, 2010 | Thesis/Dissertation | Cooperative Teaching |
| Arısoy, 2011 | Thesis/Dissertation | Cooperative Teaching |
| Kabuk, 2014 | Thesis/Dissertation | Cooperative Teaching |
| Pınar, 2007 | Thesis/Dissertation | Cooperative Teaching |
| Efe, 2011 | Thesis/Dissertation | Cooperative Teaching |
| Erdoğan, 2013 | Thesis/Dissertation | Cooperative Teaching |
| Tuğran, 2015 | Thesis/Dissertation | Cooperative Teaching |
| Yantır, 2007 | Thesis/Dissertation | Cooperative Teaching |
| Akbuğa, 2009 | Thesis/Dissertation | Cooperative Teaching |
| Gelici, 2011 | Thesis/Dissertation | Cooperative Teaching |
| Gülsar, 2014 | Thesis/Dissertation | Cooperative Teaching |
| Erdoğan, 2015 | Thesis/Dissertation | Cooperative Teaching |
| Sulak, 2002 | Thesis/Dissertation | Computer-Assisted Teaching |
| Gökcül, 2007 | Thesis/Dissertation | Computer-Assisted Teaching |
| Pilli, 2008 | Thesis/Dissertation | Computer-Assisted Teaching |
| Şen, 2010 | Thesis/Dissertation | Computer-Assisted Teaching |
| Şişman, 2007 | Thesis/Dissertation | Constructivist Teaching |
| Çiftçi, 2010 | Thesis/Dissertation | Constructivist Teaching |
| Anahtarcı, 2009 | Thesis/Dissertation | Constructivist Teaching |
| Tuğral & Güvenç, 2016 | Journal Article | Cooperative Teaching |
| Pesen & Bakır, 2016 | Journal Article | Cooperative Teaching |
| Keskin & Kılıç, 2016 | Journal Article | Cooperative Teaching |
| İçel, 2011 | Thesis/Dissertation | Computer-Assisted Teaching |
| Bayturan, 2011 | Thesis/Dissertation | Computer-Assisted Teaching |
| Orçanlı & Orçanlı, 2016 | Journal Article | Computer-Assisted Teaching |
| Yiğit, 2007 | Thesis/Dissertation | Computer-Assisted Teaching |
| Güneş & Asan, 2005 | Journal Article | Constructivist Teaching |
| Akyol, 2006 | Thesis/Dissertation | Constructivist Teaching |

**Preliminary Findings and Publication Bias**

In the research, the effect sizes of the studies adopting cooperative, constructivist, and computer-assisted teaching were compared with the traditional teaching. Firstly, as a result of the comparisons of a total of 21 studies in terms of cooperative teaching, the overall weighted effect size was $d$ = 0.698 (95% CI = 0.588 – 0.809). The $Q$-value indicated that the distribution of the effect sizes in this collection of studies was heterogeneous, $Q$ (20) = 145.115, $p$ < .001. The variance of the effect sizes of the studies was larger than could be explained by simple sampling error, so that a random effects model was performed in the research (see Table 2).

Table 2. Results related to Overall Effect Sizes of the Studies regarding Cooperative Teaching

| | | | | | | | | 95% CI | |
|---|---|---|---|---|---|---|---|---|---|
| Model | k | ES | SE | Variance | Z | Q | $I^2$ | Lower | Upper |
| Fixed Effects | 21 | 0.698 | 0.056 | 0.003 | 12.438 | 145.115 | 86.23 | 0.588 | 0.809 |
| Random Effects | 21 | 0.845 | 0.153 | 0.024 | 5.510 | | | 0.545 | 1.146 |

*Note.* k = number of effect sizes; ES = effect size; SE = standard error; CI = confidence of interval for the average value of ES.

As a result of the values obtained in the analysis, it was revealed that cooperative teaching was more successful in the improvement of academic success of students than the traditional one. Also, the obtained effect size value in the research was considered as moderate. Besides, the result of $Z$-value indicated that the effect size was statistically significant, $Z$ = 12.438, $p$ < .000. Also, as a result of the comparisons of a total of 5 studies in terms of constructivist teaching, the overall weighted effect size was $d$ = 0.831 (95% CI = 0.574 – 1.088). The $Q$-value indicated that the distribution of the effect sizes in this collection of studies was heterogeneous, $Q$ (4) = 8.838, $p$ < .001. The variance of the effect sizes of the studies was larger than could be explained by simple sampling error, so that a random effects model was performed in the research (see Table 3).

Table 3. Results related to Overall Effect Sizes of the Studies regarding Constructivist Teaching

| | | | | | | | | 95% CI | |
|---|---|---|---|---|---|---|---|---|---|
| Model | k | ES | SE | Variance | Z | Q | $I^2$ | Lower | Upper |
| Fixed Effects | 5 | 0.831 | 0.131 | 0.017 | 6.344 | 8.838 | 54.41 | 0.574 | 1.088 |
| Random Effects | 5 | 0.823 | 0.196 | 0.038 | 4.196 | | | 0.439 | 1.207 |

*Note.* k = number of effect sizes; ES = effect size; SE = standard error; CI = confidence of interval for the average value of ES.

As a result of the values obtained in the analysis, it was revealed that cooperative teaching was more successful in the improvement of academic success of students than the traditional one. Also, the obtained effect size value in the research was considered as moderate. Besides, the result of $Z$-value indicated that the effect size was statistically significant, $Z$ = 6.344, $p$ < .000. Lastly, as a result of the comparisons of a total of 8 studies in terms of computer-assisted teaching, the overall weighted effect size was $d$ = 0.788 (95% CI = 0.589 – 0.988). The $Q$-value indicated that the distribution of the effect sizes in this collection of studies was heterogeneous, $Q$ (7) = 7.946, $p$ < .001. The variance of the effect sizes of the studies was larger than could be explained by simple sampling error, so that a random effects model was performed in the research (see Table 4).

Table 4. Results related to Overall Effect Sizes of the Studies regarding Computer-assisted Teaching

| Model | k | ES | SE | Variance | Z | Q | $I^2$ | 95% CI Lower | 95% CI Upper |
|---|---|---|---|---|---|---|---|---|---|
| Fixed Effects | 8 | 0.788 | 0.102 | 0.010 | 7.738 | 7.946 | 11.55 | 0.589 | 0.988 |
| Random Effects | 8 | 0.788 | 0.109 | 0.012 | 7.235 | | | 0.574 | 1.001 |

*Note.* k = number of effect sizes; ES = effect size; SE = standard error; CI = confidence of interval for the average value of ES.

As a result of the values obtained in the analysis, it was revealed that computer-assisted teaching was more successful in the improvement of academic success of students than the traditional one. Also, the obtained effect size value in the research was considered as moderate. Besides, the result of *Z*-value indicated that the effect size was statistically significant, $Z = 7.946$, $p < .000$. Furthermore, the forest plot showing the distribution of the effect sizes for the studies included in the meta-analysis based on both effects model was presented (see Figure 2).

