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SCIENTIFIC ARTICLE |

How mathematical anxiety affects the abstraction of elementary fifth graders on fraction material through the Concrete-Representational-Abstract approach?

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ABSTRACT

Introduction. Abstraction is related to the process of manipulating and considering concepts, methods, or rules used in everyday life to understand mathematical concepts. On the other hand, anxiety is also one of the factors that hinder students' ability to understand mathematical concepts. Based on this, further research is needed to see the effect of mathematical anxiety on students' activities in manipulating or considering concepts, methods, or rules in solving problems using the CRA approach.

Study participant and methods. Participants in this study were 58 fifth-grade students (aged 10 to 11 years) at an elementary school in Mataram City, Indonesia. Based on the results of the mathematics ability test and the results of the mathematics anxiety questionnaire, one student with low mathematics anxiety (LMA) and one student with high mathematics anxiety (HMA) were selected, both of whom had moderate mathematics abilities. Both subjects will be given activities using the CRA approach to represent fractions of the part-whole concept and add fractions using fraction objects of the part-whole concept. Furthermore, both subjects will be interviewed to describe the abstraction in both activities.

Results. It can be found differences as well as similarities between LMA and HMA subjects in representing the fraction of the whole part concept and in carrying out fractional operations. In representing the fraction of the part whole concept, in the concrete phase, the LMA subject used a more advanced strategy (using three stages, namely the planning, process and results stages) than the HMA subject (using two stages, namely the process and results stages). This difference in strategy demonstrated that the LMA subject was more careful in determining the subject pieces while the HMA subject used more strategies that the subject believe would be successful in solving mathematical problems. In the problem of fractional operations, there are differences between LMA and HMA subjects in manipulating number expressions. Although the methods of manipulation carried out by the two subjects were different, both LMA and HMA carried out the right process and the results of the correct answer.

Conclusion. The results show that anxiety affects students in certain dimensions, such as in the concrete phase in representing fractions and the abstract phase in completing fraction operations. In the concrete phase to represent fractions, subjects LMA have a cautious attitude in implementing the strategies used compared to subject HMA. In the fractional operations section, there were differences in manipulated fractional expressions in the abstract phase.

KEYWORDS

abstraction, mathematical anxiety, CRA approach, fractions

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INTRODUCTION

In the world of education, anxiety is one of the main factors that hinder students' abilities and performance. Anxiety has a negative impact on students' ability to learn. Anxiety also affects a person in facing certain situations, such as exams, doing assignments or in following lessons. Many anxieties that may occur in students (general anxiety, phobia, stress, social anxiety) and the anxiety that students often face is math anxiety. Based on the results of research conducted in OCED member countries, students from 45 countries out of 63 countries (71.42%) are still plagued by fear of mathematics including Indonesia [1]. Indonesia has a math anxiety score below the average (interval 0.2-0.4) among OECD countries which results in Indonesian students' mathematics performance also being below average (interval 350-400). In addition, the report results also show that three out of four students in Indonesia experience fear when taking math lessons (the same as Argentina, Malaysia, Mexico, Romania, Tunisia and Uruguay) [1].

Mammarella et al., and Mitchell et al. revealed that mathematics anxiety has existed since childhood and usually mathematics anxiety begins at the age of 10-11 years. The authors showed that in this age group, students still have behavioral responses, emotions, lack of motivation in learning mathematics, and unstable psychophysiological changes that cause students to experience mathematics anxiety and have an impact on mathematics performance [2; 3]. Lau et al. revealed that mathematics anxiety is also influenced by teacher personality. Many mathematics teachers have a background of mathematics anxiety so these teachers only have minimal knowledge and do not have the right concept in teaching mathematics in class [4]. This situation will have an impact on the students being taught so that students often experience mathematical misconceptions. Malanchini et al. and Szczygiel et al. also showed that genetic factors can cause someone to experience mathematical anxiety. The authors showed that parents often give negative feedback to children in doing mathematics, this has an impact on children's emotions when learning mathematics so children feel anxious when making mistakes in doing mathematics or getting bad grades in mathematics [5; 6].

According to the A. Zanabazar et al. math anxiety is a fear that evokes unpleasant feelings towards mathematics as well as dyscalculia. It often leads to negative outcomes and prevents the students from handling math solutions [7].

