



Exploring the Nexus Between Calculator Competency and Higher-Order Thinking Skills in Quadratic Functions: A Needs Analysis for Malaysian Secondary Mathematics Education

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Submitted: 6 March 2026; Revised: 12 April 2026; Accepted: 18 April 2026

ABSTRACT

The study investigates how scientific calculator proficiency affects Malaysian Form 4 students' Higher-Order Thinking Skills (HOTS) advancements when studying quadratic functions. The research study has become relevant because international and national educational systems now consider HOTS development as a fundamental requirement for their mathematics programs. The researchers used a quantitative correlational needs analysis framework to study 98 students who attended national secondary schools in Johor, whom they selected through stratified random sampling. The assessment process used two tools: a Calculator Competency Assessment (CCA) and a HOTS Proficiency Test (HPT). HPT responses were scored using a 5-point analytical rubric aligned with Revised Bloom's Taxonomy (Apply, Analyse, Evaluate, Create), and descriptive statistics plus Pearson correlation were used to analyze HOTS performance. The students achieved calculator skills at a high level ($M = 8.28/10$, $SD = 1.56$), but their performance on HOTS assessments remained at a much lower level ($M = 10.74/25$, $SD = 8.26$). The study found a moderate positive relationship between calculator skills and HOTS performance ($r = 0.547$, $R^2 = 0.299$, $p < 0.001$). Calculator competency showed weak connections to two analytical tasks which needed analysis skills, according to item-level analysis results. The results show that educators who currently teach students do not use calculators as effective teaching resources which help students develop their advanced thinking skills. The results demonstrate that educational materials should connect calculator implementation with activities that require HOTS instead of treating calculator operation as separate skills.

Keywords: *Calculator competency, Higher-Order Thinking Skills, Malaysia, Quadratic functions, Scientific calculator*

How to cite: Jun, L. Z. & Ismail, N. (2026). Exploring the Nexus Between Calculator Competency and Higher-Order Thinking Skills in Quadratic Functions: A Needs Analysis for Malaysian Secondary Mathematics Education. *Journal of the Indonesian Mathematics Education Society*, 4(1), 24-39. <https://doi.org/10.26740/jimes.v4n1.p24-39>

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INTRODUCTION

The global digital economy has grown so fast that it now requires universities to produce graduates who possess advanced critical thinking and problem-solving skills and analytical abilities ([Bray & Tangney, 2017](#); [Higgins et al., 2007](#)). Educational systems across the globe now implement teaching strategies which improve students' Higher-Order Thinking Skills (HOTS) through mathematics instruction as a primary approach ([OECD, 2023](#); National Council of Teachers of Mathematics [[NCTM](#)], [2014](#)). The Malaysia Education Blueprint (MEB) 2013-2025 establishes HOTS as a fundamental skill for students to meet 21st-century challenges ([MOE, 2013](#); Ministry of Higher Education, [2015](#)).

HOTS enables students to apply, analyse, evaluate, and create knowledge ([Krathwohl, 2002](#); [Ismail et al., 2024](#)). The Sijil Pelajaran Malaysia (SPM) examinations have permitted the use of scientific calculators during upper-secondary mathematics classes and assessments since 2008 to improve calculation speed and support advanced problem-solving ([Radzuan et al., 2021](#)). The central question remains whether students use calculators to develop HOTS or merely for basic mathematical operations ([Ellington, 2003](#); [Chamoso & Cáceres, 2018](#)).

This research is critically important because Malaysian students continue to underperform in international assessments such as PISA 2022, where Malaysia scored 409 in mathematics, which is 63 points below the OECD average of 472 ([OECD, 2023](#)). The primary benefit of this study is that it provides empirical evidence on whether calculator competency actually supports HOTS development among Form 4 students studying quadratic functions. Educators and curriculum developers will benefit from concrete data showing which specific HOTS skills are associated with calculator use.

Policymakers will benefit from evidence-based recommendations that guide them to use calculators for HOTS-relevant instruction. The study needs to be conducted because three negative outcomes will happen if it remains undone. First, teachers will continue using calculators only for basic computation without understanding their potential for developing higher-order thinking. Second, curriculum materials will remain misaligned with actual student needs, which will lead to wasteful educational resource expenditure. Third, Malaysian students will continue to struggle with HOTS questions in national and international assessments because of the issues that cause them to underperform in PISA and TIMSS assessments.