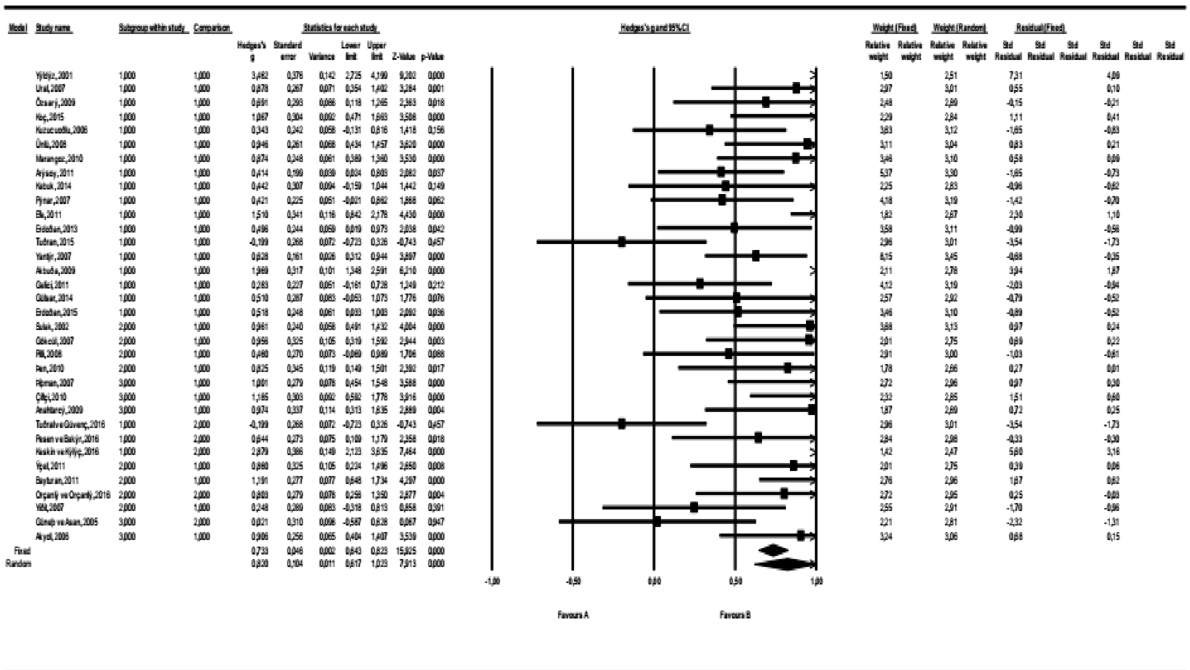

Figure 2. Forest Plot Showing the Distribution of Effect Sizes

According to Figure 2 given, it was seen that all the studies included in the current meta-analysis had positive effect sizes. Therefore, it may be revealed that the results of all the studies indicated that students-centered teaching approaches (cooperative, constructivist, and computer-assisted) had a positive effect on academic success of students. On the other hand, in order to examine the possibility of publication bias, the trim and fill method (Duval & Tweedie, 2000a) was performed to identify and correct funnel plot asymmetry. The funnel plot is asymmetrical when there is any publication bias in the studies (Duval & Tweedie, 2000b). Extreme effect sizes of interventions on the right hand of a funnel are trimmed to obtain a symmetric funnel plot in the trim and fill method (Duval & Tweedie, 2000a). In the research, the funnel plot seemed almost symmetrical (see Figure 3). The figure showed that the studies were quite neatly distributed. According to the trim and fill method performed, there were no studies missing, indicating that there was no publication bias in the meta-analysis.

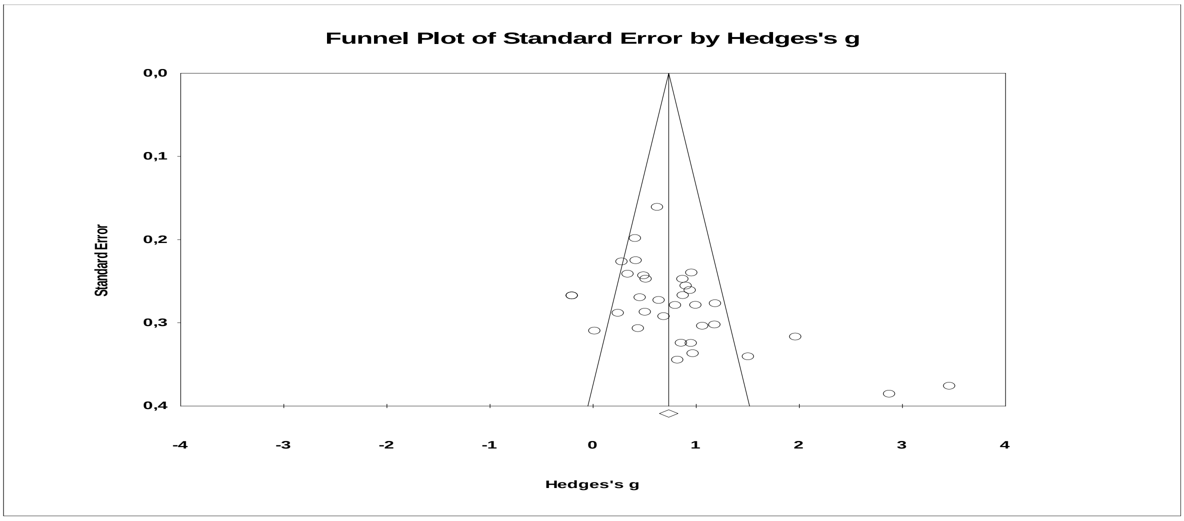


Figure 3. A Funnel Plot Assessing Possible Publication Bias

Also, there are some ways of assessing publication bias through performing statistical techniques, rather than non-statistical techniques (Lipsey & Wilson, 2001; Rothstein, Sutton, & Borenstein, 2005). Hence, in order to determine the publication bias through statistical techniques, classical fail-safe *N* analysis to reduce the average effect size to insignificant levels to increase the *p*-value for the meta-analysis to above 0.05 (Rosenthal, 1979), as well as Orwin's fail-safe *N* test to determine the values of criterion for a trivial log odd's ratio and mean log odds ratio in missing studies were performed (Orwin, 1983). In the current research, the classical fail-safe *N* analysis showed that a total of 810.00000 studies with null results would be required to bring the overall effect size to trivial level at 0.01. Besides, Orwin's fail-safe *N* test, which estimates the number of missing null studies that would be required to bring the average effect size to trivial level at 0.01, indicated that the number of missing null studies to bring the existing overall average effect sizes to 0.01 was found to be 141. Based on the results of the statistical and non-statistical techniques performed in the research, it was determined that there is no publication bias in the current meta-analysis.

**Comparison of the Effect Sizes of Student-Centered Teaching Approaches**

In the research, after examining the effectiveness of cooperative, constructivist, and computer-assisted teaching in comparison with traditional one, the three student-centered teaching approaches (cooperative, constructivist, and computer-assisted) were compared with each other. In order to compare the effect sizes of the studies in terms of cooperative, constructivist, and computer-assisted teaching approaches, a sub-group analysis was performed in the research. Two or more groups are compared to examine the difference between the effect size values in subgroup analyses (Borenstein et al., 2009). In the research, chi-square heterogeneity test Cochran's *Q*, which is the most common approach to evaluate the heterogeneity of the data acquired to determine the model to be used, was performed (Hedges & Olkin, 1985). According to the results of the heterogeneity test, a *p*-value lower than the accepted significance level demonstrates that the research results should be considered to be heterogeneous in line with the hypothesis put forward (Lipsey & Wilson, 2001). In contrast, a *p*-value upper than the accepted significance level demonstrates that the research results should be considered as homogeneous (Hunter & Schmidt, 2004). Table 5 presented the comparison of all the studies regarding student-centered teaching approaches.