According to the A. Zanabazar et al., math anxiety is a fear that evokes unpleasant feelings towards mathematics as well as dyscalculia. It often leads to negative outcomes and prevents the students from handling math solutions [7]. Zanabazar et al. also explained that math anxiety is the result of negative experiences in the form of teasing from classmates, unpleasant teacher communication patterns, lack of attention and appreciation from teachers when taking math lessons, and students' fear of being scolded when making mistakes [7]. Kizilelma et al. argue that math anxiety prevents students from solving math problems but also causes students to be weak in understanding math concepts. Students always assume that math concepts are abstract and difficult to understand, even though they are easy because their application is often found in various daily life activities [8]. A study by Alves et al. showed a relationship between mathematics anxiety and mathematics performance. Mathematics anxiety will affect mathematics performance in terms of manipulating fraction symbols and processing fraction ratios such as fluency in solving mathematics problems, written calculations, knowledge of fractions, and symbolic processing of fractions [9]. Dios et al. and Bornaa et al. also stated that math anxiety will interfere with students in living their daily lives. Math anxiety will cause a weakening or loss of will to solve problems related to math both in school and in daily life [10; 11]. One of the mathematical performances is abstraction.

Yilmaz and Argun stated that abstraction is a thinking process that involves relationships between mathematical objects and transforms those relationships into certain expressions that are independent of those mathematical objects. The authors stated that to determine the expression of the relationship between objects, one must have a clear concrete picture of a concept so that one can perform visual and non-visual visualization to create a mathematical expression of several objects [12]. Benis-Sinaceur stated that abstraction is a process of considering and manipulating operations, rules, methods, and concepts in dealing with real-world phenomena related to mathematics. The author explained that there is no single way to solve mathematical problems so that someone can solve the problem in many ways and the methods used are not considered something unique but are considered a common process [13].

Each student's abstraction in solving mathematical problems is not the same. Based on the results of the research conducted by Radiusman [14] regarding the representation of fractions in solving problems related to everyday life, there are still many students who are not able to abstract fractions, especially in considering or manipulating an object to solve a given problem. The results of the study also showed that only 9 out of 41 students (21.95%) were correct in representing fractions with a value of one-fifth, while 32 out of 41 students (78.04%) represented fractions with answers outside the fraction concept taught in school (the part-whole congruent part fraction concept). Mistakes that students still make in abstracting the concept of fractions include representing with the concept of fractions parts that are not congruent as a whole, dividing an object into 5 parts but still having objects left over, or not being able to represent the fractions inside. Examples of abstractions made by students can be seen in figure 1 [14].

Figure 1 Student abstraction in representing the value of one-fifth of an object

Based on the results of this study, it is necessary to conduct further research on the factors that cause differences in the abstraction of fractional concepts taught at the elementary school level in Indonesia (part whole congruent part), especially regarding the process of considering and manipulating strategies, concepts and operations in representing objects, and solving numerical operations of related mathematical problems in everyday life.

Kokkonen et al. explained the CRA approach is an approach based on Brunner's cognitive development theory, namely enactive, iconic, and symbolic. The enactive stage is defined as the action stage which corresponds to the concrete stage in the CRA approach, the iconic stage is defined as the image stage and corresponds to the representational stage in the CRA approach, and the symbolic stage is defined as the abstraction or language stage and aligns with the abstract stage in the CRA approach [15]. The CRA approach uses step-by-step instructions where students complete mathematical problems or tasks with the help of manipulative objects (concrete), then continue with pictures (representational) and end with using numbers or symbols only (abstract). These three stages are carried out sequentially and each stage builds on previously taught concepts, helping students transition between conceptual and content knowledge [16]. The CRA approach focuses on instruction rather than intervention [17] so that it is hoped that students can demonstrate an understanding of a mathematical concept. Research using the CRA approach has been widely conducted, such as operation with regrouping [18], single digit addition [19], algebraic symbol representation [20], multidigit multiplication problem [21]. So far, there has been no research using the CRA approach on fraction representation and fraction addition materials. This opens up the opportunity that the CRA approach can be applied to both materials.

In research using the CRA approach that has been carried out previously, generally at the concrete stage, researchers use tools that are directly related to mathematics such as base-10 Blocks and place value mats [17], analog clocks and paper banknotes [22], plastic tapes of different colors and lengths [23] and number-figure blocks [24] where the tools used have certain numerical values. In contrast to previous studies, this study did not use tools that have certain fractional values so that through the phases carried out in the CRA approach, it can be explained how abstraction activities carried out by subjects with low mathematical anxiety and subjects with high mathematical anxiety represent fractions and perform fractional operations. In line with the implementation of the CRA approach, this study used a concrete object in the form of a rectangular bread that was used by both subjects to represent fractions and complete the given fraction operations.

Based on the background described above, the purpose of this study is to find out the mathematical anxiety towards the abstraction of elementary school students in representing the concept of fractions, parts, and wholes and performing fraction operations through the CRA approach.

RESEARCH METHODS

1. Research design

This type of research is descriptive qualitative research that aims to describe the abstraction of students' fraction concepts on fraction representation and fraction addition materials using the Concrete-Representational-Abstract (CRA) approach. The abstraction of the fraction concept in question is the process of considering and manipulating rules or ways to solve fraction problems. In this study, students were given concrete objects in the form of bread that would be used to solve fraction problems using the CRA approach.

