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THE RELATIONSHIP BETWEEN STUDENTS' COMPUTATIONAL ESTIMATION SKILLS AND MATHEMATICAL SELF-EFFICIENCY

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Abstract: The factors related to estimating skills are twofold: cognitive and affective perspectives. Perception of self-efficacy in mathematics, one of the affective factors, is essential for the individual's capacity, abilities, and self-belief in mathematics for the mathematics course. The present study examined the relationship between students' computational estimation skills and mathematical self-efficacy perceptions. For this purpose, two sets of instruments were used as data collection tools: a computational estimation skills task and a mathematical self-efficacy perceptions scale. A correlational design was used in this study, and a total of 83 eighth-grade students participated in the research. As a result, it was concluded that there was a moderately positive and statistically significant relationship between computational estimation skills and mathematical self-efficacy perceptions. Students experience more stress when making estimations compared to mathematical computations whose results are specific. In addition, students mostly need to correct their estimations in questions related to computations with fractions, and they mostly use the rounding strategy when making estimations. These results are further discussed in relation to the perspective of supporting children's abilities for estimations at the primary school.

Keywords: computational estimation; estimation strategies; mathematical self-efficacy

1. Introduction

Estimation is an essential skill that complements forms of mathematical reasoning such as generalization (Segovia & Castro, 2009). Estimation is an action taken when actual values are unknown and expressed as an estimated value based on data containing uncertainties about a situation (Anagün, 2009; Boyraz & Aygün, 2017; Siegler & Booth, 2005) or expressed as an approximate value based on measurement (Enloe et al., 2001; Micklo, 1999; Segovia & Castro, 2009). Estimated values are unknowingly used when calculating the amount of shopping, the number of people in a place, the arrival time on a journey, the weight of the ingredients used in cooking, and the temperature of the air (Lemonidis et al., 2018; Tsao & Pan, 2013). Different estimation skills are used when considering whether the dimensions of an item purchased will fit in the room, and different estimation skills are used when calculating the expected score in the exam. Estimation methods also change depending on the situations encountered. While some of the estimations require computations, some require making an estimation based on measurement (Joram et al., 2005; Kılıç & Olkun, 2013). For this reason, estimation types are divided into two measurement and computational estimation by some researchers (Çilingir & Türnüklü, 2009; Hogan & Brezinski, 2003; Segovia & Castro, 2009). Computational estimation is the process of finding the number that gives the approximate result of a computation that cannot be made, or that needs to be determined precisely (Siegler & Booth, 2005). Measurement-based estimation is the approximate determination of the result of measurement using the mind, visual information, or reference point without resorting to a measurement tool (Van de Walle et al., 2014). In addition to computational and measurement estimation, there are also researchers who added heap estimation to the literature (Hanson & Hogan, 2000; Munakata, 2002). Heap estimation is used in situations such as estimating the number of people living in a settlement, the number of candies in a jar, or estimating how many grains of rice fit in a tablespoon (Pilten & Yener, 2013). However, this type can be considered within the scope of measurement-based estimation.

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2. Theoretical background

2. 1. Computational estimation

The computational estimation skill, which is based on computation, helps students think fluently and reach quick results and is a high-level skill that requires the estimator to think in multiple aspects (Segovia & Castro, 2009; Siegler & Booth, 2005). With these features, it is closely related to the concept of number sense. Number sense is defined as the ability to make sense of all the relationships of numbers, fewness-multitude, part-whole, and relations with actual quantities and measurements in the environment, rather than knowing how to count with flexible mental computation and numerical estimation components (Sowder, 1992). According to Pike and Forrester (1997), the ability to use and perceive number relations affects children's ability to estimate the area. Many mathematics educators attribute children's low estimation skills to their limited sense of numbers (Pike & Forrester, 1997; Reys & Yang, 1998; Sekeris et al., 2019; Sowder, 1992). Mental computation and estimation skills are skills that can be improved through education (Desli & Dimitropoulos, 2022; Yazgan et al., 2004), and teachers are recommended to give their students experience so that they can make better estimations (Anestakis & Lemonidis, 2014; Lemonidis & Likidis, 2021).