Table 5. Comparison of Effect Size Differences regarding Student-centered Teaching

| Subgroup | $Q_b$ | p | $I^2$ | k | ES | 95% CI | | SE |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper | |
| Cooperative Teaching | | | | 21 | 0.698 | 0.588 | 0.809 | 0.056 |
| Constructivist Teaching | 0.099 | 0.952 | 79.78 | 5 | 0.831 | 0.574 | 1.088 | 0.131 |
| Computer-Assisted Teaching | | | | 8 | 0.788 | 0.589 | 0.988 | 0.102 |

*Note.* k = number of effect sizes; ES = effect size; SE = standard error; CI = confidence of interval for the average value of ES.

The subgroup analyses performed indicated that the studies included in the meta-analysis were homogeneous, thus there was not a statistical significant difference in terms of student-centered teaching approaches, $Q_B$ (2) = 0.099, *ns*. So, it may be suggested that the effect sizes in terms of academic success of students was not significant in terms of student-centered teaching approaches in the research. Also, when the effect sizes of the studies regarding the teaching approaches were taken into consideration, it might be indicated that constructivist teaching is more effective in the improvement of academic success of students in mathematics course, rather than the other student-centered teaching approaches.

## Discussion

Although many studies have examined the effectiveness of cooperative, constructivist, and computer-assisted teaching in mathematics on academic success through meta-analysis, there has been no meta-analysis to determine the comparison amongst these approaches of teaching with the traditional one. So, the purpose of this research was to perform a meta-analysis to draw conclusions about the effectiveness of traditional, cooperative, constructivist, and computer-assisted teaching, and also to compare the effectiveness of these four approaches. The preliminary analysis of the research indicated that cooperative, constructivist, and computer-assisted mathematics teaching were more effective in the improvement of academic success of students, rather than the traditional one. The average effect size values were calculated to be 0.698 for cooperative teaching, 0.831 for constructivist teaching, and 0.788 for computer-assisted teaching, indicating that all these three approaches of teaching were effective than the traditional one to improve the student success in mathematics. In line with recent meta-analyses demonstrating the benefits of cooperative teaching (Capar & Tarım, 2015), constructivist teaching (Semerci & Batdi, 2015), and computer-assisted teaching (Yeşilyurt, 2010), the present meta-analytic research shows the benefits of student-centered approaches regarding student success. Thus, it may be suggested that student-centered teaching should be used in mathematics, rather than the traditional one. Since traditional teaching requires students to memorize the course content and mathematical formulas, it seems not sufficient for effective learning.

In Turkey, traditional teaching has been the predominant approach used in mathematics over the years. As a result of it, the Turkish students have failed in mathematics both in national and international assessments. Therefore, based on the findings of the research, it can be suggested that student-centered teaching approaches should be adopted in mathematics. With student-centered teaching approaches, students are not exposed to information; rather they are given opportunities to have experiences in life-like learning environments to create knowledge (Driscoll, 2000). They learn mathematics in natural learning environments, by analyzing and solving problems, testing hypotheses, formulating questions, and reasoning statistically (National Council of Teachers of Mathematics [NCTM], 2014). Also, in classrooms where student-centered teaching approaches are adopted, students learn how to use mathematics in everyday life. In such classrooms, students have positive attitudes towards mathematics (Topan, 2013), enjoy learning mathematics (Noyes, 2012), and improve high order mathematical thinking ability (Saragih & Napitupulu, 2015).

The related finding obtained in the research has some implications for education systems similar to the Turkish Education System itself. Firstly, the findings obtained in the research showed that traditional teaching is insufficient in achieving the academic success of students. In other words, it was found that the academic success of students in the classrooms in which the student-centered teaching approaches (i.e. cooperative, constructivist, and computer-assisted) were used was higher than the students in the classrooms in which the traditional teaching was performed. This finding implied that the traditional mathematics teaching adopted in the Turkish Education System should be abandoned. The findings, at the same time, also indicated that the traditional mathematics teaching will not be effective in increasing student success in the near future. For this reason, it is important to support the use of student-centered approaches in mathematics teaching in the classroom, and to provide teachers with in-service training. Since teachers in the Turkish Education System are lacking the efficacy in applying student-centered approaches of teaching (Bulut, 2008), they should be subjected to in-service training to implement these approaches in the classroom effectively. In addition, by reviewing the mathematics curriculum and teaching-learning process, necessary steps should be taken to construct them in a contemporary way. However, all the obstacles against the effective implementation of student-centered teaching approaches of mathematics in the classroom should be identified and eliminated.

Also, the effectiveness of cooperative, constructivist, and computer-assisted teaching were compared with each other. It was found in the research that there was not a statistical significant difference amongst these approaches of teaching. However, when the average effect sizes of the studies of these teaching approaches were compared, it was determined that constructivist approach was higher than the other approaches of teaching. This can be explained by the fact that constructivist learning activities offer life-like situations (Brooks & Brooks, 1999), and they involve socially constructed environments (Jaramillo, 1996). Constructivist teaching "is about thinking and the thinking process rather than about the quantity of information a student can memorize and recite or, in the case of math for example, about answers based on memorized formulas" (Marlowe & Page, 2005, p. 8). Constructivist learning is meaningful and derives from a real context (Wheatley, 1991). In this respect, constructivist learning is seen as more meaning-making (Terhart, 2003) and the meaning is created by the learner rather than by direct teaching (Howe & Berv, 2000). In constructivism, learners are not empty barrels waiting to be filled, but they are active organisms that search for meaning (Driscoll, 2000). At the same time, it is important in constructivist learning that the information is not received and accepted by the learner, but the individual makes sense of the information (Holloway, 1999). Therefore, it can be suggested that constructivist teaching focuses on in-depth understanding, not regurgitating and repeating back (Marlowe & Page, 2005). The National Council of Teachers of Mathematics also offers standards for effective mathematics teaching, supporting the need for students to be able to analyze and solve problems, formulate questions, reason statistically, and to connect to mathematical concepts to daily lives–all consistent with constructivist teaching (NCTM, 2014). The related finding obtained in the research has some implications for education systems similar to the Turkish Education System itself.

First of all, the fact that there was no significant difference amongst student-centered teaching approaches (cooperative, constructivist, and computer-assisted) in the research suggests whether serious investments should be made with computer- assisted applications in the education system or not. The fact that the computer-assisted teaching does not lead to a higher performance than the other student-centered approaches in improving student success justifies criticisms towards computer-assisted practices. Moreover, the effect size of the constructivist teaching was found to be higher than the effect sizes of the other teaching approaches. This finding provides a small picture of what kind of panorama will emerge if the investment made for computer-assisted teaching is directed to the constructivist teaching. As a matter of fact, while it is seen that approximately 750 million dollars were allocated to computer-assisted teaching (Dündar & Akçayır, 2014), the budget allocated for the 2005 curriculum is considerably limited (Egeli & Hayrullahoğlu, 2014). With the budget sustained for the computer-assisted teaching in Turkey, high schools as well as many primary and middle schools have been supplied with interactive white boards, and teachers and students have been distributed with tablet computers (Pamuk, Cakir, Ergun, Yilmaz, & Ayas, 2013). However, although a wide range of investment has been made on the computer-assisted teaching, the failure of the Turkish students in national as well as in international assessments in mathematics is thought-provoking.