This study makes four original contributions and is the first quantitative research to investigate how scientific calculator skills impact Malaysian Form 4 students' HOTS performance when studying quadratic functions. The study uses item-level analysis to determine which HOTS cognitive domains (applying, analysing, evaluating, creating) show the strongest relationship with calculator proficiency.

The study employs stratified random sampling across different school environments, including urban, suburban, and rural areas, to achieve its goal of obtaining representative data. The results will guide the creation of special calculator-based HOTS modules for the KSSM mathematics curriculum development. However, no previous study has quantitatively examined the direct relationship between students' actual scientific calculator competency and their demonstrated Higher-Order Thinking Skills (HOTS) specifically when solving quadratic functions ([Leong, 2025](#); [Embong et al., 2024](#)).

Teachers use calculators in educational settings primarily to demonstrate basic mathematical skills, but they lack understanding of how calculators can assist students in reasoning, solution verification, and discovery learning ([Budiman, 2008](#); [Moses et al., 2013](#)). The research uses systematic needs analysis as its primary method to assess calculator abilities and advanced thinking capacities which Form 4 students need to demonstrate through their mathematical learning under the KSSM educational system (Ministry of Education Malaysia, [2018](#); [Lim &](#)

[Kor, 2004](#)). The research examines how technology affects student learning through an analysis of student methods used to solve quadratic functions, which require three distinct reasoning approaches ([Didis et al., 2011](#); [Quezada & Letelier, 2018](#)). The research results will inform the development of specific programs designed to teach students how to use calculators in ways that meet the higher-order thinking skills requirements established by Malaysia's educational goals ([Muthiah, 2020](#); [Mohd Zulkifli et al., 2025](#)).

To establish the theoretical and empirical foundation for this study, the following sections review existing literature on HOTS in mathematics, the role of calculators in learning, calculator competency in Malaysian education, cognitive demands of quadratic functions, and technology integration frameworks.

Students develop knowledge through skills that Higher-Order Thinking Skills (HOTS) require, which Revised Bloom's Taxonomy defines as applying knowledge to analyze, evaluate, and produce new knowledge ([Anderson & Krathwohl, 2001](#)). Students who learn through procedural methods face difficulties in developing their HOTS abilities ([Boaler, 2016](#); [Schwarz et al., 2021](#); [Ceballos et al., 2025](#)). In Malaysia, teachers struggle to create HOTS assessments ([Embong et al., 2024](#); [Kim How et al., 2022](#)), and students experience mathematics anxiety ([Abdul Rahman et al., 2024](#)). Research about calculator use shows that calculators improve students' conceptual understanding when teachers use proper instructional methods to integrate calculators into their lessons ([Kamarulhaili & Lee, 2005](#); [Kissane, 2016](#); [Angco et al., 2023](#)), but students who use calculators without supervision end up learning only basic information ([Ellington, 2003](#); [Chamoso & Cáceres, 2018](#); [Amanti et al., 2023](#)).

Teachers in Malaysia use calculators for basic arithmetic functions instead of teaching their students critical thinking skills ([Moses et al., 2013](#)), but recent research demonstrates that learning to use calculators positively impacts students' higher-order thinking skills performance ([Leong, 2025](#); [Zamalik et al., 2024](#)). Students need to combine three skills, which include algebraic manipulation, graphical interpretation, and real-world applications, to solve quadratic functions according to [Didis et al. \(2011\)](#) and [Quezada & Letelier's \(2018\)](#) study. Malaysian students experience ongoing challenges with three skills, which include factorization, graphical interpretation, and HOTS problems, according to [Abdullah et al. \(2015\)](#), [Zakaria et al. \(2010\)](#), and [Kim How et al. \(2022\)](#).

The TPACK framework establishes technology integration through its requirement that educators need to merge their teaching approaches with their technological understanding ([Moses et al., 2013](#); [Agyei et al., 2023](#)). The process of professional development becomes effective when individuals receive ongoing education and they implement their newfound knowledge in actual teaching settings ([Dockendorff & Zaccarelli, 2025](#)). The three primary challenges that Malaysian teachers encounter include training shortages, material deficits, and examination-based curricula, which limit their ability to use technology ([Moses et al., 2013](#); [Lim & Kor, 2004](#)).