2. Participants and data collection

Participants in this study were 58 fifth-grade students (aged 10 to 11 years) in primary schools in Mataram City, Indonesia. Initially, all participants were given a mathematics ability test to determine their level of mathematics ability. The results of the students' mathematics ability test can be seen in table 1. After the participants completed the mathematics test, they were given a mathematics anxiety questionnaire consisting of 15 statements related to mathematics anxiety when learning mathematics (4 statements), anxiety when taking mathematics lessons (5 statements), and anxiety when facing mathematics exams (6 statements). The results of the mathematics anxiety questionnaire can be seen in table 1.

Table 1

The result of math ability level and math anxiety level

Math ability level			
Criteria	Score	N	Percentage (%)
High	0-45	8	13.79
Moderate	46-70	31	53.44
Low	71-100	19	32.75
Math anxiety level			
Criteria	Score	N	Percentage (%)
High	15≤x<37.5	17	29.31
Low	37.5<x≤60	41	79.68

Based on the results of the mathematical anxiety test and the mathematical ability test, two subjects were selected consisting of one subject of low mathematical anxiety (LMA) and one subject of high mathematical anxiety (HMA) who have relatively the same mathematical abilities which are at a moderate level. The procedure for selecting sample in this study can be seen in figure 2.

3. Data collection and research instrument

Data collection was carried out through the interview process and used time triangulation as a tool to validate the interview data obtained. Interview data were obtained based on the results of students' work in representing fractions and fraction operations where the representation of fractions and fraction operations used the concept of part whole fractions.

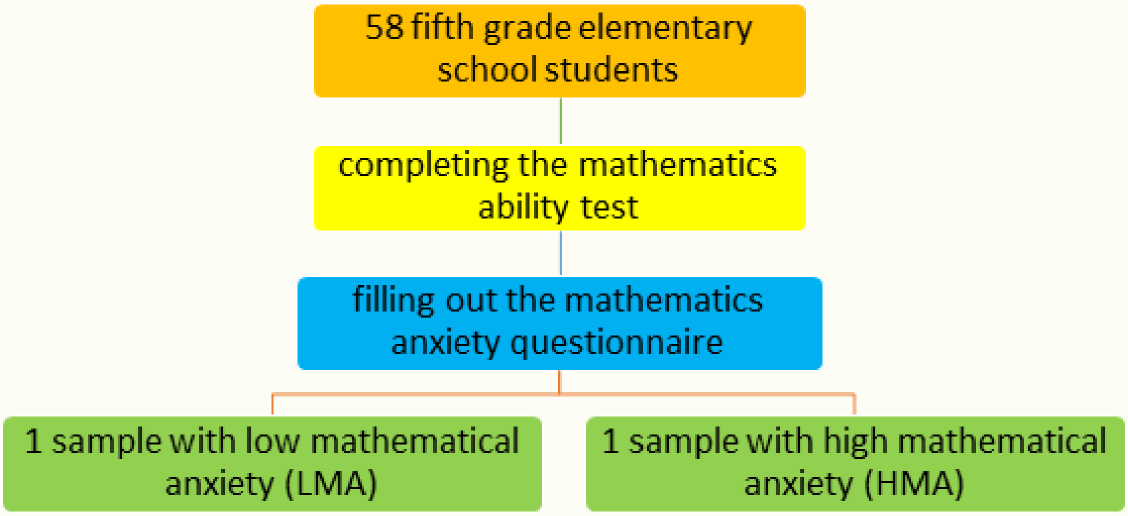


Figure 2 Sampling procedure

The instruments in this study were of two types, namely the mathematics anxiety questionnaire and the fraction abstraction test. The mathematics anxiety questionnaire in the study used a questionnaire developed by Juniati and Budayasa which was used to measure mathematics anxiety when students were learning mathematics, taking mathematics lessons, and taking mathematics exams for prospective mathematics teacher students. The mathematical anxiety questionnaire used in this study consisted of 15 statements consisting of 4 statements about anxiety in learning mathematics, 5 statements about anxiety in taking mathematics lessons, and 6 statements about anxiety in mathematics exams [25]. The anxiety questionnaire used in this study had undergone changes in language adjustment due to its use at the elementary school level prior to dissemination. This instrument was also tested using product moment validation test and Cronbach's alpha test to obtain a valid and reliable instrument. The next step was that both subjects were asked to solve the problem of the fractional representation of the whole part fractions and the fractional operation of the whole part with a CRA approach. Based on these activities, the researchers conducted data collection through interviews. Interviews were conducted repeatedly using the time triangulation technique as a technique to validate the data obtained. Furthermore, the data obtained were analyzed using data analysis techniques consisting of three stages, namely data condensation, data presentation, and conclusions [26].