According to the results of studies on estimation, students can use different strategies for computational estimation (Dowker, 1997; LeFevre et al., 1993; Lemaire et al., 2000). Students can use one or more strategies together in their estimations, depending on the problem situation (Lemonidis & Likidis, 2021). Computational estimating strategies can be grouped under four main headings: number rounding, reorganization of transactions, compensation, and random estimating (Levine, 1982; Reys et al., 1991).

In the number-rounding strategy, the last digits of the numbers are rounded to multiples of 10 or 5 when calculating the result of the operation. For example, in the 28+33 operation, if 28 is rounded to the nearest ten, 30 and 33 are added; if 33 is rounded to the nearest ten, the result is obtained by adding 28 and 30. In studies, it is observed that the strategy used most by participants is rounding numbers (Bulut, 2019; Özcan, 2015). This is the most straightforward strategy for teaching or learning (Levine, 1982; Trafton, 1986); similarly, Reys (1993) stated in his study that students thought estimation and rounding were synonymous.

In the strategy of reorganization of transactions, the result is achieved by converting decimal fractions into fraction numbers for convenience, by factoring them when dividing, or by dividing the numbers within a certain logic to make the computation easier (Dowker, 1992 Levine, 1982). It is used by changing the given numbers and choosing more functional numbers instead. In operation 343 + 318 + 294 + 305 + 287, grouping the numbers around 300 and calculating them as 300x5, when estimating the result of 24x6, using the distributive property of multiplication and calculating the operation by arranging it as 20x6 + 4x6", changing the order in the 0,68+0,31-0,38 operation and writing it as 0,68-0,38+0,31, can be given as suitable examples of the reorganization of transactions strategy.

The compensation strategy is used to compensate for deviations from the actual number by arranging numbers and transactions. Reys (1982) stated that good estimators often use compensation, which is a strategy that should be used for a successful estimation. It can be applied during or at the process's end. For example, in the 38x26 process, if 38 is rounded to 40, the result will be more, so the error made in the process is compensated by rounding the number 26 to 25.

The outcome can be estimated randomly without any basis. Random estimating strategy is a strategy that good estimators should refrain from using because it involves subjective processes (Levine, 1982; Reys et al., 1991).

When the computational estimating strategies used by the participants in the studies were examined, it was determined that the most used strategy was the rounding of numbers (rearranging the numbers) strategy, and the least used strategy was the random estimating strategy (Bulut, 2019; Özcan, 2015). The individual who uses different strategies when estimating perceives mathematics not only as a science consisting of formulas and rules but also as a way of thinking (National Council of Teachers of Mathematics [NCTM], 2000). When the questions in the field of mathematics in PISA are examined, it is seen that many of the questions include estimation (Organization for Economic Co-operation and Development [OECD], 2009).

2. 2. Mathematical self-efficacy

Mathematics self-efficacy beliefs have been shown to have an impact on mathematical reasoning situations (Honicke & Broadbent, 2016; Lent et al., 1997; Pajares & Graham, 1999; Mukuka, 2021). Self-efficacy perception is defined as the individual's beliefs about his own ability to successfully complete relevant tasks (Pajares & Kranzler, 1995). Bandura's (1997) social cognitive theory states that the most essential motivation behind an individual's behavior is self-efficacy belief. It is a skill that an individual has used and will continue to use throughout his life, and it has become a determinant of academic success in learning environments (Arseven, 2016; Klassen, 2004). It has been observed that students with a sense of self-efficacy in mathematics pay attention and concentrate longer in solving problems, are patient, and make more effort during the solution (Joët et al., 2011). As a result of this effort, it has been determined that there is a significant relationship between mathematics performance, problem-solving performance, and self-efficacy perception (Cooper & Robinson, 1991; Joët et al., 2011; Pajares & Kranzler, 1995). It has been observed that students with high self-efficacy can estimate their own performance levels more accurately and clearly than others (Bouffard-Bouchard, 1989; Klassen, 2004). Many students may feel stressed when asked to make mathematical estimations or suddenly face a situation requiring mental computation. It is possible that the strength of the student's beliefs about his/her competence in mathematics and the duration of this stress is inversely proportional (Ulusoy & Şahiner, 2017). Many studies examining students' mathematics self-efficacy perceptions appear to focus on mathematics achievement (Aldridge et al., 2013; Delioglu, 2017; Vukovic et al., 2013; Zimmerman, 2000).

