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The Enhancement of Students' Mathematical Conceptual Understanding Through RADEC Learning Model

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abstract

Students' mathematical conceptual understanding (MCU) as major part of mathematical proficiency needs to be developed since elementary school through a didactic-pedagogical activity. One of these proficiency needs to be developed in the learning of perimeter and area of a plane geometry. The reason is students often find difficulties in understanding those concepts, especially in situations of distance learning due to COVID-19 pandemic. This study aims to investigate the achievement and enhancement of students' MCU through RADEC learning model. This study used quasi-experimental method with non-equivalent pre-test and post-test control group design. Subjects of this research were 56 of 4th graders at one of private school in Bandung, Indonesia. This study found that there are significant differences in the achievement and enhancement of students' MCU between students who received RADEC learning and direct learning where the RADEC learning model was higher in achieving & enhancing students' MCU. In addition, the invention of the RADEC learning model on the achievement and enhancement of students' MCU is in the moderate effect category with the acquisition of Hedges' g of 0,922 in the level significant effect.

Keywords:
Mathematical conceptual understanding, RADEC learning model, perimeter and area, mathematics for elementary school, distance learning due to COVID-19 pandemic.

INTRODUCTION

The aspect of numeracy is one of the important things in the world of education. One of them can be realized through learning mathematics. However, this is of course still a problem where the results of the TIMSS study in 2015 showed that the learning outcomes of grade 4 Indonesian elementary school students were below the average with 44th position out of 56 countries studied (Mullis et al., 2011). This research indicates the ability of students' mathematical conceptual understanding (MCU) that are still not mastered by students. However, mathematical knowledge can be analyzed through two important components, namely conceptual and procedural components (Haapasalo & Kadijevich, 2000; Hiebert, 2013). The two components which are usually simplified by "knowing that" and "knowing how to" have a position not only in the investigation of mathematical knowledge, but also in the development of mathematics learning, including the topic area and perimeter.

The area and perimeter is one of the fundamental topics in mathematics learning in elementary and secondary schools because it acts as the most commonly used geometry and measurement domain (Tossavainen et al., 2017). The purpose of this learning is to have a conceptual understanding of the basic area and perimeter which can later be used in studying higher concepts such as volume and others, thus leading to the implementation of a comprehensive understanding in students' lives. On the other hand, area and perimeter are often a source of confusion for students because both involve the area to be measured or students are taught formulas to solve the concept simultaneously (Livy et al., 2012; Van de Walle et al., 2013).

Some of the problems that occur are that there are common errors in the area and perimeter topic, such as confusion between the concept of perimeter and area of geometry, where in solving the perimeter problem the participants use the same method as finding the area of a figure (Reinke, 1997; Tan Sisman & Aksu, 2016). In another study, it was stated that 4th graders students had a good procedural understanding due to their good ability in multiplication, but misunderstood the concept of area and showed general weakness in identifying geometric shapes and distinguishing between perimeter and area (Huang & Witz, 2012). This certainly needs attention because it indicates that the learning which occurs is still rooted in fake mathematics where students are blind to what learning to know and learning how to know means.

Some of these problems certainly will not occur if students and teachers really understand the concept of area and perimeter since elementary school. To gain an understanding of the concept of area and perimeter, teachers need to provide students with meaningful learning that is able to facilitate the construction of conceptual understanding and pay attention to student responses in solving problems and can anticipate some of the difficulties that occur in solving mathematical problems (Andini & Jupri, 2017; Nugraha et al., 2020). Especially with the challenges of education in the face of the COVID-19 pandemic when all education is forced to be able to adapt to the challenges of digital transformation by adopting distance learning. Therefore, the research is focused on the implementation of RADEC (Read-Answer-Discuss-Explain-Create) learning model which is assumed to be able to overcome some of these problems because it has characteristics that are in accordance with philosophical knowledge acquisition (perceptual, memorial, introspective, and a priori).

