Journal of Philology and Educational Sciences

EngiScience Publisher

Research Article

Optimizing Mathematical Representation Skills: Unveiling the Synergy between Quantum Teaching and Self-Esteem

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Article Info

Article History

Received Feb 27, 2024

Revised May 30, 2024

Accepted Jun 09, 20224

Keywords

Mathematical representation

Quantum learning model

Self-esteem enhancement

Mathematics education

Abstract

The ability in mathematical representation, encompassing visual, verbal, and symbolic aspects serves as a critical foundation in mathematics education. This study examines the impact of the quantum learning model and self-esteem enhancement on the advancement of these abilities in students. The primary aim of this research is to optimize students' mathematical representation abilities through the implementation of the quantum learning model and self-esteem enhancement approaches. This quantitative study involved all eighth-grade students at a junior high school as the population, with a sample consisting of 34 students in class VIII B participating in the quantum learning model and 34 students in class VIII C following the discovery learning model. Samples were obtained through cluster random sampling techniques. A quasi-experimental design was utilized as the research method, with data collection through a self-esteem questionnaire containing 18 statement items and a mathematical representation ability test comprising 5 statistical material questions. Data analysis was conducted using one-way ANCOVA (analysis of covariance). The findings indicate that the quantum learning model combined with self-esteem enhancement significantly influences the improvement of students' mathematical representation abilities, compared to the discovery learning model. The application of the quantum learning model along with self-esteem enhancement strategies has proven effective in optimizing students' mathematical representation abilities. This underscores the importance of integrating innovative teaching methods and psychological approaches in mathematics education to facilitate deeper conceptual understanding and improve student learning achievements.

1. Introduction

Mathematics as a universal science and a subject that is close to everyday life (Mamolo, 2019; Sari et al., 2020; Surat et al., 2023; Uyangör, 2019) and plays an important role in the development of students' mathematical abilities, one of which is mathematical representation abilities (Diana et al., 2020; Rambe et al., 2020; Tam et al., 2019). Mathematical representation skills require students to be able to create a method

from a problem into a new form, whether visual, verbal or symbolic (Aprilia Putri & Nia Sania Effendi, 2021; Oktaviana & Abdillah, 2021). The manifestation of mathematical representation abilities takes the form of visual, verbal and symbolic or mathematical expressions (Mulyawati & Umam, 2019; Musdi & Nari, 2019; Satria et al., 2020).

Mathematical representation skills in mathematics learning are mandatory because they support students in understanding mathematical concepts and their relationships (Hapsari & Muandar, 2019; Ulya et al., 2019). However, many students still exhibit low mathematical representation abilities, as evidenced by several studies (Fadilla & Purwaningrum, 2021; Jumri & Murdiana, 2022; Shoaib et al., 2023). To address this, learning models that can support or improve these abilities are essential.

2. Literature Review

The review of the literature explores the intersection of educational methodologies and psychological constructs, focusing on how the integration of quantum teaching and the enhancement of self-esteem can synergistically optimize mathematical representation skills. The quantum teaching learning model, known for its friendly and natural approach, aligns closely with students' talents and daily lives (Nurmalia, 2020). This model integrates students' experiences with the educators' world through six stages (Hermanto, 2019; Luh et al., 2020; Nahar et al., 2022; Pahlevy et al., 2019; Saputra et al., 2022). Specifically, in the natural stage, students observe and represent events related to statistics from their surroundings. According to NCTM, diverse forms of representation can explain concepts or relationships in various ways (Mainali, 2021; Maulyda, 2020; Rambe et al., 2020; Saleh Haji, 2019). These relationships are linked to students' affective abilities, including attitudes appreciating the usefulness of mathematics, curiosity, attention, interest, and a tenacious, confident attitude (Salavera et al., 2019). During the learning process, researchers observed that students' feelings of inadequacy reflect their self-esteem, which can significantly influence their academic achievements and development (Hasan et al., 2021; Lengkana et al., 2020). Notably, self-esteem has a 17.5% influence on academic adjustment, highlighting its importance (Mandoa et al., 2021).

