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Cognitive Abilities of Secondary Students in Solving Higher-Order Thinking Skills (HOTS) Questions in Mathematics Subjects

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Abstract

This study examines the difficulties encountered among secondary school students in Kelana Jaya when solving mathematics questions that requires high order thinking skills (HOTS). Through quantitative research methods including interviews, surveys, and observations, the study identifies various challenges faced by students, such as misconceptions, lack of cognitive abilities, mathematics anxiety, and low self-efficacy in mathematics. Additionally, the study explores the teaching strategies employed by mathematics teachers and the alignment of the curriculum with high order thinking skills (HOTS) objectives. The findings highlight the significance of addressing these difficulties to promote students' problem-solving abilities and enhance mathematics education. This study's implications extend beyond Kelana Jaya, providing valuable insights for educators and policymakers globally. By implementing the study's recommendations, stakeholders can work towards an inclusive mathematics education system that equips students with the necessary skills for success in the 21st century.

Keywords: Technology, Literacy Skills, Learning, Teaching, Mathematics

Introduction

In contemporary education, the cultivation of critical thinking skills is recognized as paramount for students to thrive in an ever-evolving world. However, despite cooperative efforts to enhance higher-order thinking skills (HOTS) in mathematics education, secondary school students continue to encounter constant challenges in solving math problems requiring deep analytical reasoning. This study seeks to delve into the complications of these difficulties faced by secondary school students when confronted with HOTS-based mathematics questions.

While secondary education curricula emphasize the development of mathematical proficiency, there exists a prominent difference between the intended objectives and the actual outcomes, particularly in the realm of higher-order thinking. Despite educators' efforts

to foster analytical thinking through various pedagogical approaches, students frequently encounter hurdles in applying their mathematical knowledge to solve complex, real-world problems.

Addressing these challenges requires a versatile approach that considers the complex teamwork of cognitive, affective, and contextual factors influencing students' mathematical problem-solving abilities. By attempting a thorough analysis of the difficulties faced by secondary school students in solving HOTS-based mathematics questions, this study aims to enlighten on effective strategies for fostering critical thinking and enhancing mathematical proficiency in the secondary education sector.

This study holds significant importance in clarifying the challenges faced among secondary school students when solving Higher Order Thinking Skills (HOTS) mathematics questions, particularly through the exploration of cognitive abilities and mathematics anxiety as independent variables. By examining these factors, the research aims to provide critical insights into the complicated interaction between students' cognitive abilities and emotional states in their mathematical problem-solving processes. Understanding these dynamics is essential for educators and policymakers to develop targeted interventions and instructional strategies that effectively address the root causes of students' difficulties in mastering HOTS mathematics.

The main purpose of this study is to analyze the difficulties in solving Mathematical questions (HOTS) among secondary school students. With this main purpose, two specific objectives are created for a more specific study. The objectives are to examine the relationship between cognitive abilities and the level of difficulties encountered by secondary school students in solving mathematics questions requiring higher-order thinking skills (HOTS).

Research Question 1: Is there any relationship between cognitive abilities and the level of difficulties encountered by secondary school students in Kelana Jaya in solving mathematics questions requiring higher-order thinking skills (HOTS)?
Research Hypothesis 1: There is a positive relationship between cognitive abilities and the level of difficulties encountered by secondary school students in Kelana Jaya in solving mathematics questions requiring higher-order thinking skills (HOTS)?

Literature Review
Mathematics reading differs from regular reading because it uses vocabulary and grammatical abstractions. The process entails acquiring mathematical knowledge, skills, ideas, methods, abilities, and achievements from mathematical materials via cognitive activities such as perceptual recognition, comprehension, memorization, evaluation, and auxiliary participation in hypothesizing, proving, inducting, generalizing, judging, and reasoning. At the secondary school level, mathematical reading entails formulating mathematical conclusions from textbooks, website text, and examination problems.

Difficulties in math can arise due to insufficient competencies in number facts, computational weakness, and inability to connect conceptual aspects of math. It can also be due to inefficiency in knowledge transfer, difficulty in making meaningful connections between information, incompetency to transform information mathematically, incomplete understanding of mathematical language, and difficulty in comprehending and visualizing mathematical concepts. These difficulties can lead to a range of mistakes and misconceptions throughout the problem-solving process.