On the other hand, when the budget sustained for the 2005 curriculum is taken into consideration, it is seen that much has been spent on the development of the curriculum, rather than the physical environment of the classrooms, teacher education, and course materials. So, it may be suggested that spending merely on the development of the curriculum is not sufficient to create constructivist teaching and learning in the classroom. Since the constructivist teaching requires more than spending on the development of the curriculum, it is considered that the physical environment of the classrooms, teacher education, and course materials should be developed, as well as philosophy of education beliefs of teachers should be changed to be constructivist. For this reason, although the 2005 curriculum was prepared with a constructivist approach in Turkey (Akşit, 2007), the implementation of the teaching in mathematics has continued in a traditional way (Bulut, 2007), due to the insufficient infrastructure of the classrooms, inability of teacher in-service training, insufficient course materials, and the dominance of high stakes assessment. Therefore, it may be revealed that the constructivist teaching was attempted to be implemented in the classrooms without eliminating the problems and improving the infrastructure of the education system. As a result of it, the constructivist teaching has fallen from the eye in a short period of time, and new searches for the improvement of student success have been initiated. In contrast, the philosophy of constructivism should be well understood by teachers as well as the authorities of the education system, so as to implement it in classroom mathematics teaching. Because constructivist teaching is more like guiding and assisting than forcing information into a supposedly empty head (Driscoll, 2000), it requires students to have life-like learning experiences (Marlowe & Page, 2005) and create their own meaning by exploring, questioning, experimenting, and problem solving (Brooks & Brooks, 1999), as well as interacting with their peers (Jaramillo, 1996). From this point of view, the investments on the constructivist teaching in mathematics should be well planned and the learning environments in schools should be designed to be constructivist (Brooks & Brooks, 1999; Marlowe & Page, 2005). So, the results of the constructivist teaching in mathematics regarding the student success should be waited with patience, since it moves slowly in the classroom and creation of meaning and construction of the knowledge take considerable time. Despite the constructivist teaching requires more time for student learning (Brooks & Brooks, 1999); the end of it deserves this waiting, resulting in higher student academic success.

## Conclusions

In conclusion, the preliminary analysis of the research indicated that cooperative, constructivist, and computer-assisted mathematics teaching were more effective in the improvement of academic success of students, rather than the traditional one. Also, when the effectiveness of the cooperative, constructivist, and computer-assisted teaching approaches were compared with each other, it was found that there was not a statistical significant difference amongst these approaches of teaching. However, when the average effect sizes of the studies of these teaching approaches were compared, it was determined that constructivist approach was higher than the other approaches of teaching. In light of these findings, it may be indicated that all student-centered teaching approaches taken into consideration (i.e. cooperative, constructivist, and computer-assisted) are effective in the improvement of student academic success in mathematics, rather than the traditional one. Although cooperative, constructivist, and computer-assisted teaching are seen to be effective in the improvement of student academic success in mathematics, constructivist teaching is seen to be more effective than the other student-centered approaches of teaching. Since the present research was carried out by considering empirical studies only in the Turkish context, future research is suggested to be conducted to understand the role of cooperative, constructivist, and computer-assisted teaching in mathematics in diverse settings. Similar research can well be carried out in comparison with the international literature.

### Limitations

This research has not without its limitations, of course. One of the limitations was that only the empirical studies conducted in the Turkish context were involved in the research. The present research aimed to develop an understanding to make a comparison amongst student-centered teaching approaches and then make a policy analysis. So, a limited number of empirical studies could be involved in the meta-analysis. Also, this research merely focused on the comparison of the effectiveness of traditional, cooperative, constructivist, and computer-assisted teaching approaches, excluding their moderator analyses such as course type, instructional level, socioeconomic status, etc. Lastly, this research focused on a limited number of student-centered teaching approaches (i.e. cooperative, constructivist, and computer-assisted), without considering other student-centered teaching approaches.

## References

*Studies marked with (*) were included in the meta-analysis.*

Adıgüzel, A. (2009). Yenilenen ilköğretim programının uygulanması sürecinde karşılaşılan sorunlar. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, *9*(17), 77–94.

*Akbuğa, S. (2009). *İlköğretim 4. sınıf matematik dersinde işbirlikli öğrenme ilkelerine göre yapılandırılmış grup etkinliklerinin öğrenci erişilerine ve tutumlarına etkisi*. (Unpublished master's thesis), Dokuz Eylül University, Izmir.

Akinsola, M. K., & Olowojaiye, F. B. (2008). Teacher instructional methods and student attitudes towards mathematics. *International Electronic Journal of Mathematics Education*, *3*(1), 60–73.

Alessi, S. M., & Trollip, S. R. (2001). Computer-based instruction: Methods and development. Englewood Cliffs, NJ: Prentice-Hall.

Alsup, J., & Sprigler, M. J. (2003). A comparison of traditional and reform mathematics curricula in an eighth-grade classroom. *Education 3-13*, *123*(4), 689–694.

Akpınar, B., & Gezer, B. (2010). Öğrenen merkezli yeni eğitim yaklaşımlarının öğrenme-öğretme sürecine yansımaları. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi*, *14*, 1–12.

Akşit, N. (2007). Educational reform in Turkey. *International Journal of Educational Development*, *27*(2), 129–137.

Alsup, J. (2004). A comparison of constructivist and traditional instruction in mathematics. *Educational Research Quarterly*, *28*(4), 3–17.

*Akyol, M. (2006). *Oluşturmacı yaklaşımın matematik başarısına etkileri*. (Unpublished master's thesis), Yüzüncü Yıl University, Van.

*Anahtarcı, S. (2009). *Yapılandırmacı yaklaşıma dayalı matematik programında portfolyonun başarıya ve matematiğe karşı tutuma etkisi*. (Unpublished master's thesis), Trakya University, Edirne.

Anthony, G. (2000). Factors influencing first-year students' success in mathematics. *International Journal of Mathematical Education in Science and Technology*, *31*(1), 3–14.

*Arısoy, B. (2011). *İşbirlikli öğrenme yönteminin ÖTBB ve TOT tekniklerinin 6. sınıf öğrencileri matematik dersi "istatistik ve olasılık" konusunda akademik başarı, kalıcılık ve sosyal beceri düzeylerine etkisi*. (Unpublished master's thesis), Çukurova University, Adana.

Ayaz, M. F., & Sekerci, H. (2015). The effects of the constructivist learning approach on student's academic achievement: A meta-analysis study. *Turkish Online Journal of Educational Technology*, *14*(4), 143–156.

Baş, G., & Kıvılcım, Z. S. (2019). Türkiye'de öğrencilerin merkezi sistem sınavları ile ilgili algıları: Bir metafor analizi çalışması. *Eğitimde Nitel Araştırmalar Dergisi*, *7*(2), 639–667.