Background of the Problem

The Malaysian educational system needs to include Higher-Order Thinking Skills, which the KSSM educational program established through its 2014 implementation ([MOE, 2018](#)). The Malaysian Ministry of Education required secondary schools to design their Mathematics syllabus under KSSM principles, which needed students to solve non-routine mathematical problems while learning to assess their solutions and use math in different situations ([MOE, 2013](#)). This new approach for assessment purposes uses international benchmarks which PISA assesses through mathematical literacy, instead of measuring test performance through correct answer counts ([OECD, 2019, 2023](#); [Antonio & Prudente, 2024](#)).

The research shows that students continue to fall short of achieving curriculum objectives, which assessment results demonstrate ([Kim How et al., 2022](#); [Abdul Rahman et al., 2024](#)). The examination results show that Malaysian students perform better on standard procedural questions than on mathematical tasks which require them to use HOTS-based reasoning and justification skills ([Zakaria et al., 2010](#)). International assessments reinforce this trend: in PISA 2022, Malaysia achieved a mean Mathematics score of 409, below the OECD average of 472 ([OECD, 2023](#)). The mathematical literacy test showed that only 41% of students achieved the basic proficiency requirements which form the foundation of HOTS ([OECD, 2023](#)). Despite Malaysia's sustained emphasis on HOTS through curriculum, pedagogy, and assessment reforms, TIMSS 2019 and 2023 results indicate that lower-secondary students continue to experience difficulties with higher-level mathematical reasoning, as reflected in Malaysia's below-centrepoint reasoning performance in 2019 and the further decline in the reasoning domain in 2023 ([Mullis et al., 2020](#); [von Davier et al., 2024](#)). The analysis shows that ongoing problems exist, as established research indicates students cannot perform analysis and evaluation work ([Jacob et al., 2010](#)).

The process of solving advanced mathematical problems becomes easier for students when they use scientific calculators, which have been approved for this purpose since the calculators can perform basic calculations automatically ([Sweller, 2011](#); [Paas & Sweller, 2012](#)). The Malaysian education system mandates students to use calculators during upper secondary classes and national examinations, which begin at that educational level ([Lim & Kor, 2004](#); [Krishnan & Idris, 2013](#)). The research shows that people use the tool only for basic math functions and to replace one number with another, yet they do not use it to think critically or verify answers or test different methods ([Budiman, 2008](#); [Thomas, 2006](#)). The potential of calculators for teaching purposes remains unexploited because teachers need to understand how to use calculators effectively in their teaching ([Moses et al., 2013](#); [Chamblee et al., 2008](#)).

The Form 4 Mathematics curriculum in KSSM, which includes quadratic functions as its main subject, demonstrates these difficulties ([MOE, 2018](#)). Students must use advanced cognitive skills to complete the assessment because it requires them to interpret algebraic expressions, analyze graphs, and establish links between three types of mathematical representation ([Quezada & Letelier, 2018](#); [Ellis & Grinstead, 2008](#)). The SPM assessments include quadratic problems which require students to interpret real-world situations and assess graph-based information through vertex analysis and decision making ([Kim How et al., 2022](#)). The elements follow the framework of Bloom's Taxonomy, which encompasses the processes of analyzing, evaluating, and creating new knowledge ([Anderson & Krathwohl, 2001](#)). Malaysian students face ongoing difficulties with these subjects because their solution methods depend solely on mathematical procedures which express solutions through factorization or formula substitution ([Abdullah et al., 2015](#); [Zakaria et al. 2010](#); [Eraslan, 2008](#)).

Students can use scientific calculators to learn because the calculators help students solve problems and create tables and draw graphs ([Chechan, 2025](#); [Angco et al., 2023](#)). The exact function of calculators in helping Form 4 students solve problems remains unknown, according to [Muthiah \(2020\)](#). The study needs to investigate how HOTS skills interact with calculator use when students learn about quadratic functions, because Mathematics research needs to be examined as a single subject ([Leong, 2025](#); [Mohd Zulkifli et al., 2025](#)).