To address these difficulties, it is necessary to take a multi-faceted approach. This includes incorporating explicit instruction in critical thinking and problem-solving skills, promoting the use of effective problem-solving strategies, fostering mathematical reasoning abilities, developing conceptual understanding through meaningful learning experiences, establishing connections between mathematics and real-world contexts, revising instructional practices and curriculum design to prioritize High Order Thinking Skills (HOTS) , and providing teachers with professional development opportunities to enhance their pedagogical content knowledge and instructional strategies.

Methodology

Research design is the foundation of every study and choosing the research approach is the most important step in the research design process. This option impacts how we will collect relevant data for the study. The study design process entails multiple interconnected decisions that must be taken with extreme caution to ensure the validity and dependability of the research findings (Sileyew, 2020).

To analyze the difficulties in solving mathematics questions (high order thinking skills) among secondary schools in Kelana Jaya, we adopted descriptive correlation research. This method is intended to describe the relationship between variables. It is beneficial when the independent variable that is thought to cause or impact the dependent or outcome variable is beyond the researcher's control. (Taking the Mystery Out of Research: Descriptive, ProQuest, 2000).

A study was carried out in a secondary school located in Kelana Jaya. The selection of this school was based on the research topic and the belief that it was important to understand the integration of analysis of difficulties in solving mathematics questions (high order thinking skill) (HOTS) among secondary students, with the variables that had been studied and determined.

The target population of this research is secondary school in Kelana Jaya. They include students from Form 1 until Form 5. This study focuses on 100 secondary school students in Kelana Jaya. To identify the number of populations, a stratified sampling method was used. This method divides the population into smaller groups for better analysis.

The research process begins by identifying and defining the most common problems experienced by students in secondary schools. With clear research objectives, questions, and hypotheses, we present a single proposal that needs approval from our supervisor. We collect

the data through an online survey consisting of 22 questionnaires, distributed via the WhatsApp application. After collecting the data, we analyze it using Statistical Package for The Social Science (SPSS) software, and we interpret the results in a report that summarizes the details of the entire research.

Data collection forms the bedrock of any study. For this research, the researcher took several essential steps and underwent numerous stages to ensure that the study's objectives were met. The primary objective of the survey was to gather data on the difficulties that high school students in Kelana Jaya encounter when solving high order thinking skills (HOTS) mathematics questions. The survey was conducted among secondary school students in Kelana Jaya.

Result and Discussion

Mean and Standard Deviation of Cognitive Abilities

Table 1

Mean and Standard deviation of Cognitive Abilities

Statement (Items)	Mean	Standard deviation
1. When faced with mathematics problems requiring higher-order thinking skills (HOTS), I feel confident in my ability to analyze and solve them.	4.19	1.16076
2. I find it easy to understand complex mathematical concepts presented in class.	4.21	1.13969
3. I feel comfortable reasoning through mathematical problems and explaining my thought process.	4.29	1.15728
4. I am able to recognize patterns and connections between different mathematical concepts.	4.28	1.11988
5. I am able to think critically and evaluate different approaches to solving mathematical problems.	4.29	1.14852
6. I believe my cognitive abilities positively contribute to my success in solving HOTS mathematics questions.	4.28	1.06439

Table 1 shows six (6) items from the independent variable of cognitive abilities. From the table, the average mean is 4.26 and the average standard deviation is 1.1318. It can be statistically observed that the highest mean is 4.29 for the item "I feel comfortable reasoning through mathematical problems and explaining my thought process'' and 'I can think critically and evaluate different approaches to solving mathematical problems'.

The lowest mean would be 4.19 with the item "When faced with mathematics problems requiring higher-order thinking skills (HOTS), I feel confident in my ability to analyze and solve them". Other than that, the table above statistically observed that the highest standard deviation is 1.16076 for the item "When faced with mathematics problems requiring higher-order thinking skills (HOTS), I feel confident in my ability to analyze and solve them". Finally,

the lowest standard deviation would be 1.06439 for the item "I believe my cognitive abilities positively contribute to my success in solving HOTS mathematics questions''.
Therefore, the lowest value of standard deviation indicates a relatively high level of agreement or consistency among respondents in their perceptions regarding the role of cognitive abilities in addressing Higher Order Thinking Skills (HOTS) mathematics questions. Consequently, it can be inferred that the students, as represented groups within the survey, share similar perspectives on this aspect. This suggests a convergence in the belief that cognitive abilities play a crucial role in achieving success in HOTS mathematics questions, irrespective of a student.