*Bayturan, S. (2011). *Ortaöğretim matematik eğitiminde bilgisayar destekli öğretimin, öğrencilerin başarıları,* *tutumları ve bilgisayar öz-yeterlik algıları üzerindeki etkisi*. (Unpublished doctoral dissertation), Dokuz Eylül University, İzmir.

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education*, *32*(3), 347–364.

Bilgin, T. (2004). İlköğretim yedinci sınıf matematik dersinde (çokgenler konusunda) öğrenci takımları başarı bölümleri tekniğinin kullanımı ve uygulama sonuçları. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi*, *17*(1), 19–28.

Breunlin, R. J. (1999). *The effects of hypermedia-aided anchored learning upon the achievement and retention of polygonal area concepts in high school geometry*. (Unpublished doctoral dissertation), Loyola University of Chicago, Chicago, IL.

Brooks, J. G., & Brooks, M. G. (1999). *In search of understanding: The case for constructivist classrooms*. Alexandria, VA: Association for Supervision and Curriculum Development.

Boaler, J. (2002). *Experiencing school mathematics: Traditional and reform approaches to teaching and their impact on student learning*. New York, NY: Routledge.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to meta-analysis*. New York: John Wiley and Sons.

Brooks, J. G. & Brooks, M. G. (1999). *In search of understanding: The case for constructivist classrooms*. (Revised ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Brown, M., Brown, P., & Bibby, T. (2008). "I would rather die": Reasons given by 16-year-olds for not continuing their study of mathematics. *Research in Mathematics Education*, *10*(1), 3–18.

Bruning, R. H., & Schraw, G. J., Norby, M. M., & Ronning, R. R. (2004). *Cognitive psychology and instruction* (4th ed.). Upper Saddle River, NJ: Prentice Hall.

Bukova-Güzel, E., & Alkan, H. (2005). Evaluating pilot study of reconstructed Turkish elementary school curriculum. *Educational Sciences: Theory & Practice*, *5*(2), 410–420.

Bulut, İ. (2008). Yeni ilköğretim programlarında öngörülen öğrenci merkezli uygulamalara ilişkin öğretmen görüşleri (Diyarbakır ili örneği). *Kuram ve Uygulamada Eğitim Yönetimi, 14*(4), 521–546.

Bulut, M. (2007). Curriculum reform in Turkey: A case of primary school mathematics curriculum. *Eurasia Journal of Mathematics, Science and Technology Education*, *3*(3), 203–212.

Capar, G., & Tarim, K. (2015). Efficacy of the cooperative learning method on mathematics achievement and attitude: A meta-analysis research. *Educational Sciences: Theory & Practice*, *15*(2), 553–559.

Card, N. A. (2012). *Applied meta-analysis for social science research*. New York: The Guilford Press.

Cuoco, A. A., & Goldenberg, E. P. (1996). A role for technology in mathematics education. *Journal of Education*, *178*(2), 15–32.

Çelik, S. (2013). *İlköğretim matematik derslerinde kullanılan alternatif öğretim yöntemlerinin akademik başarıya etkisi: Bir meta analiz çalışması* (Unpublished master's thesis), Eskişehir Osmangazi University, Eskişehir.

Cohen, J. A. (1992). Statistical power analysis. *Current Directions in Psychological Science*, *1*(3), 98–101.

Cohen, J. A. (1960). A coefficient of agreement for nominal scales. *Educational Psychology Measurement*, *20*, 37–46.

Cooper, H., Hedges, L. V., & Valentine, J. C. (Eds.). (2009). *The handbook of research synthesis and meta-analysis*. New York, NY: Sage.

*Çiftçi, E. (2010). *İlköğretim 6. sınıf matematik dersi geometri öğrenme alanında yapılandırmacı öğrenme yaklaşımına dayalı öğretimin öğrenci başarısı ve tutumuna etkisi*. (Unpublished master's thesis), Gazi University, Ankara.

Davidson, N. (1990). *Cooperative learning in mathematics: A handbook for teachers*. Menlo Park, CA: Addison-Wesley.

De Witte, K., Haelermans, C., & Rogge, N. (2015). The effectiveness of a computer-assisted math learning program. *Journal of Computer-Assisted Learning*, *31*(4), 314–329.

Driscoll, M. P. (2005). *Psychology of learning for instruction* (3rd ed.). Boston, MA: Allyn & Bacon.

Durnalı, M., Orakcı, Ş., & Aktan, O. (2019). The smart learning potential of Turkey's education system in the context of FATIH project. In Kanwar, A. S. (Ed.), *Cases on smart learning environments* (pp. 227–243). Hershey, PA: IGI Global.

Dursun, Ş., & Dede, Y. (2004). Öğrencilerin matematikte başarısını etkileyen faktörler matematik öğretmenlerinin görüşleri bakımından. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi*, *24*(2), 217–230.

Duval, S., & Tweedie, R. (2000a). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, *56*, 455–463.

Duval, S., & Tweedie, R. (2000b). A nonparametric "trim and fill" method of accounting for publication bias in meta-analysis. *Journal of American Statistical Association*, *95*, 89–98.

Dündar, H., & Akçayır, M. (2014). Implementing tablet PCs in schools: Students' attitudes and opinions. *Computers in Human Behavior*, *32*, 40–46.

Driscoll, M. P. (2000). *Psychology of learning for instruction*. Boston, MA: Allyn and Bacon.

Durlak, J. A. (2005). *Reading and understanding multivariate statistics*. Washington, DC: American Psychological Association.

Educational Reform Initiative [ERI]. (2005). *Report on the new curricula.* Istanbul: Istanbul Policy Center. Retrieved from http://www.erg.sabanciuniv.edu/

*Efe, M. (2011). *İşbirlikli öğrenme yönteminin, öğrenci takımları başarı bölümleri ve küme destekli bireyleştirme tekniklerinin ilköğretim 7. sınıf öğrencilerinin matematik dersi "istatistik ve olasılık" ünitesindeki başarılarına, tutumlarına ve motivasyonlarına* etkisi. (Unpublished master's thesis), Mustafa Kemal University, Hatay.

Egeli, H., & Hayrullahoğlu, B. (2014). Türkiye ve OECD ülkelerinde eğitim harcamalarının analizi. *Finans Politik & Ekonomik Yorumlar*, *51*(593), 93–108.

Ellis, P. D. (2010). *The essential guide to effect sizes: Statistical power, meta-analysis, and the interpretation of research results*. Cambridge: Cambridge University Press.

Erçelebi, E. (1995). *Geleneksel öğretim yöntemleri ile işbirlikli öğrenme yönteminin matematik öğretimi üzerindeki etkileri*. (Unpublished master's thesis), Dokuz Eylül University, Izmir.

*Erdoğan, F. (2015). *İşbirlikli öğrenme yönteminin ilkokul 4. sınıf matematik dersinde öğrencilerin akademik başarılarına ve üst bilişsel farkındalıklarına etkileri*. (Unpublished master's thesis), Dokuz Eylül University, İzmir.