STUDY RESULTS

1. The instrument's reliability test result

The test of the mathematical anxiety questionnaire was tested on 116 elementary school students in 5th grade and then the results obtained were tested for reliability and validation of the question items using the Cronbach alpha test available on the SPSS software. Based on the Cronbach alpha test, the results obtained were 0.769 ($r \geq 0.6$). Therefore, the instrument was reliable to be used to measure the anxiety of elementary school students over time. Furthermore, the validation results of the question items can be seen in table 2.

Based on table 2, it can be seen that the validation value of each question item was greater than 0.1809 (DF= n-2) so that each valid mathematical anxiety questionnaire statement was used to measure mathematical anxiety when students study mathematics, do mathematics assignments, and take mathematics exams. Furthermore, it was described about the abstraction from subject with low math anxiety (LMA) and subject with high math anxiety (HMA) in solving two problems of fraction, namely representing fractions and performing fractional operations.

Table 2

The result of validation of question items

Anxiety	Item number	Item validation value	Description
Anxiety in learning mathematics	1	0.387	Valid
	2	0.344	Valid
	3	0.398	Valid
	4	0.357	Valid
Anxiety following math lessons	5	0.519	Valid
	6	0.393	Valid
	7	0.453	Valid
	8	0.300	Valid
	9	0.453	Valid
Anxiety towards math exams	10	0.306	Valid
	11	0.480	Valid
	12	0.474	Valid
	13	0.416	Valid
	14	0.446	Valid
	15	0.263	Valid

2. Representing fractions

In the first problem, namely representing fractions, both subjects were asked to represent the value of the fraction with a value of two-fifths using the CRA approach. Both subjects were given concrete objects that represented the concept of whole part fractions. In the concrete phase, the LMA subject was not able to find the direction of cutting the object so that the strategy was carried out using three stages, namely the planning stage, the process stage, and the results stage. At the process stage, the subjects interpreted different ways of obtaining pieces of the object. The LMA subject performed hand movements in the form of imaginative movements and concrete movements on the object. The imaginative movements were carried out by moving the fingers over the object as if making a line on the object so that the object was divided into several parts. Furthermore, the subject LMA made a concrete movement by folding the object into several parts to strengthen the suspicion of the previous imaginative movement. This is in line with the findings of Faradiba et al. who stated that LMA subjects use hand movements in solving problems [27] and Živković et al. and Ashkenazi and Eisner who stated subjek LMA used more advanced strategies to obtain the right answers [28; 29]. At the process stage, the LMA subject chose a tool that was considered to be able to cut objects based on the results obtained at the planning stage and at the results stage the LMA subject grouped the object pieces into two groups and chose a group that represented a fraction with a value of two-fifths. Based on the three phases carried out, the results are obtained in line with the opinion of Jenifer et al. who stated that LMA subjects did not experience difficulties in making decisions to choose groups that represented the problems given [30].

In the representational phase, the LMA subject represented the activities in the concrete phase into the picture and the results given were completely in accordance with the activities carried out in the concrete phase. The study by Geary et al. also showed that LMA subjects have good spatial abilities in representing the activities carried out [31]. In the abstract phase, the LMA subject manipulated the object by representing the image of the object into the form of a fractional symbol and the result of the fractional symbol was true. The ability to write fraction symbols that represent the instructed fractional values is in line with the opinion of Kızılelma et al. who stated that LMA subjects can solve simple problems [8]. The activities carried out by the LMA subjects in representing the concept of part-whole fractions using the CRA approach can be seen in figure 3.