Problem Statement

Malaysian Form 4 students still face difficulties in solving advanced mathematics problems even though schools teach Higher-Order Thinking Skills (HOTS) and permit calculator use in secondary mathematics programs ([Embong et al., 2024](#); [Abdul Rahman et al., 2024](#)). The results from national and international assessments demonstrate that students struggle with non-routine

problems which require them to use application skills, analysis skills, and evaluation skills (OECD, 2023; Mullis et al., 2020, von Davier et al., 2024).

The situation exists because students display different patterns of calculator use compared to the calculators which teachers provide for classroom use (Radzuan et al., 2021; Zamalik et al., 2024). Students use calculators during examinations to perform basic calculations, yet these devices fail to support their development of higher-order thinking skills, according to Ellington (2003) and Kastberg & Leatham (2005). The research shows that students use calculators for solving advanced problems because there exists no empirical data which shows their current higher-order thinking skills (HOTS) and their calculator usage patterns in Form 4 (Leong, 2025; Muthiah, 2020).

If these needs are not clearly understood, then the design of effective teaching interventions or modules may lack proper contextualization and thus become irrelevant (Kim How et al., 2022; Chamblee et al., 2008). A systematic needs analysis must be conducted to determine which particular gaps exist in HOTS skills assessment and calculator usage patterns and the teaching challenges that Malaysian secondary school students and their teachers encounter (Abdul Rahman et al., 2024; Schwarz et al., 2021; Ceballos et al., 2025).

Research Questions

The study investigates the needs of students who study Quadratic Functions because it serves as an essential Form 4 topic that combines three skills: algebraic manipulation, graphical interpretation, and real-world application (Didis et al., 2011; Quezada & Letelier, 2018). The research questions of this study exist to investigate these two main areas:

1. What is the competency level of Form 4 students in using scientific calculators for tasks related to quadratic functions?
2. What is the current level of Higher-Order Thinking Skills demonstrated by students in solving quadratic function problems?
3. Is there a statistically significant correlation between calculator competency and HOTS performance among Form 4 students in the context of quadratic functions?

Conceptual Framework

The study is guided by an integrative conceptual framework which combines Cognitive Load Theory (CLT) and Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001), as shown in Figure 1.

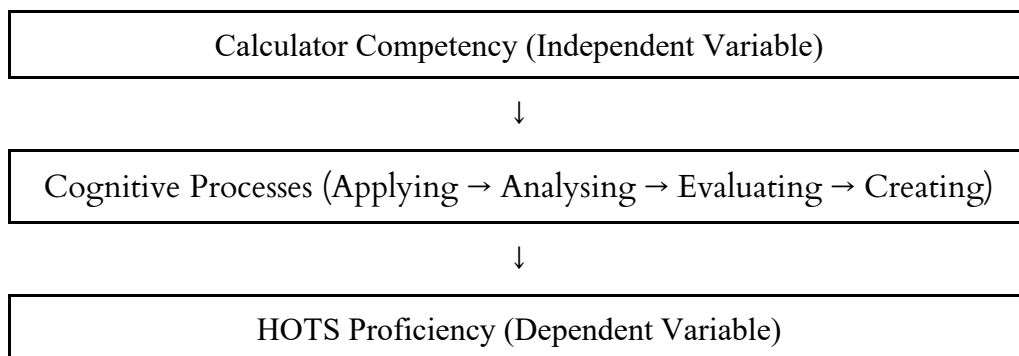


Figure 1. Conceptual Framework Linking Calculator Competency to HOTS Development

CLT states that calculators decrease unnecessary cognitive load because they remove the need for students to perform tedious arithmetic tasks, which allows students to use their mental capacity for essential cognitive work needed for pattern recognition, strategy evaluation, and solution justification functions ([Sweller, 2011](#); [Drijvers & Sinclair, 2024](#)). The framework establishes calculator competency as an essential component which allows students to show their HOTS abilities through their actual academic performance ([Leong, 2025](#); [Muthiah, 2020](#)). The effective integration of calculator use should center on tasks which correspond to the advanced levels of Bloom's Taxonomy (Apply, Analyse, Evaluate, Create) because this practice transforms the calculator into a tool which promotes advanced cognitive processes ([NCTM, 2014](#); [Liang, 2016](#)).