Mean and Standard Deviation of the level of difficulties in solving (HOTS) Mathematics Question.

Table 21
Mean and Standard deviation of level of difficulties in solving (HOTS) Mathematics Question

Statement / (Items)	Mean	Standard deviation
1. I struggle to apply the necessary problem-solving skills when attempting HOTS mathematics questions.	2.05	1.43812
2. I often encounter difficulties in identifying the correct approach to solving HOTS mathematics questions.	2.01	1.33708
3. I frequently make errors or mistakes when solving HOTS mathematics questions.	2.07	1.45126
4. I find it difficult to connect the concepts learned in class to solving HOTS mathematics questions.	2.07	1.42315
5. I feel overwhelmed by the complexity of HOTS mathematics questions.	2.10	1.46680
6. I feel discouraged or frustrated when I encounter difficulties in solving HOTS mathematics questions.	1.95	1.38808

Table 2 above shows six (6) items from the dependent variable of the level of difficulties in solving (HOTS) mathematics questions. From the table, the average mean is 14.29 the average standard deviation is 1.4174. It can be statistically observed that the highest mean is 2.10 for the item "I feel overwhelmed by the complexity of HOTS mathematics questions".

The lowest mean would be 1.95 with the item "I feel discouraged or frustrated when I encounter difficulties in solving HOTS mathematics questions". Other than that, the table above can be statistically observed that the highest standard deviation is 1.46680 for the item "I feel overwhelmed by the complexity of HOTS mathematics questions". Finally, the lowest standard deviation would be 1.33708 for the item "I often encounter difficulties in identifying the correct approach to solving HOTS mathematics questions".

Therefore, from the lowest value of standard deviation, it can be concluded that while there is general agreement regarding the frustration and discouragement experienced when dealing with HOTS mathematics questions, there is greater variability in experiences related to identifying the correct approach. This variability highlights the diverse needs and challenges students may face in mastering HOTS mathematics questions, indicating potential areas for targeted support and intervention to enhance problem-solving skills and confidence in tackling such questions.

Reliability Analysis

Rule of Thumb Measures For Cronbach's Alpha

Cronbach's alpha	Internal consistency
Alpha ≥ 0.9	Excellent reliability
0.8≤ Alpha<0.9	Good reliability
0.7≤Alpha <0.8	Acceptable reliability
0.6≤Alpha <0.7	Questionable reliability
0.5≤Alpha <0.6	Poor reliability
Alpha<0.5	Unacceptable reliability

Figure 1: Rule of Thumb Measures for Cronbach's Alpha

The reliability test was conducted to check on internal consistency, that is, how closely related a set of items are as a group for each variable of study. (Cronbach, 1951; Salkind, 2015). In other words, Cronbach's alpha coefficient indicates if the multiple-item Likert scale surveys are reliable or not based on a certain range. (Green & Salkind, 2014). Based on the Rules of Thumb for Reliability Test in Table 4.3.1, the closer the reading of Cronbach's alpha coefficient to 1.0, the better the internal consistency of items and selection of items for the questionnaire. Thus, the reliability analysis for this current study should be more than 0.7 for the internal consistency to be acceptable.

Table 2
Reliability Analysis Statistics

Variables	Cronbach's Alpha	Number of items
Cognitive abilities	0.976	6
Level of difficulties in solving (hots) mathematics question	0.985	6

Table 4.3.2 above shows 1 independent variable and 1 dependent variable. The 1 independent variable are cognitive abilities while the dependent variable is the level of difficulties in solving (HOTS) mathematics questions. Statistically, it can be observed that Cronbach's alpha coefficient value for the 2 variables is more than 0.7 with each variable represented by 6 items. This is followed by the reading of the alpha coefficient of cognitive abilities which is 0.976 which has also quite a high alpha coefficient reading. As for the dependent variable, the level of difficulty in solving (HOTS) Mathematics question has a good

value of Cronbach's alpha value which is 0.985. Generally, all three Cronbach's alpha values in Table 4.3.2 are within the acceptable and good range.