*Erdoğan, F. (2013). *Matematik öğretiminde üstbilişsel stratejilerle desteklenen işbirlikli öğrenme yönteminin 6. sınıf öğrencilerinin akademik başarılarına, üstbilişsel becerileri ve matematik tutumuna etkisinin incelenmesi*. (Unpublished doctoral dissertation), Marmara University, İstanbul.

Eğitim Reformu Girişimi [ERG] (2005). *Yeni öğretim programları hakkında rapor*. İstanbul: İstanbul Politikalar Merkezi.

Fosnot, C. T., & Perry, R. S. (1996). Constructivism: A psychological theory of learning. In C. T. Fosnot & R. S. Perry (Eds.), *Constructivism: Theory, perspectives, and practice* (pp. 8–33). New York, NY: Teachers College Press.

Gagnon, G. W., & Collay, M. (2001). *Designing for learning: Six elements in constructivist classrooms*. Thousand Oaks, CA: Corwin Press.

*Gelici, Ö. (2011). *İşbirlikli öğrenme tekniklerinin ilköğretim yedinci sınıf öğrencilerinin matematik dersi cebir öğrenme alanındaki başarı, tutum ve eleştirel düşünme becerilerine etkileri*. (Unpublished master's thesis), Mustafa Kemal University, Hatay.

Glass, G. V., McGaw, B., & Smith, M. L. (1981). *Meta-analysis in social research*. Beverly Hills, CA: Sage.

*Gökcül, M. (2007). *Keller'in ARCS güdülenme modeline dayalı bilgisayar yazılımının matematik öğretiminde başarı ve kalıcılığa etkisi*. (Unpublished master's thesis), Çukurova University, Adana.

*Gülsar, A. (2014). *İşbirlikli öğrenmenin matematik başarısına etkisi ve bu yönteme ilişkin öğrenci görüşleri*. (Unpublished master's thesis), Uludağ University, Bursa.

*Güneş, G., & Asan, A. (2005). Oluşturmacı yaklaşıma göre tasarlanan öğrenme ortamının matematik başarısına etkisi. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi*, *25*(1), 105–121.

Hartung, J. Knapp, G., & Sinha, B. K. (2008). *Statistical meta-analysis with applications*. New York: John Wiley and Sons.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis.* San Diego, CA: Academic Press.

Hedges, L. V. (1983). A random effects model for effect sizes. *Psychological Bulletin*, *93*, 388–395.

Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 371–404). Charlotte, NC: Information Age Publishing.

Holloway, J. H. (1999). Caution: Constructivism ahead. *Educational Leadership*, *57*(3), 85–86.

Hossain, A., & Tarmizi, R. A. (2013). Effects of cooperative learning on students' achievement and attitudes in secondary mathematics. *Procedia-Social and Behavioral Sciences*, *93*, 473–477.

Howe, K. R., and Berv, J. (2000). Constructing constructivism: Epistemological and pedagogical. In D. C. Phillips (Ed.), *Constructivism in education: Opinions and second opinions on controversial issues* (pp. 19–40). Chicago, IL: The University of Chicago Press.

Hunter, J. E., & Schmidt, F. L. (2004). *Methods of meta-analysis: Correcting error and bias in research findings* (2nd ed.). Thousand Oaks, CA: Sage.

*İçel, R. (2011). *Bilgisayar destekli öğretimin matematik başarısına etkisi: GeoGebra örneği*. (Unpublished master's thesis), Selçuk University, Konya.

Jaramillo, J. A. (1996). Vygotsky's sociocultural theory and contributions to the developoments of constructivist curricula. *Education*, *117*, 133–140.

Johnson, D. W., & Johnson, R. T. (1999). *Learning together and alone: Cooperative, competitive and individualistic learning*. Boston, MA: Allyn & Bacon.

Johnson, D. W., & Johnson, R. T. (1991). *Learning mathematics and cooperative learning: Lesson plans for teachers*. Edina, MN: Interaction Book Company.

Johnson, D. W., & Johnson, R. T. (1990). Using cooperative learning in math. In N. Davidson (Eds.), *Cooperative learning in mathematics* (pp. 103–125). Menlo Park, CA: Addison-Wesley.

Jolliffe, W. (2007). *Cooperative learning in the classrooms*. London: Paul Chapman.

Jonassen, D. H., & Rohrer-Murphy, L. (1999). Activity theory as a framework for designing constructivist learning environments. *Educational Technology Research and Development*, *47*(1), 61–79.

*Kabuk, Ö. (2014). *İşbirlikli öğrenmeye dayalı tekniklerin öğrencilerin matematik başarısına etkisinin incelenmesi*. (Unpublished master's thesis), Mehmet Akif Ersoy University, Burdur.

Kapa, E. (1999). Problem solving, planning ability and sharing processes with LOGO. *Journal of Computer Assisted Learning*, *15*, 73–84.

Karacaoğlu, Ö. C., & Acar, E. (2010). Yenilenen programların uygulanmasında öğretmenlerin karşılaştığı sorunlar. *Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, *7*(1), 45–58.

*Keskin, S., & Kılıç, D. (2016). Ortaokul 7. sınıf matematik dersinde olasılık konusunun işbirlikli öğrenme yöntemiyle öğretiminin öğrencilerin akademik başarılarına etkisi. *Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *20*(3), 1173–1183.

*Koç, B. (2015). *İşbirlikli öğrenme yönteminin matematik dersindeki erişiye, kalıcılığa ve sosyal beceriye etkisi*. (Unpublished master's thesis), Adnan Menderes University, Aydın.

Kolawole, E. B. (2008). Effects of competitive and cooperative learning strategies on academic performance of Nigerian students in mathematics. *Educational Research and Reviews*, *3*(1), 33–37.

Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in the classroom: The effects of cooperative learning and metacognitive training. *American Educational Research Journal, 40(1),* 281–310.

*Kuzucuoğlu, G. (2006). *İşbirlikli öğrenme yönteminin ilköğretim 5. sınıf öğrencilerinin matematik dersindeki başarılarına etkisi*. (Unpublished master's thesis), Afyon Kocatepe University, Afyon.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1), 159–174.

Lessani, A., Yun, A. S. M., & Bakar, K. B. A. (2017). Comparison of new mathematics teaching methods with traditional method. *People: International Journal of Social Sciences*, *3*(2), 1285–1297.

Lightner, S. L. (1999). A comparison of the effectiveness of applied and traditional mathematics curriculum. *Journal of Industrial technology*, *15*(2), 1–9.

Lipsey, M., & Wilson, D. (2001). *Practical meta-analysis*. Thousand Oaks, CA: Sage.

Macnab, D. S., & Payne, F. (2003). Beliefs, attitudes and practices in mathematics teaching: Perceptions of Scottish primary school student teachers. *Journal of Education for Teaching*, *29*(1), 55–68.

*Marangoz, İ. (2010). *İlköğretim 6. sınıf matematik dersi geometri öğrenme alanında işbirlikli öğrenme yönteminin öğrenci başarısı ve tutumlarına etkisi*. (Unpublished master's thesis), Gazi University, Ankara.

Marlowe, B. A., & Page, M. L. (2005). *Creating and sustaining the constructivist classroom* (2nd ed.). Thousand Oaks, CA: Corwin.