The RADEC learning model is a learning model that was developed based on several things including the goals of national education, the availability of adequate and independently accessible learning resources, and time effectiveness in accordance with the demands of the dense Indonesian curriculum, as well as priorities for improving literacy and numeracy skills (Sopandi, 2017). Based on the syntax, the RADEC learning tries to provide innovation in designing learning starting from managing the readiness of the actual development zone, where there is material that is mastered independently before learning through reading and answering pre-learning questions activities. Then learning activities emphasize the development of the zone of proximal development. In addition, due to the COVID-19 pandemic conditions that demand the transformation of online learning, RADEC learning has high flexibility to be designed both in face-to-face learning, blended learning, and full online learning with a note that this repackaging must still pay attention to essential things such as the curriculum. and the support capacity of qualified human resources (Sukardi et al., 2021), so that learning can adapt well according to conditions. However, this research does not forget the direct learning that is usually done in schools in general during the pandemic as a comparative study in looking at differences in learning achievement focused on students' MCU.

Based on this explanation, in this research, the answers to two research questions are explored, namely 1) whether there are differences in the achievement and improvement of students' mathematical conceptual understanding between students who receive RADEC learning and direct learning, 2) how much influence RADEC learning interventions have on achievement and enhancement of students' mathematical conceptual understanding. To answer this question, of course, an analysis is needed that can add and update students' understanding of the area and perimeter topic, especially since the implementation of RADEC learning in mathematics education has not been done much. Thus, this study was conducted to compare the results of achieving and increasing students' MCU as a result of two different learning processes in order to find a description of understanding and appropriate learning designs in solving area and perimeter problems, especially in situations and conditions of distance learning that require full online learning during the COVID-19 pandemic.

METHODS

Population and Sample

The population of this study were all 4th grade elementary school students in one of the private elementary schools in Bandung. The study involved two sample groups, namely the experimental group (RADEC learning) of 29 students and the control group (direct learning) of 27 students. The research subjects in the two sample groups were 4^{th} graders students in a private school in Bandung. The characteristics of the prior mathematical ability of all research subjects based on the students' mathematics learning scores are heterogeneous and all students have an age range of 9-10 years.

Research Design

This study aims to determine the effectiveness of learning and also the differences in the enhancement of students' mathematical conceptual understanding between RADEC learning and direct learning. Therefore, the study was conducted using a quasi-experimental method where the random selection of samples in schools and classrooms was impractical (Cohen et al., 2007). The study was designed through a noneequivalent pretest-posttest control group design (Creswell, 2014) involving two sample groups. Therefore, the research design used can be described clearly in Figure 1 below.

O X O

O O

Description:

1) O = Pretest-Posttest on mathematical conceptual understanding.
2) X = Treatment in the form of teaching with RADEC learning model.

Figure 1
Research Design (Adapted from (Nugraha, 2017; Prabawanto, 2017)

Frame Work Flow

The procedures that have been taken in this research are divided into three stages, namely the preparation/preliminary study, implementation, and data analysis stages. In this study, the implementation of learning was carried out for 2 months with ditance learning mode. The details of the research procedure can be seen in the Figure 2 below.

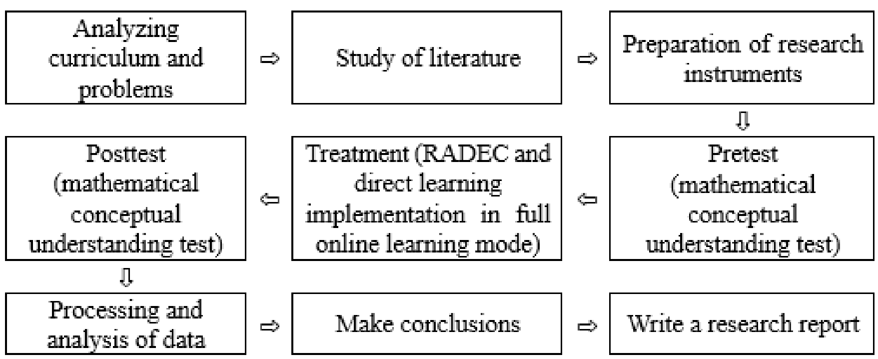

Figure 2
Research Procedure

Data Collection and Analysis

Data collection was carried out through a students' MCU test instrument adopted from (Nugraha, 2021). The test contains 4 questions where each question represents the students' MCU indicators, namely 1) restating the problem, 2) applying a problem solving algorithm, 3) representing mathematical concepts, 4) relating mathematical concepts internally/externally. (Kilpatrick et al., 2001).

Several steps of processing and analyzing quantitative data carried out in this study include preparing data for analysis, starting data analysis, reporting the results found, and ending with interpreting the results of data analysis (Creswell, 2012). In this case, there are three data analyzed, namely pretest, posttest and n-gain of students' MCU. Therefore, to answer the research question, a two-party statistical test was carried out from two independent samples where the data used to compare the experimental and control groups with the measurement scale used was in the interval-ratio level, which can be seen in the Figure 3.