Normality Analysis

Normality test is used to test the normality data gathered from the respondents. Ghasemi and Zahediasl (2012) mentioned normality test compare the scores in the sample by assuming the sample distribution is normal. The distribution is normally distributed if the test is significant, where the p-value is greater than 0.05 ($p > 0.05$). About this current study, small sample sizes cause normality tests to have little power to reject the null hypothesis and therefore small samples most often pass normality tests (Ghasemi and Zahediasl, 2012). The main tests of normality for the SPSS Software version 27 are Kolmogorov-Smirnov and Shapiro-Wilk test.

Based on Table 9, the value of Kolmogorov-Smirnov shows that all three variables are less than 0.05. Hence, it can be concluded that the variable data of cognitive abilities, Mathematics anxiety, and level of difficulties in solving (hots) mathematics questions are not normally distributed.

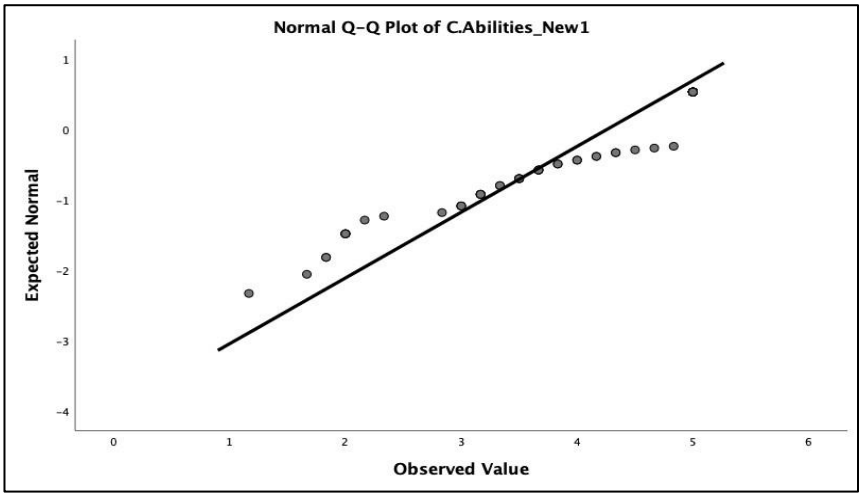

Figure 2 : Q-Q Plot of Cognitive Abilities

The normality test results were created as shown in Table 4.4.1. Based on the Q-Q Plot, the researcher found that the points plotted on the graph for the independent variable of cognitive abilities and the dependent variable of the level of difficulties in solving (HOTS) Mathematics questions intersected with the quantiles from the normal distribution in the graph. Therefore, when most of the dots are close to the diagonal line, then the data normality distributed is evidenced.