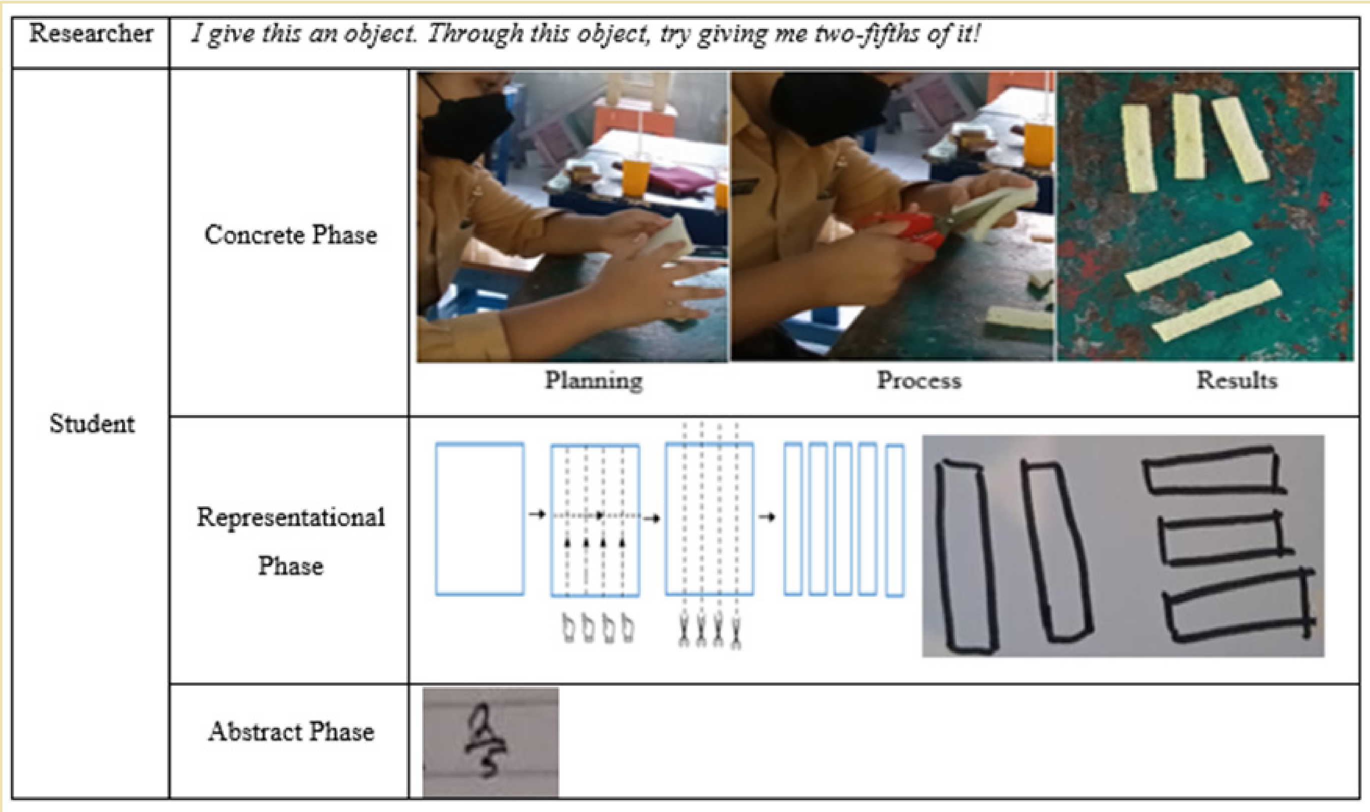


Figure 3 LMA subjects in representing the concept of part-whole fractions using the CRA approach

Furthermore, in representing the fraction, the subject of HMA used a strategy with two stages in the concrete phase, namely the process and the results stage. At the process stage, the HMA subject seemed to know the direction and how to produce slices of bread so the subject immediately chose a tool to cut the object into several pieces. A study by Ashkenazi and Eisner showed that HMA subjects do not hesitate to take action in solving problems so subjects do not use strategies that are considered more sophisticated to get the correct answer [29]. At the results stage, the HMA subject arranged the use of objects by grouping pieces of objects into two groups. In line with the research results of Jenifer et al., the HMA subject did not experience difficulty and hesitation in making the decision to choose a group that represented the instructed fraction [30].

Next, in the representational phase, the HMA subject manipulated the process that had been carried out in the previous phase by describing the process carried out and the subject did not experience difficulty in representing the process that has been carried out. This is contrary to a prior study by Malanchini et al. and Moscoso et al. that stated mathematical anxiety would affect a person in symbolic representation [5; 32]. In the abstract phase, the subject manipulated the image by representing the image obtained in the previous stage into a fractional symbol. The problem in writing fraction symbols is simple and this is in line with the results of the study by Escarez et al. which stated that HMA subjects did not experience difficulties in solving simple problems, especially in writing symbols that represent certain fractions [33]. The activities carried out by the HMA subjects in representing the concept of part-whole fractions using the CRA approach can be seen in figure 4.

3. Fractional operations

In the second problem, both subjects were asked to perform fractional operations, namely fractional addition operations using concrete objects. In the concrete phase, the LMA subject was asked to perform the operation of adding one-half plus one-fourth. The first step, the LMA subject carried out the activity of cutting the object into several parts according to the fractional value to be operated. Furthermore, the LMA subject used a strategy by taking three pieces of objects consisting of 2 small objects (representing a fraction of one-fourth) and one large object (representing a fraction of one-half). Furthermore, the subject manipulated two objects of different sizes by placing two objects representing one-fourth above the object representing one-fourth so that the object representing one-fourth was filled with two objects representing one-fourth. Furthermore, the subject observed the position of the three objects and finally the subject found a relationship that the object representing one-third was an 2 x object that represented one-sixth. Based on this, the subject mentioned the results of the sum of the fractions that were instructed appropriately. The strategies used by LMA subjects are strategies that are rarely used, these results are in line with the opinion of Alves et al. who stated that LMA subjects use sophisticated strategies to find ways to solve mathematical problems [9].