The development of mathematical representation skills requires a comprehensive approach that integrates effective teaching strategies, diverse representations, self-efficacy, and quantum teaching methods. Research shows that quantum teaching can positively impact student achievement (Agung & Surtikanti, 2020). Using various representations, including pictorial and mathematical forms, is crucial to enhance learning outcomes without hindering progress (Musil et al., 2021). Self-efficacy, especially in mathematics, is essential for student success (Asoy & Dagohoy, 2023). Converting verbal representations into symbolic forms is vital for problem-solving and effective teaching (Boshoff-Knoetze et al., 2022; Naylor & Nyanjom, 2020). Gunarhadi et al. (2014) found that the Quantum Teaching Strategy significantly impacts Indonesian and Science achievements, particularly in terms of self-esteem. This study presents an innovative framework to enhance students' mathematical representation skills by integrating quantum teaching methods,

self-esteem enhancement, and diverse representations. While previous studies highlighted the importance of these aspects separately, this research explores their combined effect on students' confidence and skills. This study aims to fill the gap in the literature on quantum teaching's effectiveness and provide evidence of self-esteem's impact on mathematical representation abilities, emphasizing the need to combine quantum learning with self-esteem efforts to optimize these skills.

3. Methodology

3.1. Design

This research employed a quantitative approach with a Quasi-Experimental Design. The study aimed to connect two independent variables—quantum teaching learning model and self-esteem—with one dependent variable, mathematical representation ability. The design utilized a 1x2 factorial structure to compare the experimental group (quantum teaching) with the control group (discovery-based learning). The research design uses a 1 2 factorial design which is presented in the table below:

Table 1. Research Factorial Design 1×2

Group			
Experiment		**Control**	
X_1	Y_1	X_2	Y_2
$X_{1.1}$	$Y_{1.1}$	$X_{2.1}$	$Y_{2.1}$
$X_{1.2}$	$Y_{1.2}$	$X_{2.2}$	$Y_{2.2}$
$X_{1.3}$	$Y_{1.3}$	$X_{2.3}$	$Y_{2.3}$
…	…	…	…
…	…	…	…
$X_{1.n}$	$Y_{1.n}$	$X_{2.n}$	$Y_{2.n}$

3.2. Participants

The study was conducted at a state junior high school in East OKU during the 2022/2023 academic year. The population comprised 103 eighth-grade students, divided into three classes. Using a cluster random sampling technique, 68 students from classes VIII B and VIII C were selected as the sample. One class was assigned as the experimental group and the other as the control group.

3.3. Instruments

The research instruments included both non-test and test techniques. The non-test instrument was a self-esteem questionnaire containing 32 items covering four aspects: power, significance, virtue, and competence. The questionnaire's validity and reliability were tested using Excel, resulting in 18 valid items and a reliability coefficient of 0.829. The test instrument measured students' mathematical representation abilities through 10 descriptive questions, with 6 valid items and a reliability coefficient of 0.739.

3.4. Data Analysis

Data analysis involved prerequisite tests and hypothesis testing. Prerequisite tests included normality, homogeneity, regression linearity, and data variance homogeneity tests. Hypothesis testing was conducted using ANCOVA (analysis of covariance) with SPSS version 26 for Windows. This analysis aimed to determine the impact of the quantum teaching model and self-esteem on students' mathematical representation abilities.

4. Results and Discussions

After the learning process and data collection have been completed for the experimental class and control class, the following are presented the average results of the pretest and posttest self-esteem and mathematical representation ability.

Table 2. Observed Data on Pretest and Posttest Self Esteem Values and Mathematical Representation Ability

Mark	Variable	Group	$\bar{x}$
Pretest	Self esteem	Experiments	52,7
		Control	43,3
	Mathematical Representation	Experiments	40,8
		Control	38,9
Posttest	Self esteem	Experiments	74,8
		Control	71,8
	Mathematical Representation	Experiments	79,5
		Control	65,1

Based on Table 2, the results of the pretest self-esteem and mathematical representation ability, the conclusion obtained is that the results of the pretest self-esteem and mathematical representation ability of the experimental class are higher than the control class. Likewise, the results of the posttest self-esteem and mathematical representation ability in the experimental class were higher than those in the control class. Next, test the proposed hypothesis using analysis of covariance (one-way ANCOVA). The results of the ANCOVA test can be seen in the table below:

Table 3. ANCOVA Test Result

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4207.498[a]	2	2103.749	58.173	.000
Intercept	47.233	1	47.233	1.306	.257
X1 Model	3234.786	1	3234.786	89.449	.000
X2 Self Esteem	2150.498	1	2150.498	59.466	.000
Error	2350.619	65	36.163		
Total	333072.000	68			
Corrected total	6558.118	67			

a. R Squared = .642 (Adjusted R Squared = .631)

Table 3, results of ANCOVA analysis shows that the significance number for self-esteem (X2) is 0.000. Because the Sig value. < 0.05 then H0 is rejected, or it can also be said that there is a linear relationship between self-esteem and mathematical representation ability. Meanwhile, the significance of the quantum teaching learning model is 0.000, which means the Sig value is <0.05, so H0 is rejected, and it can be said that there is an influence between the quantum teaching learning model on mathematical representation abilities. Meanwhile, to determine the influence of the quantum teaching and self-esteem learning model on students' mathematical representation abilities obtained simultaneously can be seen from the significance numbers in the corrected model section. The sig. value < 0.05, namely 0.000, means that H0 is rejected, so it can be said that there is an influence of the quantum teaching learning model and self-esteem on mathematical representation abilities.