McGlinn, J. E. (1991). Cooperative problem solving in mathematics: Beginning the process. *The Clearing House, 65(1),* 14–15.

Miles, M. B., Huberman, A. M., & Saldana, J. M. (2013). *Qualitative data analysis: A methods sourcebook* (3rd ed.). Thousand Oaks, CA: Sage.

Milli Eğitim Bakanlığı [MEB] (2018). *2018 liselere geçiş sistemi (LGS) merkezi sınavla yerleşen öğrencilerin performansı*. Ankara: Milli Eğitim Bakanlığı. Retrieved from https://www.meb.gov.tr/meb_iys_dosyalar/2018_12/17094056_2018_lgs_rapor.pdf

Milli Eğitim Bakanlığı [MEB] (2013). *Milli eğitim bakanlığı, basın ve halkla ilişkiler müşavirliği basın açıklaması*. Retrieved from http://karabuk.meb.gov.tr/www/egitimde-fatih-projesi-konulu-basin-aciklamasi/icerik/558

National Council of Teachers of Mathematics [NCTM] (2014). *Principles to actions: Ensuring mathematical success for all*. Reston, VA: National Council of Teachers of Mathematics.

Nguyen, D. M., Hsieh, Y. J., & Allen, G. D. (2006). The impact of web-based assessment and practice on students' mathematics learning attitudes. *The Journal of Computers in Mathematics and Science Teaching*, *24*(1), 5–25.

Noyes, A. (2012). It matters which class you are in: Student-centered teaching and the enjoyment of learning mathematics. *Research in Mathematics Education*, *14*(3), 273–290.

Olssen, M. (1996). Radical constructivism and its failings: Anti-realism and individualism. *British Journal of Educational Studies*, *44*(3), 275–295.

Organisation for Economic Cooperation and Development (OECD) (2004). *Learning for tomorrow's world: first results from PISA 2003.* Paris: OECD.

Organisation for Economic Cooperation and Development (OECD) (2007). *PISA 2006 science competencies for tomorrow's world*. Paris: OECD.

Organisation for Economic Cooperation and Development (OECD) (2010). *PISA 2009 science competencies for tomorrow's world*. Paris: OECD.

Organisation for Economic Cooperation and Development (OECD) (2013). *PISA 2012 science competencies for tomorrow's world*. Paris: OECD.

Organisation for Economic Cooperation and Development (OECD) (2016). *PISA 2015 science competencies for tomorrow's world*. Paris: OECD.

*Orçanlı, H. B., & Orçanlı, K. (2016). Bilgisayar destekli geometri öğretiminin 7. sınıf öğrencilerinin geometri başarısına ve geometri özyeterlik algısına etkisi. *Sosyal Bilimler Araştırma Dergisi*, *5*(1), 80–97.

Orwin, R. G. (1983). A fail-safe N for effect size in meta-analysis. *Journal of Educational Studies*, *8*(2), 157–159.

Ölçme, Seçme ve Yerleştirme Merkezi [ÖSYM] (2018). *2018 YKS değerlendirme raporu*. Ankara: Ölçme, Seçme ve Yerleştirme Merkezi Başkanlığı.

*Özsarı, T. (2009). *İlköğretim 4. sınıf öğrencileri üzerinde işbirlikli öğrenmenin matematik başarısı üzerine etkisi: Probleme dayalı öğrenme (PDÖ) ve öğrenci takımları-başarı bölümleri (ÖTBB)*. (Unpublished master's thesis), Ege University, İzmir.

Pamuk, S., Cakir, R., Ergun, M., Yilmaz, H. B., & Ayas, C. (2013). The use of tablet PC and interactive board from the perspectives of teachers and students: Evaluation of the FATİH Project. *Educational Sciences: Theory & Practice*, *13*(3), 1815–1822.

Perkins, D. (1999). *The many faces of constructivism. Educational Leadership*, *57*(3), 6–11.

*Pesen, A., & Bakır, B. (2016). İşbirliğine dayalı öğrenme yaklaşımının 6. sınıf öğrencilerinin matematik dersi alan konusundaki başarılarına etkisi. *Uluslararası Eğitim Programları ve Öğretim Çalışmaları Dergisi*, *6*(11), 71–84.

Phillips, D. C., & Soltis, J. (2004). *Perspectives on learning*. New York, NY: Teachers College Press.

Phillips, D. C. (2000). An opinionated account of the constructivist landscape. In D. C. Phillips (Ed.), *Constructivism in education: Opinions and second opinions on controversial issues* (pp. 1–16). Chicago, IL: University of Chicago Press.

*Pınar, S. (2007). *"Ölçüler" konusunun eğitim teknolojileri ve işbirlikli öğrenme yöntemleriyle öğrenilmesinin öğrencilerin matematik başarısına etkisi*. (Unpublished master's thesis), Marmara University, Istanbul.

*Pilli, O. (2008). *The effects of computer-assisted instruction on the achievement, attitudes, and retention of fourth grade mathematics course*. (Unpublished doctoral dissertation), Middle East Technical University, Ankara.

Przychodzin, A. M., Marchand-Martella, N. E., Martella, R. C., & Azim, D. (2004). Direct instruction mathematics programs: An overview and research summary. *Journal of Direct Instruction*, *4*(1), 53–84.

Ramani, P., & Patadia, H. (2012). Computer assisted instruction in teaching of mathematics. *IOSR Journal of Humanities and Social Science*, *2*(1), 39–42.

Reynolds, D., & Muijs, D. (1999). The effective teaching of mathematics: A review of research. *School Leadership & Management*, *19*(3), 273–288.

Rosenthal, R. (1979). The file drawer problem and tolerance for null results. *Psychological Bulletin*, *86*(3), 638–641.

Rothstein, H. R., Sutton, A. J., & Borenstein, M. (2005). *Publication bias in meta-analysis: Prevention, assessment, and adjustments*. West Sussex: Wiley.

Ruthven, K., Hennessy, S., & Brindley, S. (2004). Teacher representations of the successful use of computer-based tools and resources in secondary-school English, mathematics and science. *Teaching and Teacher Education*, *20*(3), 259–275.

Ruthven, K., & Hennessy, S. (2002). A practitioner model of the use of computer-based tools and resources to support mathematics teaching and learning. *Educational Studies in Mathematics*, *49*(1), 47–88.

Savaş, E., Taş, S., & Duru, A. (2010). Matematikte öğrenci başarısını etkileyen faktörler. *İnönü Üniversitesi Eğitim Fakültesi Dergisi*, *11*(1), 113–132.

Schrifter, D., & Fosnot, C. T. (1993). *Reconstructing mathematics education: Stories of teachers meeting the challenge of reform*. New York, NY: Teachers College Press.

Schwerdt, G., & Wuppermann, A. C. (2011). Is traditional teaching really all that bad? A within-student between-subject approach. *Economics of Education Review*, *30*(2), 365–379.

Semerci, Ç., & Batdi, V. (2015). A meta-analysis of constructivist learning approach on learners' academic achievements, retention and attitudes. *Journal of Education and Training Studies*, *3*(2), 171–180.

Shelby, L. B., & Vaske, J. J. (2008). Understanding meta-analysis: A review of the methodological literature. *Leisure Sciences*, *30*(2), 96–110.