The research shows that although the education levels differ, students' examination skills are generally not very good (Dorko & Speer, 2015; Şişman & Aksu, 2016). When the studies were examined, it was seen that computational examination was more involved in research than measurement examination (Aydoğdu, 2020; Boyraz & Aygün, 2017; Bulut, 2019). Students feel more comfortable estimating the result with approximate values than calculating the results with exact values. It has been observed that students' feelings and thoughts about examination affect their examination performance, and affective factors are as influential as cognitive factors in examination success (Ashcraft & Faust, 1994; Boz & Bulut, 2012; Hopko et al., 2003). Sowder and Wheeler (1989) divided the computational examination skill, which is considered necessary for successful examination performance, into four components, one of which is called the emotional component. Reys et al. (1982) examined students with good computational estimation skills in three dimensions: number skills, cognitive processes, and emotional characteristics. Wong et al. (2021) stated in their study that low-achieving students presumably experienced short-term motivational benefits. Si et al. (2016) observed that adults' computation estimation competencies were affected by mathematics anxiety. Mukuka et al. (2021), in their quasi-experimental study on 11th-grade students, found that not only did the instructional approach have an impact on students' mathematical reasoning situations, but also their mathematics self-efficacy and task-specific self-efficacy beliefs had a significant impact. In the study conducted by Tella (2011), it was seen that self-efficacy is necessary for the mathematics success of secondary school students. According to Sulak (2008), one of the common characteristics of people who tend to make reasonable estimations is their self-confidence. It has been observed that students who have high self-confidence in mathematics but lower self-confidence in estimating prefer rule-based strategies in using estimation strategies compared to other students (Boz, 2009). In his study examining students' opinions on estimating skills, Aydoğdu (2020) found a difference between the estimate scores of students who evaluated themselves as successful or unsuccessful in estimating before the application, that is, those who determined their self-efficacy after the application.

2. 3. Purpose of the study

The factors related to estimating skills are twofold: cognitive and affective perspectives (Boz, 2009). Perception of self-efficacy in mathematics, which is one of the affective factors, is essential for the individual's capacity, abilities, and self-belief in mathematics for the mathematics course. When the literature is examined, it is seen that most of the studies on estimating are aimed at examining the estimating skill, and one of the least studied areas is the relationship between estimating and the affective factor (Boz, 2009; Hogan & Parlapiano, 2008; Reys et al., 1982). With the studies (Hogan & Parlapiano, 2008; Reys et al., 1982; Si et al., 2016) determining that the estimation also includes affective factors, it seems that the perception of self-efficacy, which is the cause of anxiety, prejudice, and feelings of insecurity towards the mathematics course, is worth examining. Therefore, the aim of the research is to examine the relationship between students' computational estimation skills and their self-efficacy perceptions towards mathematics. For this purpose, the sub-problems addressed in the research are as follows:

(1) What is the level of students' computational estimation skills?

(2) What is the level of students' self-efficacy perceptions?

(3) Is there a significant relationship between students' procedural estimation skills and their self-efficacy perceptions?

3. Method

3. 1. Research model

A correlational design was used in this study, which aimed to examine the relationship between students' estimation performances and their perceptions of mathematics self-efficacy. Correlational design is a quantitative research design that determines whether there is a correlation between two or more variables and what kind of relationship there is between the variables (Christensen, 2015). In this design, the researcher reveals the relationship between variables through correlation statistics without any intervention (Creswell, 2013).

3. 2. Participants

The research sample consists of 8th-grade students studying in a city in the north of Turkey. The sample group was determined in this way so that there were no deficiencies in the student's basic mathematical knowledge required to make estimations. Convenience sampling was preferred while collecting research data, and in this context, 83 students studying in three public schools were reached. 47 of these students are girls, and 36 are boys. Students were allowed to participate after written consent from their parents and teachers and their own wishes to participate. Participating students did not receive any special training on estimating before this study.