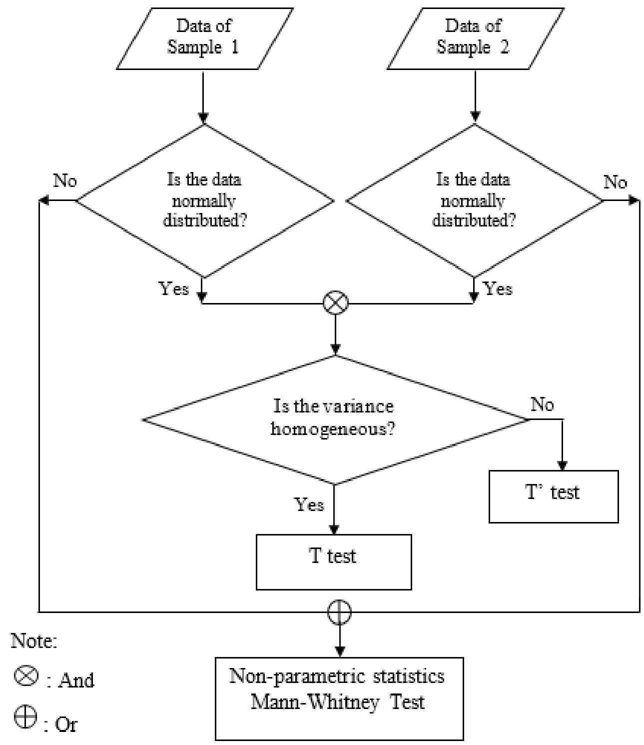

Figure 3
Two-party testing flow from two independent samples (adapted from Nugraha, 2021; Prabawanto, 2013)

The difference between the two learning models will be more visible if we know how much influence the RADEC learning intervention has on the achievement and enhancement of students' MCU. Therefore, we need an effect size test as a measure of magnitude that sees how much influence the two learning models have on increasing students' MCU to support the statistical significance that has been carried out so that the magnitude of the effect is known (Cohen et al., 2018). The effect size test used is the Hedges' g test because this research has unequal sample sizes or small sample groups. After obtaining the effect size, then the magnitude is interpreted into the effect size classification of Cohen's d, which is presented in table 1 below.

Table 1
The classification of effect size Cohen's d
(adapted from Borenstein et al., 2009)

Effect Size	Interpretation
$0 \leq x \leq 0{,}20$	Weak effect
$0{,}21 \leq x \leq 0{,}50$	Modest effect
$0{,}51 \leq x \leq 1{,}00$	Moderate effect
> 1,00	Strong effect

RESULT AND DISCUSSION

This study obtained the results of descriptive statistical analysis regarding students' mathematical conceptual understanding which plays a key role in seeing the differences in the achievement and enhancement of students' MCU. The descriptive statistical analysis can be represented in Table 2 below.

Table 2
Descriptive Statistics of Students' MCU

Group	Pretest (Prior Ability)		Posttest (Achievement)		N-Gain (Enhancement)	
	Mean	SD	Mean	SD	Mean	SD
Experiment (RADEC Learning)	20.75	9.67	71.99	9.88	0.64	0.13
Control (Direct Learning)	20.43	12.50	61.46	23.56	0.51	0.15

Based on Table 2, an illustration is obtained that the mean score of the prior ability of students' MCU who will receive RADEC learning can be stated not much different from direct learning. The opposite occurs in the achievement and enhancement of students' MCU where students who receive RADEC learning have relatively higher scores than students who receive direct learning. However, the description of the descriptive statistics is not sufficient to prove this assumption, so some inferential statistical tests are needed on the pretest score as prior ability, posttest as achievement of students' MCU and n-gain as enhancement of students' MCU.

The Students' MCU Differences between RADEC Learning and Direct Learning

To ensure the significance of the difference in the mean of the two independent samples, several inferential statistical tests, both parametric and nonparametric, are needed based on the fulfillment of the assumptions of normality and homogeneity of data variance. Inferential statistical analysis is intended to see three aspects of the comparison of learning, namely prior ability, achievement and enhancement of students' mathematical conceptual understanding between students who received RADEC learning and direct learning, which is presented in Table 3 below.