METHODS

Research Design

The researchers implemented a quantitative descriptive study which used needs analysis as its primary method while employing correlational analysis to examine calculator competency and HOTS skills as well as their relationship in Form 4 mathematics students ([Creswell & Creswell, 2023](#); [Field, 2024](#)). This study does not aim to establish causality; it only describes associations between variables ([Creswell & Creswell, 2023](#); [Field, 2024](#)). The research design enabled researchers to carry out precise variable measurements together with precise statistical relationship assessments which allowed them to test their research questions through empirical methods ([Creswell & Creswell, 2023](#); [Cohen, 1988](#)).

Population and Sampling

The study examined mathematics students who attended Form 4 at public secondary schools across three educational districts in Johor, Malaysia ([Leong, 2025](#)). The researchers applied stratified random sampling by using school location (urban, suburban, rural) and academic performance tier (high, medium, low) as their basis for creating strata ([Creswell & Creswell, 2023](#)).

The researchers selected 16 to 17 students from each school, which produced a total sample of 98 students (48 male, 50 female). The sample size fulfills the basic criteria required to identify medium effect sizes according to [Cohen \(1988\)](#) and [Mukaka \(2012\)](#), while it delivers adequate statistical power needed for upcoming analyses. The final sample represented a diverse cross-section of the student population across the three educational districts ([Ghasemi & Zahediasl, 2012](#)).

Data Collection Instruments

Calculator Competency Assessment (CCA): The assessment is a paper-based performance test consisting of 10 items that assess basic scientific calculator skills needed to solve quadratic functions, including squaring, square root, exponentiation, fraction calculation, and use of the quadratic formula ([Leong, 2025](#); [Zamalik et al., 2024](#)). Each item was scored dichotomously (0 = incorrect, 1 = correct), yielding a maximum score of 10. Regarding instrument quality, content validity was established by having two mathematics education experts review the items for relevance and clarity. Reliability was examined using the Kuder-Richardson Formula 20 (KR-20), which yielded a coefficient of 0.85, indicating good internal consistency for dichotomously scored items. The researchers developed this assessment tool based on existing studies on calculator competency ([Radzuan et al., 2021](#); [Abdul Rahman et al., 2022](#)).

HOTS Proficiency Test (HPT): The assessment is a paper-based written test containing five open-ended items designed to measure students' higher-order thinking skills according to Revised Bloom's Taxonomy ([Anderson & Krathwohl, 2001](#)). Each item was evaluated using a 5-point analytical rubric (0–5) based on correctness of solution and quality of reasoning (Kim How et al., 2022). The items assess five cognitive levels: Item 1 (Apply), Item 2 (Analyse), Item 3 (Evaluate), Item 4 (Apply), and Item 5 (Create). Regarding instrument quality, content validity was established through expert review by three mathematics educators who confirmed that all items aligned with the intended HOTS cognitive levels. Inter-rater reliability was calculated by having two independent raters score 20% of the tests, yielding an intraclass correlation coefficient (ICC) of 0.88, indicating strong agreement. Internal consistency was examined using Cronbach's alpha, which produced a coefficient of 0.82, demonstrating acceptable reliability for the five-item test.

Data Analysis Procedures

The research team performed quantitative data analysis through SPSS software version 26.0 ([Ghasemi & Zahediasl, 2012](#)). The researchers used descriptive statistics which included frequencies and percentages and means and standard deviations to present the findings about calculator competency levels and HOTS proficiency scores ([Field, 2024](#)). The researchers performed Pearson correlation analyses at a significance level of 0.05 to study how calculator competency is related to HOTS performance ([Mukaka, 2012](#); [Cohen, 1988](#)). The researchers assessed normality assumptions through the analysis of skewness and kurtosis values ([Ghasemi & Zahediasl, 2012](#)).

RESULTS AND DISCUSSION

Calculator Competency

The Calculator Competency Assessment results showed that Form 4 students demonstrated calculator proficiency through their ability to perform basic operations. The mean total calculator competency score of 8.28 (SD = 1.56) out of 10, along with the percentages shown in [Table 1](#), demonstrates that students were able to execute the majority of required calculator functions. The competency distribution showed that 73.5% of students achieved high proficiency (scores 8–10), while 24.5% demonstrated moderate proficiency (scores 4–7), and only 2.0% of students showed low proficiency (scores 0–3). The findings demonstrate that Malaysian students can operate basic calculator functions, which confirms previous research results.