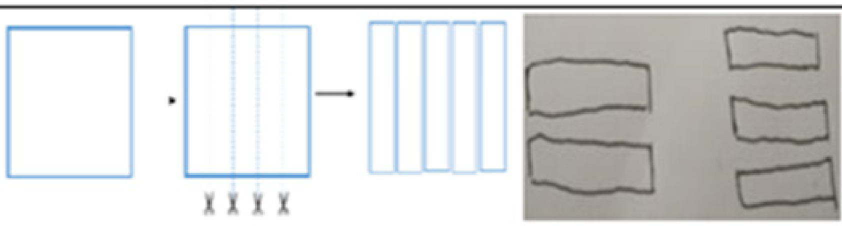
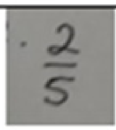
Researcher	*I give this an object. Through this object, try giving me two-fifths of it!*	
Student	Concrete Phase	  Process Results
	Representational Phase	
	Abstract Phase	

Figure 4 HMA subjects in representing the concept of of part-whole fractions using the CRA approach

In the representational phase, the subject did not describe the process carried out but only describes objects of different sizes. In the abstract phase, the subject LMA wrote the process of completing the fraction summation operation using symbols and fraction operations. In the final process, the subject manipulated the larger fraction value into a n x fraction whose value was smaller so that both fractions have the same denominator value. Next, the subject chose the addition operation to solve the problem. These results are in line with the research of Escarez et al. and Szczygiel who revealed that LMA subjects have good mathematical performance in solving mathematical problems involving mathematical symbol calculations [33; 34] and Xu et al. and Ilhan et al. who stated that LMA subjects had no interference in manipulating numbers to solve problems [35; 36]. However, the written completion process showed that the LMA subject was unable to use the operation symbol appropriately because the subject wrote the equal symbol "=" in the same line. This finding is not in line with a study by Szczygiel [34] who stated students with low mathematical anxiety are good at operating symbols. The activities carried out by the LMA subjects in completing part-whole fraction operations using the CRA approach can be seen in figure 5.

In the problem of fractional operations, in the concrete phase, the HMA subject cut the object into several parts according to the summed fractional values. Next, the subject took 3 pieces of objects consisting of two objects representing one-fourth and one object representing one-half. Then, the subject placed two objects of one-fourth value on top of the object of one-fourth value so that the top of the object of one-fourth value is covered by two objects of one-fourth value. Based on this, the subject of HMA said that an object with a value of one-half is equal to twice the object with a value of one-fourth. The use of this strategy by HMA is also the result of research conducted by Alves et al. [9] and by Živković et al. [28] which states that someone with high math anxiety tends to have difficulty using more advanced strategies.