3. 3. Data collection tool

3.3.1. Computational estimation skills task. Before data collection, the relevant literature was examined, and the questions used in the studies regarding estimation skills were examined. It was observed that the majority of the studies examined included open-ended questions. For this reason, it was decided to keep the questions open-ended in this study to reduce the chance factor. Since the questions were applied to 8th-grade students, 12 questions covering the achievements of the mathematics curriculum up to the 8th grade were created by the researcher. For validity, the questions were also submitted to the opinion of an academician specialized in mathematics education. The pilot study of the task was administered to students in a public school. After the pilot application, it was observed that the students needed to answer some questions. For this reason, considering that students may have difficulty with specific questions or get bored of estimating, three questions were removed from the task with expert opinion. As a result, the Computational Estimation Skills Task consists of 9 questions. The questions in the task and the learning areas they relate to are given in Table 1.

Table 1. *Questions and learning areas in the Computational Estimation Skills Task*

Questions	Learning areas
1- After a while of renovation of the 1233-meter coastal road, the 326-meter section of the road was completed. Accordingly, how many meters of the road remain?	Computation with Natural Numbers

2- A newly opened library was visited by 74 students in the first week, 97 in the second week, and 103 in the third week. Accordingly, how many students visited the library in three weeks?	Computation with Natural Numbers
3- 4826 liters of water will be discharged into 12 tankers. Approximately how many liters of water does each tanker hold?	Computation with Natural Numbers
4- A transportation company purchased 125 trucks, each truck carrying 83 boxes. Approximately how many total parcels can this company transport?	Computation with Natural Numbers
5- $\frac{11}{12}+\frac{21}{10}=?$ What is the estimated result of the operation?	Computation with Fractions
6- $23+\frac{4}{10}=?$ What is the estimated result of the operation?	Computation with Fractions
7- Ayşe wants to cut 3 and 1/2 pizzas into quarter slices. How many equal slices can Ayşe divide this pizza into?	Computation with Fractions
8- In a school canteen, toast costs 3.75 TL, ayran costs 2.30 TL and water costs 1.15 TL. How much change does a student who pays 20 TL get from the canteen?	Calculating with Decimal Numbers
9- Mehmet paid 100 TL for almonds, which cost 32.25 TL per kilo. Accordingly, how many kilograms of almonds did Mehmet buy?	Calculating with Decimal Numbers

As seen in Table 1, the task includes questions that include mathematics used in daily life and in which the student can use more than one estimation strategy. For each question in the task, there are spaces where students can write their estimation results and answer the question, "What method did you follow when making your estimation? Explain".

3.3.2. Mathematics self-efficacy scale. In the study, the Mathematics Self-Efficacy Scale developed by Umay (2001) was used to determine students' perceptions of mathematics self-efficacy. The scale is divided into three sub-dimensions: mathematics self-perception, awareness of behavior in mathematics subjects, and ability to transform mathematics into life skills. The 3rd, 10th, 11th, 12th, and 13th items are in the self-perception dimension, the 4th, 5th, 6th, 7th, 8th, and 9th items are in the awareness of their behavior in mathematics subjects, and the 1st, 2nd, 14th items are in the dimension of ability to transform mathematics into life skills. There are a total of 14 items in the scale, which is prepared as a five-point Likert-type scale. With 8 items containing positive expressions and 6 containing negative expressions, the highest self-efficacy perception score that can be obtained from the scale is 70, and the lowest is 14 points. Responses are scored according to five levels ranging from "Strongly disagree (1)" to "Strongly agree (5)". Students participating in the research were asked to choose the most appropriate option from the options opposite each item.

3. 4. Data collection process

Before the data collection process, the necessary permission was obtained from the Provincial Directorate of National Education for the implementation of the research in the second semester of the 2021-2022 academic year. First of all, the computational estimation task was piloted on 20 students in a public school during one lesson. The Computational Estimation Skills Task and the Self-Efficacy Perception Scale were administered to 83 students in three public schools who did not participate in the pilot study during one class hour. Students answered the tasks in the given time. The students were informed about the purpose of the research before the application, and they were asked to answer the questions sincerely, not to leave any questions unanswered, to ask the researcher questions on unclear points, and to make detailed explanations. Then, 20-minute semi-structured interviews were held at separate times at school with students who only wrote their estimated results and did not write down how they calculated their computations in order to determine their estimation strategies. Interviews were recorded with a voice recorder, and then the audio recordings were converted into text.