Table 1. Descriptive Statistics for Calculator Competency and HOTS Scores (N=98)

Measure	Mean	SD	Minimum	Maximum	Skewness	Kurtosis
Calculator Total Score (/10)	8.28	1.56	2	10	-1.23	1.45
HOTS Total Score (/25)	10.74	8.26	0	25	0.34	-0.89
HOTS Item 1 (/5)	2.55	2.13	0	5	-0.12	-1.31
HOTS Item 2 (/5)	2.14	2.17	0	5	0.35	-1.38
HOTS Item 3 (/5)	1.33	2.12	0	5	1.13	-0.40
HOTS Item 4 (/5)	1.84	2.08	0	5	0.64	-1.10
Calculator Total Score (/10)	8.28	1.56	2	10	-1.23	1.45

HOTS Proficiency

Descriptive analysis of the HOTS Proficiency Test revealed substantial gaps in students' higher-order thinking skills. The data illustrated in [Table 2](#) show that the average total HOTS score was 10.74 out of 25 (SD = 8.26), which corresponds to 43.0% of the highest possible score. The score distribution showed a positive skew at 0.34 (skewness) while displaying moderate kurtosis at -0.89, which showed that most students earned lower scores while only a few students achieved extremely high scores ([Ghasemi & Zahediasl, 2012](#)).

Most students could not complete higher-order thinking tasks because their proficiency levels showed analysis that revealed this situation ([Kim How et al., 2022](#)). According to [Table 2](#), 63.3% of students (n = 62) were rated at low HOTS proficiency (scores 0–8), while only 16.3% (n = 16) reached a high level of proficiency (scores 17–25). The distribution shows a major deficiency in developing the required cognitive abilities for solving advanced mathematical problems ([Tajudin & Chinnappan, 2016](#); [OECD, 2023](#)).

Table 2. HOTS Proficiency Level Distribution

Proficiency Level	Score Range	Frequency	Percentage (%)	Cumulative Percentage (%)
Low	0-8	62	63.3	63.3
Median	9-16	20	20.4	83.7
High	17-25	16	16.3	100
Total	0-25	98	100	100

Note: Proficiency levels were determined based on percentage of maximum score: 0-33% = Low, 34-66% = Medium, 67-100% = High.

Examination of individual items revealed specific challenging areas corresponding to their cognitive demands ([Table 3](#)). The most challenging item proved to be Item 5 (Create), because 95.9% of students attained a score of 0, while the two easier items were Items 1 and 2 (Apply and Analyse). The pattern of this study demonstrates that students encounter more difficulties when they attempt to solve problems which require higher cognitive abilities that include both evaluating and creating ([Anderson & Krathwohl, 2001](#)).

Table 3. Score Distribution by HOTS Item

Score	Item 1 (n/%) (Apply)	Item 2 (n/%) (Analyse)	Item 3 (n/%) (Evaluate)	Item 4 (n/%) (Apply)	Item 5 (n/%) (Create)
0	24 (24.5%)	29 (29.6%)	51 (52.0%)	37 (37.8%)	94 (95.9%)
1	0 (0.0%)	1 (1.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
2	33 (33.7%)	19 (19.4%)	8 (8.2%)	12 (12.2%)	2 (2.0%)
3	10 (10.2%)	12 (12.2%)	8 (8.2%)	14 (14.3%)	0 (0.0%)
4	13 (13.3%)	13 (13.3%)	9 (9.2%)	12 (12.2%)	1 (1.0%)
5	18 (18.4%)	24 (24.5%)	22 (22.4%)	23 (23.5%)	1 (1.0%)

Relationship Between Calculator Competency and HOTS Performance

The Pearson correlation analysis showed that calculator proficiency had a strong positive connection with students' ability to complete higher-order thinking tasks ([Leong, 2025](#); [Muthiah, 2020](#)). The correlation between total calculator scores (SUM_B) and total HOTS scores (SUM_C) reached a value of $r = 0.547$ ($p < 0.001$), which showed a moderately strong positive relationship between the two variables ([Table 4](#)). Students who perform better on higher-order thinking tasks show better calculator proficiency, which accounts for 29.9% of the variance in their performance ($R^2 = 0.299$).