Table 3
The Difference of Students' Mathematical Conceptual Understanding between Experiment (RADEC Learning) and Control (Direct Learning) Groups

Variable	Group	Normality (*Shapiro-Wilk*)	Homogeneity (*Levene Test*)	Mean Difference (*T-test/Mann-Whitney*)
Prior Ability of Students' MCU	Experiment	0.004 (abnormal)	-	0.556 (insignificant difference)
	Control	0.007 (abnormal)		
Achievement of Students' MCU	Experiment	0.702 (normal)	0.081 (homogeneous)	0.001 (significant difference)
	Control	0.264 (normal)		
Enhancement of Students' MCU	Experiment	0,168 (normal)	0.179 (homogeneous)	0,001 (significant difference)
	Control	0,054 (normal)		

Note: the level of significance α = 0,05.

Based on Table 3, it can be seen that there is no significant difference in the mean of the prior ability of students' MCU between students who received RADEC learning and students who received direct learning. This indicates that the students' MCU in the two sample groups has been proven to be equal before the treatment. Meanwhile, after the two sample groups obtained learning experiences through different models, namely RADEC learning in the experimental group and direct learning in the control group, a significant difference was found with the acquisition of a p-value of 0.001 which was less than the value of (0.05). This can be seen at a glance in Table 2 which states that the students' MCU mean scores of the experimental group and the control group have a considerable difference, even though the achievement of students' MCU in the control group is more spread out than the control group with reference to the standard deviation value.

The Effectiveness of RADEC Learning on the Achievement and Enhancement of Students' Mathematical Conceptual Understanding

After it was known that there were differences in the achievement and enhancement of students' MCU ability in the experimental and control groups, in addition to looking at the measures of central tendency (Table 2) and differences in significance (Table 3), an analysis of the effectiveness of the learning model was needed. The level of effectiveness of the learning model in the experimental and control groups on the achievement and enhancement of students' MCU in this study was then reviewed based on three criteria according to "How do you know if the experiment has worked" (Cohen et al., 2018), namely: 1) Effect size or the influence of RADEC learning in the experimental group on the achievement and improvement of students' MCU; 2) the comparison of the average score to the learning completeness score (which in this study is the large learning mastery score in question, which is 70); 3) the percentage of complete learning in each group.

The first effectiveness review was carried out by looking for Effect Size which was carried out by processing descriptive statistical data through Hedges'g test analysis with the help of the Comprehensive Meta Analyses application (Borenstein et al., 2009; Nugraha & Suparman, 2021). The results of the test obtained the Effect Size value which is presented in Table 4 below.

Table 4
The effect size of RADEC learning on students' MCU

Hedges' g	P-Value	Interpretation
0,922 (moderate effect)	0,001 (significant effect)	The effect size of RADEC learning on the achievement and enhancement of students' MCU is classified as a moderate and significant effect.

Based on Table 4, it can be obtained information that the effect size test on the mean value, standard deviation and also the sample size of the MCU students' posttest scores, both the experimental and control groups obtained a Hedges' g effect size value of 0.922 with a p-value of 0.001. This means that the influence of RADEC learning on the achievement and enhancement of MCU students is included in the moderate effect category according to the effect size classification proposed by Cohen (Cohen et al., 2018). Meanwhile, based on the obtained p-value, it can be seen that the magnitude of the effect given is significant.

The second effectiveness review related to the effectiveness of the learning model on the achievement and enhancement of students' MCU was carried out by comparing the average score with the minimum learning completeness score (KBM) for elementary schools, which was 70. Therefore, RADEC learning in this study had an average score of 71.98 which means more from the KBM score. Meanwhile, direct learning in this study has a mean score of 61.46 which is less than the KBM score.

In addition, the third effectiveness review is carried out by calculating the percentage of the number of students who pass or achieve minimum learning mastery from each sample group. Based on this, for RADEC learning, the percentage of learning completeness is 68.97% (20/29 students score > 70). Meanwhile, for control learning, learning completeness was 33.33% (9/27 students scored >70). Thus, it can be assumed that RADEC learning in distance learning conditions during the COVID-19 pandemic is more effective in improving students' MCU compared to direct learning which is usually done during the pandemic.