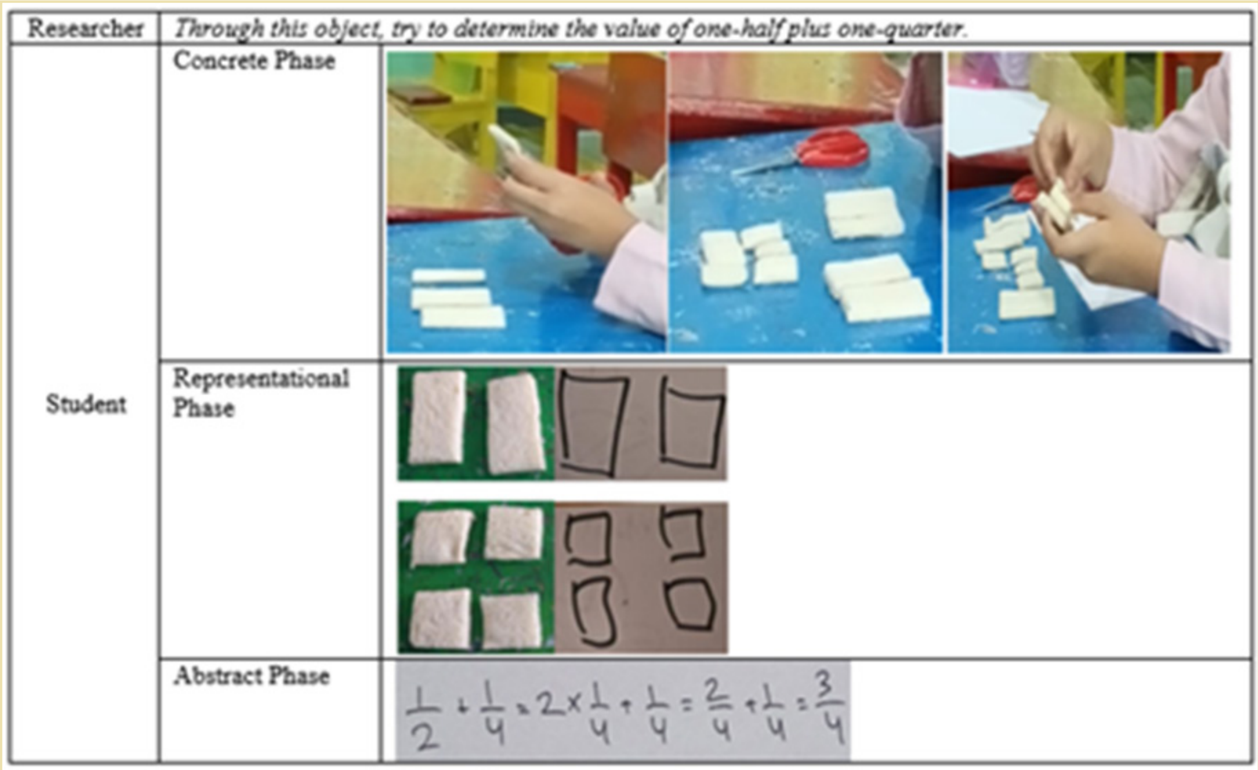


Figure 5 LMA subjects solve part-whole fraction operations using the CRA approach

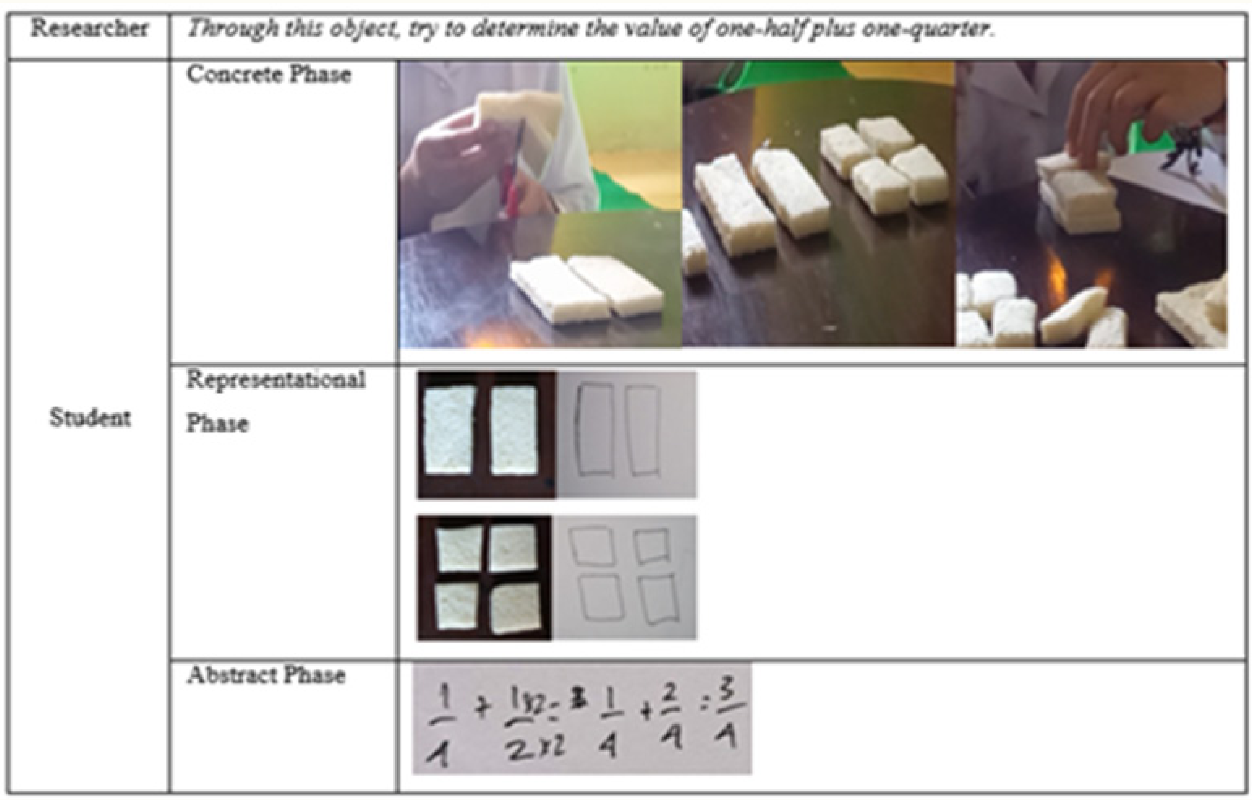


Figure 6 HMA subjects solve part-whole fraction operations using the CRA approach