The item-level analysis found different correlations which matched calculator competency. The strongest correlations were observed for Item 3 (Evaluate: $r = 0.510$, $p < 0.001$) and Item 4 (Apply: $r = 0.429$, $p < 0.001$), followed by moderate correlations for Item 1 (Apply: $r = 0.370$, $p < 0.001$) and Item 5 (Create: $r = 0.362$, $p < 0.001$). Item 2 (Analyse) showed a correlation that did not reach statistical significance because its correlation coefficient value of $r = 0.143$ and p value of 0.159 . The results show that calculator use helps certain mental processes while showing an extremely low connection to analysis abilities ([Ellington, 2003](#)).

Table 4. Correlations Between Calculator Competency and HOTS Performance

Measure	SUM_B	SUM_C	C1 (Apply)	C2 (Analyse)	C3 (Evaluate)	C4 (Apply)	C5 (Create)
SUM_B	1	.547**	.370**	.143	.510**	.429**	.362**
SUM_C	.547**	1	.597**	.457**	.845**	.810**	.528**
C1 (Apply)	.370**	.597**	1	-.031	.411**	.332**	.232*
C2 (Analyse)	.143	.457**	-.031	1	.191	.225*	-.136
C3 (Evaluate)	.510**	.845**	.411**	.191	1	.656**	.543**
C4 (Apply)	.429**	.810**	.332**	.225*	.656**	1	.394**
C5 (Create)	.362**	.528**	.232*	-.136	.543**	.394**	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

The results of this needs analysis provide important insights into the relationship between calculator skills and higher-order thinking abilities among Form 4 mathematics students (Leong, 2025; Muthiah, 2020). Students demonstrated high calculator proficiency ($M = 8.28/10$; 73.5% high proficiency) but showed major challenges in completing higher-order thinking tasks ($M = 10.74/25$; 63.3% low proficiency), which established a significant gap between their technical abilities and their ability to think. Previous studies showed that people cannot make cognitive progress just by receiving technological equipment ([Ellington, 2003](#)). The finding that calculator competencies are largely confined to basic operations suggests that current teaching methods emphasize procedural application of the tool rather than its integration for cognitive development ([Budiman, 2008](#); [Moses et al., 2013](#)). The international mathematics education literature shows that technology integration in classrooms fails to meet educational standards ([Drijvers & Sinclair, 2024](#); [Bray & Tangney, 2017](#)).

People who conducted a systematic review of technology implementation in secondary mathematics education discovered that schools need to implement their educational technology programs through instructional methods which contain more than their current use of basic operational functions. The technology implementation study demonstrates that educational technology success happens only when teachers establish learning objectives and assessment methods and training for teachers, which needs to be completed before teachers can start using technology in classrooms (Embong et al., 2024; Chamblee et al., 2008).

The hierarchy of HOTS abilities shows that students perform better in applying skills than they do in evaluating and creating abilities, which reflects the evolution of mathematics education that occurred in Malaysia and other countries ([Tajudin & Chinnappan, 2016](#); [OECD, 2023](#); [Abdul Rahman et al., 2024](#)). The test results show that students performed very poorly on creation tasks, which resulted in an average score of 0.23 out of 5 for creation tasks and 95.9% of students getting zero points on Item 5, which indicates an urgent need for students to learn how to develop generative mathematical thinking skills which represent the highest cognitive ability according to Revised Bloom's Taxonomy ([Anderson & Krathwohl, 2001](#)). The educational framework requires students to develop their understanding of correct answers through methods that emphasize answering questions correctly instead of explaining their

answers and analyzing their work and showing creativity in their thinking processes ([Kim How et al., 2022](#)). The current method limits students from developing their skills to solve complex mathematical problems which do not follow standard practice ([Boaler, 2016](#); [Schwarz et al., 2021](#); [Ceballos et al., 2025](#)).