The explanation of the results of the research above which has indicated that the RADEC learning model can enhance the students' mathematical conceptual understanding ability which has been proven in a descriptive statistical review, null hypothesis significance testing, effect size, statistical power, n-gain as the subtraction approach and also comparing the average score and calculating the percentage as the contingency approach (Cohen et al., 2018). If analyzed more deeply, each step in RADEC learning has a role in increasing students' mathematical concept understanding ability. The initial key to student success is in the pre-learning activity (Read-Answer) which is intended so that students prepare themselves before virtual face-to-face learning is carried out. This is consistent with one of the laws of learning readiness expressed by Thorndike, namely the law of learning readiness. The majority of students already have learning readiness as evidenced by being able to master the main concepts after reading and before learning. Nevertheless, the effectiveness of reading mathematical concepts at the Read stage still needs to be reviewed further, because previous findings confirm that the reading strategies adopted by students are not sufficient for them to understand mathematical concepts and procedures without teacher guidance, so that the instructions and guidance in the strategies used are not sufficient. specifically related to reading mathematics is needed to help students (Mutodi & Ngirande, 2014).

Another factor supporting the enhancement of students' MCU in RADEC learning is the Discuss and Explain activity which provides opportunities to learn from peers collaboratively as an information acquisition that is valued by students even though it is only through virtual face-to-face discussions relying on the Zoom Cloud Meetings Breakout Room feature. It should be emphasized that discussions in RADEC learning are different from discussions in direct learning where in RADEC learning students already have the provision of information obtained through pre-learning activities (Read-Answer) so that they are consistent with collaborative mathematical work in the collaborative mathematical groups (Galton & Williamson, 2005; Kalogeropoulos et al., 2021). Strictly, RADEC learning at the Discuss-Explain-Create stage is consistent with the sociocultural theory that cognitive development in students can be maximized through interaction with their social environment armed with an adequate actual development zone which was previously built at the Read-Answer stage.

On the other hand, it was found that direct learning facilitates the explanation of concepts at the beginning of learning by the teacher, so that the teacher's role in designing and presenting systematic material at the beginning of learning has a great influence. In addition to direct explanation factors, direct learning has aspects of mathematical working groups. In working group activities, each student is given the same task with the same outcome, that is, each student completes the same task independently (Galton & Williamson, 2005), meaning that the group assignment given is more directed at how students complete the task according to the explanation and does not involve the collaboration process. Thus, this comparative study reaffirms not to judge any of the learning designs, so the research is aimed at looking for patterns and opportunities that can be improvements for further learning.

CONCLUSION AND IMPLICATION

Conclusion

This study is in line with previous research and found new findings that RADEC learning can significantly improve students' mathematical conceptual understanding. In addition, in the analysis aspect of its implementation, it implies that each component or stage of RADEC learning can affect the achievement and enhancement of students' MCU if the role of each stage can be maximized properly even in the situation and conditions of the COVID-19 pandemic. The existence of law of readiness that is built on pre-learning activities (Read-Answer stage) and the existence of mathematical collaborative groups (Discuss-Explain-Create stage) in RADEC learning are assumed to be determinants of achievement and enhancement of students' mathematical conceptual understanding on the one hand. As for the philosophical point of view, each stage in RADEC learning is allegedly consistent with the source of knowledge acquisition in the learning process, namely perceptual (occurring in the Read stage), memorial (occurring in the Answer stage), introspective and a priori (occurring in the Discuss-Explain-Create stage). In addition, the existence of a direct explanation from the teacher (teacher explanation) and the existence of mathematical working groups in direct learning are assumed to be determinants of the achievement and enhancement of students' MCU on the other hand. This study has limitations in terms of the number of samples, depth of qualitative analysis, and limited topics. Therefore, the effectiveness of RADEC learning in mathematics learning needs to be traced back to its influence on other aspects of mathematical proficiency, other math topics, and needs to be expanded to students of different ages, gender, number of samples and qualitative exploration.

Implication

Integration of learning models with several applications and features of information and communication technology provides convenience for teachers and students in facilitating or accessing learning materials and conducting learning activities in PJJ conditions by using virtual meetings (synchronous) and accessing learning materials independently without direct interaction (asynchronous). Because the effectiveness of RADEC learning was found in the moderate effect category, this indicates the potential for RADEC learning to improve students' MCU by considering the improvements and limitations of both learning and research that have been revealed in this study.

Disclosure statement

No potential conflict of interest was reported by the authors.

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