Furthermore, in the representational phase, the subject represented pieces of the resulting object into the image. In the abstract phase, the subject manipulated the fraction by changing the value of the expression of the fraction that had a greater value by multiplying the numerator and denominator with a natural number so that finally the fraction had the same denominator value as the fraction with a smaller value. The ability to manipulate carried out by HMA was not in line with two previous studies namely Geary et al. and Lubienski et al. which stated that someone with high anxiety will have difficulty in manipulating numbers [31; 37]. Next, the subject chose the addition operation to complete the operation. However, the written completion process showed that the HMA subject was not good at operating symbols precisely because the subject still wrote the equal symbol "=" in the same line. This study's results align with Szczygiel's findings which state that LMA subjects are not good at operating symbols [34]. The activities carried out by the HMA subjects in completing part-whole fraction operations using the CRA approach can be seen in figure 6.

DISCUSSION

Based on the results described above, it can be found differences as well as similarities between LMA and HMA subjects in representing the fraction of the whole part concept and in carrying out fractional operations. In representing the fraction of the whole part concept, in the concrete phase, the LMA subject used a more advanced strategy (using three stages, namely the planning, process and results stages) than the HMA subject (using two stages, namely the process and results stages) in obtaining pieces of objects to represent the value of a certain fraction. This is in line with the opinion of Živković et al. who stated that mathematics anxiety influences the application of strategies in solving problems. [28]. Lubienski et al. added, this difference in strategy demonstrated that the LMA subject was more careful in determining the subject pieces while the HMA subject used more strategies that the subject believe would be successful in solving mathematical problems [37]. Although using different strategies in the concrete phase, The final results of the HMA and LMA subjects are in line with the research results of Silver et al. and Szczygieł and Sarı which showed equally good performance in obtaining pieces of the object to be used in representing fractions with certain values [38; 39]. However, for the representational phase and the abstract phase, both subjects showed the same results in representing objects into images as well as into mathematical symbols. This result is in line with the findings of Van Dijck et al. who stated that LMA and HMA subjects both have good abilities in solving simple problems [40].

In the problem of fractional operations, both subjects used the same strategy in the concrete phase, namely placing pieces of objects that represented smaller fractional values on pieces of objects with large values. The use of this same strategy is not in line with the opinion stated by Živković et al. [28], and by Ashkenazi and Eisner [29] which proposed that students with high anxiety use unsophisticated or unusual strategies compared to students with low anxiety. At the representational stage, both subjects performed equally well by representing chunks of objects into the image. In the abstract phase, both subjects manipulated number expressions in completing numerical operations. The subject LMA manipulated the expression of numbers by converting large n x fractions into smaller fractions while the subject HMA changed the expression of large numbers by n/n x larger numbers. Although the methods of manipulation carried out by the two subjects were different, both LMA and HMA carried out the right process and the results of the correct answer. This is in contrast to the research of Lubienski et al. and Geary et al. which stated that mathematics anxiety is negatively correlated with mathematics performance, especially numerical operations [37; 41]. In this study, the results obtained are in line with the opinions of Alves et al. and Moscoso et al. who stated that mathematical anxiety does not affect numerical operation ability [9; 32].

The CRA approach used in this study also appeared to be able to reduce the impact of students' mathematical anxiety in solving problems. This is in line with the opinion of Furner and Siller et al. who stated that the use of concrete objects in the CRA approach can help students eliminate the impact of mathematical anxiety [42; 43]. In addition, Furner argued the use of concrete objects in learning activities also helped students in solving problems because students directly work by manipulating objects in solving problems [42].

CONCLUSION

Based on the results and discussions that have been described above, mathematical skills affect a person's abstraction in certain dimensions. The differences in abstractions carried out by low anxiety students and high anxiety students were found in the concrete stage in fractional representation activities and the abstract stage in fractional operation activities. At the concrete stage of fractional representation activities, the student with mathematical anxiety had an advanced strategy in representing fractions with a certain value where the LMA subject thought of a plan in obtaining object pieces while the other subject directly used a method that the subject believed was correct. However, the LMA subject and the HMA subject did not experience any differences at all in carrying out activities in the representational phase or the abstract phase. In the fractional operation activity using a concrete object using the CRA approach, in the abstract phase, there were differences between the two subjects in manipulating the expression of fractional numbers (changing the fractional value that has a greater value) but both subjects had the same good mathematical performance in the concrete phase and the representational phase. This indicates that mathematical anxiety only affects certain dimensions. In addition, the use of concrete objects in the CRA approach also helps students reduce the impact of mathematical anxiety and improve performance in solving mathematical problems, especially fraction material.

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