3. 5. Data analysis

Before analysis, acceptable estimation ranges were determined for the questions in the Computational Estimation Skills Task. When the literature is examined, there are studies in which the estimation acceptance range is accepted as 50% points below and 50% points above the honest answer (Baroody & Gatzke, 1991; Boz, 2004; Crites, 1992; Siegel et al., 1982), and there are also studies in which the estimation acceptance range is accepted as 25% (Aydoğdu, 2020; Baroody ve Gatzke, 1991; Çilingir, 2008). In some studies, it has been observed that values 10% below or above the acceptance range are accepted (Boz, 2009; Özcan, 2015). In this study, considering the age range of the students values 25% points below and 25% points above the actual answer were deemed appropriate as the acceptable estimation range. Values within the acceptable estimation range were evaluated as "one" point, and values outside the range were considered as "zero" points. In the estimation study, data were collected in two stages. First, all students were asked to write their estimation results for all questions in the relevant spaces, without using paper and pencil. After this stage was completed, the forms were collected and each form was photographed. Then, the forms were distributed to the students again and they were asked to write in the relevant spaces how they arrived at their answers to the questions. Therefore, ratings are given only based on the estimation results they made.

In the Mathematics Self-Efficacy Scale, the items are determined as "I strongly disagree, I disagree, I am undecided, I agree, and I strongly agree." Positive items were scored as "Strongly agree: 5, Agree: 4, Undecided: 3, Disagree: 2, Disagree: 1". For negative items, the scoring is "Strongly Agree: 1, Agree: 2, Undecided: 3, Disagree: 4, Strongly Disagree: 5".

SPSS Statistical Package Program was used when analyzing the data of the research. Students were coded as S1, S2,… and the participants' Computational Estimation Skills Task scores and Mathematics Self-Efficacy Scale scores were recorded. According to the Kolmogorov-Smirnov test results, it can be said that the scores students received from the Computational Estimation Skills Task ($p = 0{,}07 > 0{,}05$) and the scores they received from the Mathematics Self-Efficacy Scale ($p = 0{,}2 > 0{,}05$) both had a normal distribution. For this reason, Pearson correlation coefficients were used to determine the relationship between the two data.

3. 6. Validity and Reliability

While creating the Computational Estimation Skills Task, questions appropriate to the grade level of the students participating in the research were used. During the preparation of the estimation task and for the analysis of the results, the opinions of two mathematics teachers and a lecturer specialized in mathematics education were consulted. In addition, both male and female students from all achievement levels participated in the research. For reliability, participant confirmation was sought after data analysis, and expert confirmation was sought at many stages of the study. Additionally, the KR-20 internal reliability coefficient of the Mathematics Self-Efficacy Scale is 0.982.

One of the researchers has been working as a mathematics teacher in a secondary school affiliated with the Ministry of Education in Turkey for a long time. For this reason, she noticed the issues that students had difficulty with in mathematics class and also had an idea about the issues that needed to be focused on, considering her own and her colleagues' experiences. As a result, she determined the problem of the research. Then, she created the questions of the test to be applied to the sample and presented it to experts in the field of mathematics education. In order to increase the content validity of the test, she tried to ask questions about each achievement. She was present in the classroom during the pilot and leading applications. She warned the students to answer the questions individually and answered the students' questions.

4. Results

4. 1. Findings regarding the first sub-problem

Descriptive statistics regarding the scores received from the Computational Estimation Skills Task by the 83 students participating in the research are presented in Table 2.

Table 2. *Descriptive statistics for computational estimation scores*

	Mean	Standard deviation
Scores	4,93	1,63

The highest score that can be obtained in the task is 9. The average of the scores obtained was measured as 4,93, and the standard deviation was 1,63.

In Table 3, the frequencies of the correct answers given by the students to the questions in the task are given.

Table 3. *Correct estimations and strategies*

Task Item	Learning Area	Correct Answers		Estimation Strategies (f)		
		f	%	Rounding	Reorganization	Compensation
1	Computation with Natural Numbers	76	91,5	45	31	
2	Computation with Natural Numbers	72	86,7	14	58	
3	Computation with Natural Numbers	39	46,9	22		17
4	Computation with Natural Numbers	39	46,9	12		27
5	Calculating with Fractions	32	38,5	11	17	4
6	Calculating with Fractions	20	24,0	5	14	1
7	Calculating with Fractions	24	28,9	3	16	5
8	Calculating with Decimal Numbers	59	71,0	26	11	22
9	Calculating with Decimal Numbers	53	63,8	24		29

According to Table 3, while the 1st (%91,5) and 2nd (%86,7) items were the questions with the most correct estimations, the least correct answers were given to the 6th and 7th questions. Since the first two questions involve addition and subtraction of natural numbers, the estimation success in these questions is high. It is noteworthy that the 6th and 7th questions, which have the lowest success rates, are questions that require operations with fractions. In addition, it was observed that the most used strategy by the students was "rounding numbers," and the least used was "compensating."