The research found a strong positive relationship between calculator skills and HOTS performance which had a correlation coefficient of 0.547. The study found that students with better calculator skills attained higher HOTS scores because their skills explained 29.9% of the test results ([Leong, 2025](#); [Muthiah, 2020](#); [Özgün-Koca, 2009](#)). The data shows correlations but it does not provide evidence for establishing definite causal links ([Mukaka, 2012](#)). The differences in how HOTS items relate to each other show that students who used calculators needed particular cognitive abilities to solve quadratic function problems while their other reasoning abilities developed without using technology ([Ellington, 2003](#); [Kastberg & Leatham, 2005](#)).

The performance results indicate that students succeed at using calculators but they lack the ability to understand concepts and assess their own learning ([Radzuan et al., 2021](#); [Zamalik et al., 2024](#)). The educational system faces fundamental obstacles which require specific solutions because only 16.3% of students reach advanced HOTS proficiency ([Kim How et al., 2022](#); [Embong et al., 2024](#)). The educational system creates a major problem because students lack essential technical skills for mathematics, which prevents them from developing cognitive skills in this field through technology use according to higher-order thinking standards established by the Malaysian Education Blueprint ([MOE, 2013](#); [Kementerian Pendidikan Malaysia, 2013](#)).

The current research demonstrates that existing teaching methods do not use calculators effectively to build higher-order thinking skills in students who study quadratic functions ([Muthiah, 2020](#); [Mohd Zulkifli et al., 2025](#)). The excessive dependence on calculators for verification and substitution tasks together with the established patterns of HOTS proficiency proves that educational institutions do not properly balance their learning resources with their teaching requirements ([Lim & Kor, 2004](#); [Krishnan & Idris, 2013](#)). The educational system needs to implement particular educational solutions which combine technological expertise with cognitive development through two different stages, which require students to use calculators for advanced assessment tasks ([Liang, 2016](#); [Tseng & Chen, 2023](#)). Future instructional design should be grounded in real-world problem contexts that necessitate using calculators for exploration and justification, thereby transforming their role from computational devices to facilitators of higher-order mathematical thinking ([NCTM, 2014](#); [Drijvers & Sinclair, 2024](#)).

CONCLUSION

The research study investigated three questions which examined Form 4 students' abilities to use calculators, their performance in HOTS tests, and the connection between these two aspects when studying quadratic functions. The research findings regarding students' calculator proficiency demonstrate that students are able to operate basic calculator functions at a high level, as 73.5% of students achieved advanced proficiency in their calculator skills. The results of the second research question about HOTS performance showed a significant performance gap, with students obtaining a score of 10.74 out of 25, which corresponds to 43.0% of the total score, while 63.3% of students showed low HOTS proficiency. Performance declined systematically across cognitive levels, with creation tasks proving most challenging, as 95.9% of students scored zero on the create item. The research study discovered a moderate positive correlation between the two variables, indicating that higher calculator proficiency is associated with better HOTS test scores ($r = 0.547$, $p < 0.001$, $R^2 = 0.299$). The analysis of individual items

showed a weak, non-significant relationship with analysis tasks, which varied according to different cognitive domains.

The study's primary strength is that it serves as the first study to conduct a quantitative assessment of the direct link between scientific calculator skills and HOTS results for Malaysian Form 4 students studying quadratic functions, using a method that employs stratified random sampling and tools validated against Revised Bloom's Taxonomy. However, several limitations must be acknowledged. As a correlational study, this research did not establish any cause-and-effect relationships between the two variables. The study had a narrow focus, examining only quadratic functions, and its sample was drawn from only three districts in Johor, Malaysia, which restricts the generalizability of the results to other subjects and populations. Although the sample size of 98 students provided sufficient statistical power to detect moderate correlations, it nevertheless limits the ability to generalize findings to broader populations.

Future research should employ experimental designs to evaluate whether calculator-based HOTS training leads to improvements in higher-order thinking skills. Longitudinal studies are needed to track how calculator competency and HOTS skills develop over time. Replication studies should be conducted across different mathematical topics, across different Malaysian states, and with larger, more diverse samples. Finally, qualitative research is recommended to investigate how students utilize calculators when solving HOTS problems and to understand their thinking patterns during problem-solving.

ACKNOWLEDGEMENT

The authors express gratitude to the participating school administrators and students who contributed to this research.

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