Table 4. Advanced Test Result Parameter Estimates

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	-19.298	10.824	-1.783	.079	-40.916	2.320
X2	1.113	.144	7.711	.000	.825	1.402
[X1 = 1]	14.115	1.416	9.966	.000	11.287	16.944
[X1 = 2]						

This parameter is set to zero because it is redundant

From Table 4, it can be observed that the row [X1= 1] shows that the value of t0 = 9.966 with a p-value = .000 and a degree of significance of 0.05. This shows that the p-value <0.05 so that H0 is rejected and H1 is accepted. The conclusion that can be drawn is that the mathematical representation abilities of students who are given teaching using the quantum teaching learning model are better than students who are given teaching using the discovery learning model after controlling for self-esteem.

The research findings indicate a significant improvement in mathematical representation abilities and self-esteem levels in the experimental group, which followed the quantum teaching model, compared to the control group that employed the discovery learning model. The significance of innovative learning approaches, particularly those focusing on students' holistic learning experiences, such as the Quantum Learning Model, in enhancing mathematical representation abilities, is well-supported in the literature. Utari et al. (2020) demonstrated the effectiveness of the Quantum Learning Model in improving students' written mathematical communication skills. Additionally, Azmidar et al. (2021) highlighted the importance of the Concrete-Pictorial-Abstract (CPA) approach in enhancing students' mathematical representation abilities. These findings underscore the value of incorporating innovative and student-centered learning methods to enhance mathematical representation skills. Further insights are provided by Putra et al. (2023), who examined the positive relationship between mathematical representation ability and other mathematical skills,

emphasizing the need to strengthen representation skills for overall mathematical proficiency. This supports the notion that cultivating robust mathematical representation abilities through innovative approaches can lead to improved mathematical connections and dispositions among students.

Further ANCOVA analysis confirmed that there is a significant linear relationship between self-esteem and mathematical representation abilities, as well as a positive influence of the quantum teaching model on these abilities. These results indicate that it is not only the teaching method that affects the enhancement of mathematical representation abilities but also the improvement of students' self-esteem. Therefore, the integration between learning methods that facilitate active learning experiences and strategies designed to enhance students' self-esteem can be an effective approach in mathematics education. This combination seems to not only improve mathematical understanding but also fosters a positive attitude towards learning mathematics, which in turn influences overall learning outcomes.

This study also underscores the importance of considering students' psychological factors, such as self-esteem, in designing and implementing mathematical learning strategies. By focusing on learning approaches that support and reinforce students' confidence, educators can create a more conducive learning environment for mathematical exploration and conceptual understanding (Ibrahim, 2021). Furthermore, these findings challenge traditional learning approaches that may not fully accommodate the emotional and cognitive needs of students, bolstering the argument for more holistic and student-centered approaches in mathematics education. Thus, this research contributes significantly to the literature on mathematics education, offering new insights into how mathematics education can be enhanced through the integration of innovative learning methods and psychological support for students.

5. Conclusions

In conclusion, the present study underlines the remarkable influence of integrating quantum teaching techniques and strategies with the advancement of self-esteem on promoting mathematical representation skills. The findings demonstrated that the significance of modern teaching methodologies and psychological support in nurturing academic achievement. Through the collaboration between these elements, teachers/educators can build a more supportive and effective learning environment, ultimately leading to enhanced mathematical proficiency among learners. Based on the analyzed research findings, it can be concluded that the quantum teaching learning model, when integrated with self-esteem enhancement strategies, significantly impacts the improvement of students' mathematical representation abilities. These findings affirm that the combination of innovative teaching methods and the enhancement of students' self-confidence not only enriches students' conceptual understanding of mathematics but also aids in optimizing

mathematical representation abilities. Therefore, this research provides evidence supporting the implementation of holistic and student-centered approaches in mathematics education, which consider not only the cognitive aspects but also the psychological aspects of students.

Declaration of Competing Interest: The authors declare that they have no known competing of interest.

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