For each item in the estimation task, students were asked to first estimate and then write down the way they followed while making the estimation. Below are examples of strategies students used in their estimations.

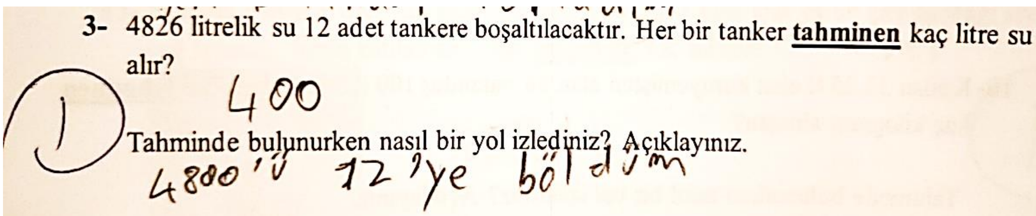
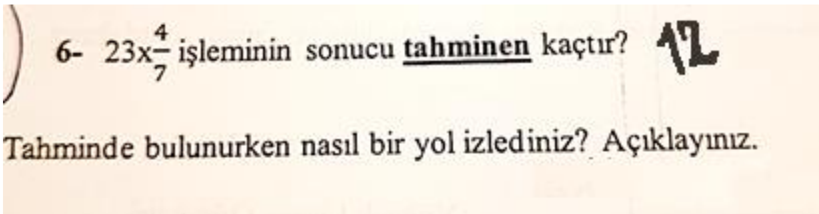


Figure 1. *Answer example for rounding strategy*

As seen in Figure 1, in the third question, the student used the rounding strategy, thus estimating 4826 liters by rounding it to 4800.


6- $23x\frac{4}{7}$ işleminin sonucu **tahminen** kaçtır? 12

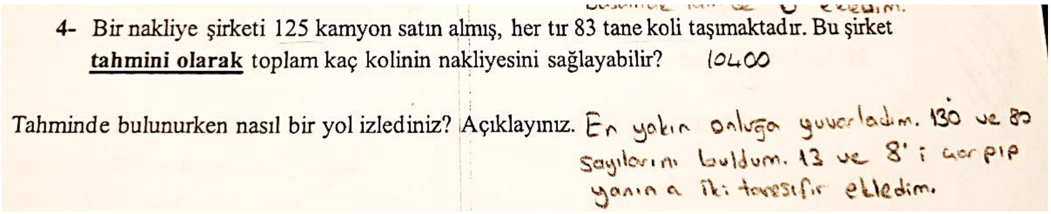
Tahminde bulunurken nasıl bir yol izlediniz? Açıklayınız.

Figure 2. *Answer example for reorganization strategy*

As seen in Figure 2, in the sixth question, the student used the strategy of reorganization of transactions and estimated the result as 12 without writing any explanation. In order to examine the reason for this student's answer and make a more detailed analysis, the part of the semi-structured interview conducted with the student regarding this question is presented below.

Researcher: *How did you go about the estimation you used to answer this question?*

S21: *I need help simplifying 23 with 7. However, I thought of 23 as 21 and divided it by 7. So the result is 12.*


4- Bir nakliye şirketi 125 kamyon satın almış, her tır 83 tane koli taşımaktadır. Bu şirket **tahmini olarak** toplam kaç kolinin nakliyesini sağlayabilir? 10400

Tahminde bulunurken nasıl bir yol izlediniz? Açıklayınız. En yakın onluğa yuvarladım. 130 ve 80 sayılarını buldum. 13 ve 8'i çarpıp yanına iki tane sıfır ekledim.

Figure 3. *Answer example for a compensation strategy*

As seen in Figure 3, in the fourth question, the student estimated by using the number 130 by rounding to the next higher decimal place instead of 125 and by using the number 80 by rounding to the lower decimal place instead of 83. This shows that he follows the compensation strategy.