Slavin, R. E. (1995). *Cooperative learning: Theory, research, and practice* (2nd ed.). Boston, MA: Allyn & Bacon.

Smith, J. P. (1996). Efficacy and teaching mathematics by telling: A challenge for reform. *Journal for Research in Mathematics Education*, *27*(4), 387–402.

Stigler, J. W., & Hiebert, J. (2004). Improving mathematics teaching. *Educational Leadership*, *61*(5), 12–17.

*Sulak, S. A. (2002). *Matematik dersinde bilgisayar destekli öğretimin öğrenci başarı ve tutumlarına etkisi*. (Unpublished master's thesis), Selçuk University, Konya.

Şahin, İ. (2010). Curriculum assessment: Constructivist primary mathematics curriculum in Turkey. *International Journal of Science and Mathematics Education*, *8*(1), 51–72.

*Şen, N. (2010). *İlköğretim altıncı sınıf matematik dersinde bilgisayar destekli sezgisel düşünme kontrollü olasılık öğretiminin öğrencilerin akademik başarı ve sezgisel düşünme düzeylerine etkisi*. (Unpublished master's thesis), Çukurova University, Adana.

*Şişman, M. (2007). *İlköğretim 8. sınıf matematik dersi çarpanlara ayırma ve özdeşlikler konusunun yapılandırmacı öğrenme yaklaşımına uygun olarak öğretiminin öğrenci başarısına etkisi*. (Unpublished master's thesis), Gazi University, Ankara.

Terhart, E. (2003). Constructivism and teaching: A new paradigm in general didactics? *Journal of Curriculum Studies*, *35*(1), 25–44.

Topan, B. (2013). *Matematik öğretiminde öğrenci merkezli yöntemlerin akademik başarı ve derse yönelik tutum üzerindeki etkililiği: Bir meta-analiz çalışması*. (Unpublished master's thesis), Kocaeli University, Kocaeli.

*Tuğral, Z., & Güvenç, H. (2016). İşbirlikli öğrenmenin lise öğrencilerinin matematik özyeterlik algıları, Başarı ve etkin katılımlarına etkileri. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, *17*(2), 259–274.

*Tuğran, Z. (2015). *İşbirlikli öğrenmenin lise öğrencilerinin matematik özyeterlik algısı ve başarısı üzerindeki etkileri*. (Unpublished master's thesis), Çanakkale Onsekiz Mart University, Çanakkale.

Türel, Y. K., Akgün, K., Aydın, M., & Yaratan, A. S. (2020). Uzak doğu ülkelerinin eğitimde teknoloji politikalarının incelenmesi. *İnönü Üniversitesi Eğitim Fakültesi Dergisi*, *21*(1), 48–61.

Türkmen, H. (2016). Evaluation of teachers' views of cooperative learning and their interventions in cooperative learning process. *Journal of European Education*, *6*(1), 60–72.

*Ural, A. (2007). *İşbirlikli öğrenmenin matematikteki akademik başarıya, kalıcılığa, matematik özyeterlilik algısına ve matematiğe karşı tutuma etkisi*. (Unpublished doctoral dissertation), Gazi University, Ankara.

Uyar, M. Y., & Doğanay, A. (2018). Öğrenci merkezli strateji, yöntem ve tekniklerin akademik başarıya etkisi: Bir meta-analiz çalışması. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, *14*(1), 186–209.

*Ünlü, M. (2008). *İşbirlikli öğretim yönteminin 8. sınıf öğrencilerinin matematik dersi "permütasyon ve olasılık" konusunda akademik başarı ve kalıcılık düzeylerine etkisi*. (Unpublished master's thesis), Gazi University, Ankara.

Wittwer, J., & Senkbeil, M. (2008). Is students' computer use at home related to their mathematical performance at school? *Computers & Education*, *56*, 736–746.

Wheatley, G. H. (1991). Constructivist perspectives on science and mathematics learning. *Science Education*, *75*(1), 9–21.

Whicker, K. M., Bol, L., & Nunnery, J. A. (1997). Cooperative learning in the secondary mathematics classroom. *The Journal of Educational Research*, *91*(1), 42–48.

Wolf, F. M. (1986). *Meta-analysis: Quantitative methods for research synthesis*. Thousand Oaks, CA: Sage.

Yağcı, E., Kaptı, S., & Beyaztaş, D. İ. (2012). İşbirliğine dayalı öğrenme tekniklerinin fen ve teknoloji dersinde uygulanmasına ilişkin nitel bir çalışma. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, *1*(23), 59–77.

*Yantır, N. (2007). *İlköğretim matematik öğretmenliği öğrencilerinin işbirlikli öğrenme yöntemiyle geometri dersine ilişkin erişi düzeylerinin belirlenmesi*. (Unpublished master's thesis), Dokuz Eylül University, İzmir.

Yeşilyurt, M. (2010). Meta-analysis of the computer assisted studies in science and mathematics: A sample of Turkey. *Turkish Online Journal of Educational Technology*, *9*(1), 123–131.

*Yıldız, N. (2001). *"İşbirlikli öğrenme" yönteminin ilköğretim 7. sınıf matematik öğretiminde öğrenci başarı üzerine etkisi*. (Unpublished master's thesis), Balıkesir University, Balıkesir.

Yıldız, V. (1998). *İşbirlikli öğrenme ve geleneksel öğretimin okulöncesi çocuklarının temel matematik başarıları üzerindeki etkileri ve mevcut uygulamalarla ilgili öğretmen görüşleri*. (Unpublished doctoral dissertation), Gaziantep University, Gaziantep.

*Yiğit, A. (2007). *İlköğretim 2. sınıf seviyesinde bilgisayar destekli eğitici matematik oyunlarının başarıya ve kalıcılığa etkisi*. (Unpublished master's thesis), Çukurova University, Adana.

Yolcu, H. (2011). Hanehalkının eğitim harcamalarını etkileyen etmenler: Kuramsal bir çalışma. *Mehmet Akif Ersoy Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *3*(5), 12–35.

Yorgancı, S., & Terzioğlu, Ö. (2013). Matematik öğretiminde akıllı tahta kullanımının başarıya ve matematiğe karşı tutuma etkisi. *Kastamonu Eğitim Dergisi*, *21*(3), 919–930.

Zain, S. F. H. S., Rasidi, F. E. M., & Abidin, I. I. Z. (2012). Student-centered learning in mathematics – constructivism in the classroom. *Journal of International Education Research*, *8*(4), 319–328.

Zakaria, E., Chin, L. C., & Daud, M. Y. (2010). The effects of cooperative learning on students' mathematics achievement and attitude towards mathematics. *Journal of Social Sciences*, *6*(2), 272–275.

Zhao, Y., & Cziko, G.A. (2001) Teacher adoption of technology: A perceptual control theory perspective. *Journal of Technology and Teacher Education*, *9*(1), 5–30.

## Author Information

**Gokhan Bas**

https://orcid.org/0000-0002-9755-0003

Nigde Omer Halisdemir University

School of Education

Department of Educational Studies

Turkey

Contact e-mail: *gokhanbas51@gmail.com*

**Zafer S. Kivilcim**

https://orcid.org/000-0002-7056-726X

Ministry of National Education

Turkey