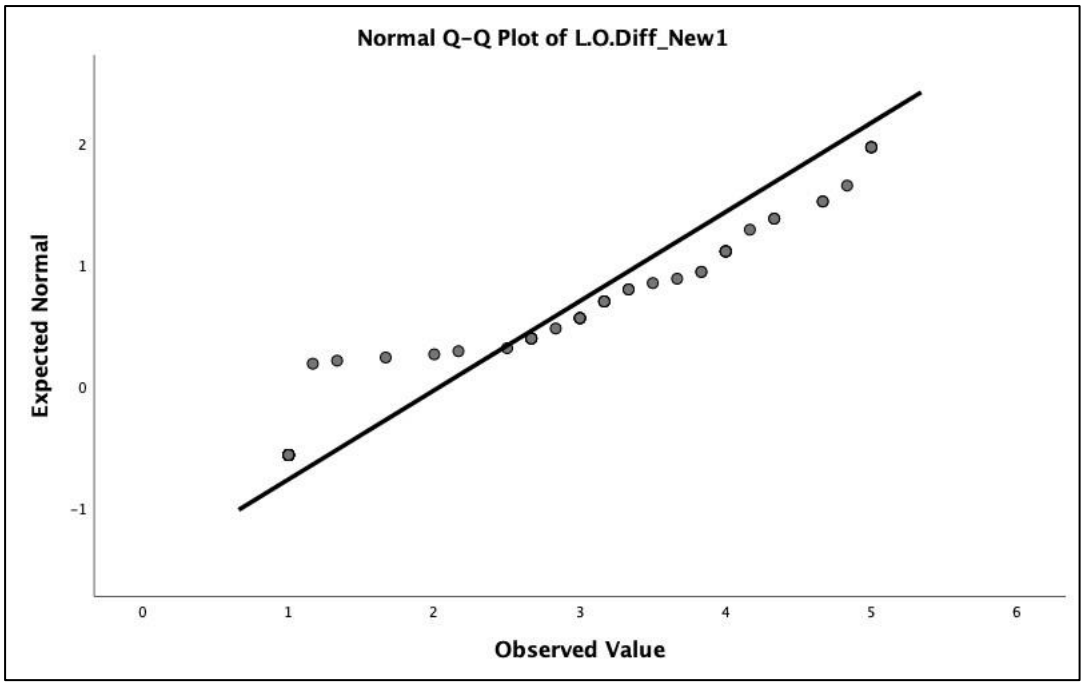

Figure 3: Q-Q Plot of the level of difficulty in solving (HOTS) Mathematics questions

As for the dependent variable of the level of difficulties in solving (HOTS) Mathematics questions, it indicated that the graph clearly explained the normal distribution because the dots intersect with the quantiles from the normal distribution in the graph. In addition, a few dots fit on a straight line meaning that both the data set and the normal distribution have comparable quantiles despite there being no variance in the respondent's response.

Correlation Analysis

According to Mukaka (2012), correlation is a statistical method used to assess a possible linear association between two continuous variables. Pearson Correlation Coefficient statistics are used to determine the r-value to indicate the strength and magnitude of the correlation. Webster's Online Dictionary defines correlation as a statistic representing how closely two variables co-vary; it can vary from −1 (perfect negative correlation) through 0 (no correlation) to +1 (perfect positive correlation).

Table 3
Correlation Analysis Statistics

Variables	Pearson Correlation (Sig.)	Sig. (2-tailed)	Relationship
Cognitive abilities	-0.904	0.000	Weak negative relationship

Based on Table 4.5 above, Pearson's correlation coefficient value for cognitive abilities and the level of difficulties in solving (HOTS) Mathematics questions indicates the lowest reading for this study that is, r = -0.904 and p = 0.000 which is p< 0.001 for a two-tailed test based on 100 responses. The direction of the relationship between cognitive abilities and the level of difficulties in solving (HOTS) Mathematics is weakly related. While a significant correlation exists, the negative relationship between cognitive abilities and mathematics

anxiety might not be particularly relevant to the study's primary objectives or research questions. Therefore, further exploration or emphasis on other variables may be more pertinent for understanding the research topic or phenomenon under investigation.

Understanding the relationship between cognitive abilities could provide insights into how individual differences in cognitive functioning relate to emotional responses to mathematical tasks. Therefore, it is relevant to explore this relationship further in the context of the study's objectives and research questions.

The study underscores the importance of addressing students' difficulties in high order thinking skills (HOTS), including misconceptions, lack of critical thinking skills, anxiety, and low self-efficacy in mathematics. Educators must understand these challenges and design targeted interventions such as remedial programs, differentiated instruction, and promoting a growth mindset to support students in developing their problem-solving abilities.

By addressing these recommendations and conducting further research, mathematics education can be improved. The findings of this study contribute to the ongoing efforts to promote high order thinking skills and create an engaging and supportive learning environment for students. Ultimately, the aim is to prepare students for future academic success and equip them with the problem-solving skills necessary for their personal and professional lives.

Conclusion

This research provides significant contributions to the existing knowledge on students' cognitive abilities and their challenges in solving higher-order thinking skills (HOTS) mathematics questions. Theoretically, it expands the understanding of the intricate relationship between cognitive abilities and mathematics problem-solving, offering insights into how these abilities, coupled with emotional factors such as anxiety, impact students' performance. This study also contextualizes these findings within the secondary school education system, highlighting the specific difficulties faced by students in Kelana Jaya, Malaysia. The results serve as a valuable resource for educators and policymakers to develop targeted interventions aimed at improving critical thinking and problem-solving skills, ensuring that teaching strategies are more aligned with students' cognitive capacities. By addressing these challenges, the research plays a pivotal role in bridging the gap between theoretical mathematical knowledge and its practical application in secondary education.

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