4. 2. Findings regarding the second sub-problem

The analysis results of the answers to the sub-problem "What is the level of students' self-efficacy perceptions?" are shown in Table 4.

Table 4. *Descriptive statistics of mathematics self-efficacy perception scores*

	Mean	Standard deviation
Scores	45,78	9,70

The lowest score can be 14, and the highest score can be 70 from the Mathematics Self-Efficacy Perception Scale, which is a 5-point Likert-type scale consisting of 14 items. The average of the scores received by the students was found to be 45.78.

4. 3. Findings regarding the second sub-problem

According to the correlation computation, it was concluded that there was a moderate ($r = 0.424$; $p = 0.000 < 0.01$) positive and statistically significant relationship between computational estimation skills and mathematics self-efficacy perceptions.

5. Discussion and Conclusion

When the findings regarding the estimation skill level were examined, it was seen that the students received above-average scores. When the answers given by the students in the research were examined according to their topic distribution, most of the students reached the correct answers to the questions regarding computations with natural numbers. It was determined that most students needed to have corrected estimations in questions related to computations with fractions. It has been observed that most of the students try to perform computations by adhering to algorithms in addition to making estimations in the fraction questions, and they reach the wrong conclusion due to operation errors in fractions. Based on this, it can be concluded that students have low estimation skills in fractions and that they have difficulty, especially in the sub-field of learning computations with fractions. This result is parallel to the results of the studies conducted by Aytekin and Toluk-Uçar (2014) and Bulut (2019). Accordingly, Aytekin and Toluk-Uçar (2014) concluded that although secondary school students' mathematics achievement was high, their fraction estimation skills were relatively low. Bulut (2019) stated that students had difficulty with computational estimation skills when answering questions on computations with fractions.

It was observed that the students participating in the research concentrated on specific strategies when making estimations. Accordingly, students primarily use the rounding strategy. It was also observed that students tried all strategies for natural numbers, mostly preferred the strategy of reorganization for fractions, and used compensation strategies along with rounding for decimal numbers. According to Boz & Bulut (2012) and Özcan (2015), students prefer the rounding strategy the most. It can be said that students use the rounding strategy because they are familiar with it from their achievements in mathematics lessons. Additionally, when the students' answers are examined, it can be said that they try to solve the question by performing mental operations with classical algorithms rather than using an estimation strategy. It has also been observed that students look for precise and correct answers rather than estimated results. It has also been observed that students can use more than one estimation strategy when necessary.

It was concluded that there was a moderately positive and statistically significant relationship between computational estimation skills and mathematics self-efficacy estimation. Students experience more stress when making estimations compared to mathematical operations whose results are specific. It is expected that a student with low self-efficacy, who believes that he cannot do computations even with paper and pencil, will also have low success in estimation. Considering that students with high self-efficacy and belief in their own abilities in mathematical computations may experience less anxiety when estimating, the error rate in the computations may also decrease, and they will achieve higher scores. Based on this, the student's high performance in estimation skills depends on their firm beliefs and attitudes about their own abilities. In previous years, studies have been conducted that concluded that there is a positive relationship between estimation skill and mathematics achievement (Dowker, 1997; Levine, 1982; Van Garderen, 2003). It has been observed that students with good mathematics performance also have good estimation skills. Boz and Bulut (2012) stated in their study that the student's feelings and thoughts about estimation have an impact on whether the estimation performance is good or bad. Affective factors, as well as cognitive factors, have an impact on estimation performance. Similar to these studies, students with a high perception of mathematics self-efficacy also have high estimation performances. Students who consider themselves proficient in mathematics also achieved good results in their estimation skills.

The students' estimation performances could be at a reasonable level. In order to reason and make comments in solving daily life problems in mathematics, estimation skills must be developed. For this reason, teachers can be recommended to tell students more about the existence of specific strategies for estimation and to include appropriate estimation exercises in their lessons. This study was conducted with the students determined as the sample group, regardless of their achievement level and gender. Other similar studies can be conducted by taking such variables into account. Additionally, future studies can include experimental studies examining students' estimation skills.

Disclosure statement

No potential conflict of interest was reported by the authors.

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