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Higher order thinking skills, school-based assessment and students' mathematics achievement: Understanding teachers' thoughts

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ABSTRACT

The purpose of this study was to investigate the effect of incorporating higher order thinking skills (HOTS) in a school-based assessment (SBA) on mathematics achievement among students. A mixed-method case study design was used to assess a sample size of 158 students and three mathematics teachers. The students' proficiency in mathematics was determined by using the standard based curriculum for secondary schools (*kurikulum standard sekolah menengah/KSSM*). Mathematics assessment paper that was assiduously organized by incorporating HOTS questions. The students' thoughts on the incorporation of HOTS in the SBA were obtained through one-to-one face-to-face semi-structured interviews. The quantitative findings, which were analyzed using descriptive and regression tests, showed that 11.9% of the achieved mathematics score was contributed by incorporating HOTS in SBA, while 7.7% was contributed by SBA mastery level in mathematics. Students' maturity and misconceptions about math are among the challenges in implementing HOTS in SBA. The challenges in applying HOTS in SBA had a positive effect on teachers' pedagogical approach in a sense that they could devise a new strategy for meeting the needs of students and teach topics in alternative ways.

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1. INTRODUCTION

The incorporation of higher order thinking skills (HOTS) in school-based assessment (SBA) is assumed to potentially affect students' mathematical achievement. Thus, the findings of this study are expected to be useful for the relevant authorities to continuously improve and enhance mathematics learning and assessment activities in schools. Assessment is the practice of collecting, reviewing, and using information about educational programs systematically to improve student learning and development [1]. Assessment can be considered as a systematic basis for making inferences on students' achievements [2]. It is also about making judgments, identifying strengths and weaknesses, as well as right or wrong for an educational program, and it is more than giving marks or grades, although these are all part of the assessment. The role of assessment in any educational system is very important because it guides a teacher to choose learning tasks and approaches to optimize the use of those tasks. SBA is an effort to develop human capital holistically through emphasis on the mastery of knowledge, intellectual capital, cultivating a progressive attitude and the practice of high values, ethics and morals. It is a holistic assessment that assesses the cognitive (intellectual), affective (emotional and spiritual) and psychomotor (physical) aspects. The SBA is designed to lessen excessive dependence on scores and grades that students obtain through centralized examinations. SBA is expected to enhance the focus on student development as well as the development [3].

Teachers have been given the responsibility to develop didactic materials to assess their students' academic achievement and learning outcomes because they can understand the context, content and background of their students [4]. Hence, teachers must take advantage of this opportunity to continuously provide constructive feedback and monitor the achievements and abilities of their students [5], [6]. Quizzes, questioning sessions, short essay writing, and role-play, among others, can be used to assess students' abilities [4]. The implementation of SBA is structured in ways that encourage self-empowering of learning among students [7]. Another important aspect of the SBA model is that it apportions teachers' teaching strategies into three main components that are teaching, learning, and assessment which complement each other to achieve optimum results [8].

The SBA has three main objectives: i) Assessment of learning (informs parents and societies about the school and students' curriculum-related ability); ii) Assessment for learning (enables teachers to determine steps to improve students' learning experience); and iii) Assessment as learning (allows students to control and self-assess their learning) [8]. According to previous study [9], in SBA, the formative and summative assessments can be integrated through the teaching and learning process, which can be achieved using various forms of assessment such as portfolio, projects and written tests [4]. In the case of Malaysia, the main components of SBA in Malaysia are the academic component (centralized and SBAs) and the non-academic component (co-curricular activities, physical activity and psychometric assessments) [10].

Notably, the main objective of SBA's implementation in Malaysia is to acquire a holistic education for students as well as to help them improve their potential development through individual assessments [11]. SBA assessments will allow students to obtain knowledge through individual learning, study environment, institutional involvement and educational system [12]. As for mathematics learning, teachers in Malaysia have been taking initiatives to help their students master the subject. There is a system in Malaysian public secondary schools that record the students' mathematics performance. Although SBA practice is being accepted internationally, empirical research on its implementation in terms of success, strength and weaknesses is still lacking, especially in Malaysia [13]. The lack of studies on SBA in Asian countries is obvious, and this gap was one of the impetuses for implementing this study [14].

HOTS is a cognitive activity or thinking skill at a high level [15]. The term HOTS is usually differentiated with the term lower order thinking skills (LOTS) which require routine applications of information that has been acquired beforehand [16]. On the other hand, HOTS requires students to interpret, analyze, or manipulate information. HOTS encompasses the cognitive process analysis, synthesis, and evaluation in Bloom's taxonomy and LOTS refers to the cognitive process knowledge, understanding, and application [17]. Critical thinking and creative thinking as HOTS and recall and knowledge as components for LOTS [18]. HOTS can apply knowledge or methods to solve problems creatively, innovatively, and subsequently create something new based on the acquired knowledge [19]. Thus, in a sense, it can be construed that HOTS involves complex thinking that can be used to solve diverse problems whereby critical thinking and creative thinking are a part [20].

2. LITERATURE REVIEW

2.1. Mathematics assessment

Assessment is one of the six principles of mathematics education [9], as it provides useful information for teachers and students to support the potential benefits of learning the subject. Building the students' understanding of mathematical concepts and skills should be a continuous process throughout teaching and learning [21]. Since the 1980s, previous researchers [9], [22] have been encouraging the transformation of the mathematics curriculum by emphasizing cognitive factors in its teaching and learning assessments that include the application of high-level thinking skills [7]. Developing mathematical problems that require HOTS as provocations to develop students' cognitive abilities is important because this sort of problem allows students to use HOTS when solving the problems [15]. Moreover, HOTS is needed by every individual in the education environment [23].

Within the Malaysia's context, a greater emphasis was given on the inclusion of HOTS in the mathematics assessment, mainly due to the drop in mathematics achievement among Malaysian students in 2007, as reported by trends in international mathematics and science study (TIMSS). The analysis also showed that Malaysia was in the bottom third; lower than the international average and OECD [7]. Malaysian students were also not able to respond well to questions that required higher thought processes for instance, the questions within the programme for international student assessment (PISA) examination, which compel students to make interpretations, reactions and judgments based on real-life problems [24].

2.2. Problem solving and non-routine problems

Problem solving in mathematics is one of the necessary elements integrated into the teaching and learning process inside the classroom [25]. One main focus in mathematics education is to guide students to develop general problem-solving skills that they can apply in new and non-routine situations [26]. Problem solving in mathematics involves routine and non-routine problems. Previous study [27] defined non-routine problems as the procedure used in an attempt to solve problems by exploring, analyzing and researching non-routine aspects of the problem. Non-routine problem is a complicated problem that requires some level of creativity or originality to solve, and usually do not have a clear and easy strategy to solve [28].

Using non-routine problem-solving in mathematics assessment is considered an effective step to stimulate HOTS among students [27], so the answers to a common mathematical problem become far and wide, and cannot be resolved solely through traditional pedagogies. The importance of having skills to solve non-routine mathematics problem should not be doubted. The ability to solve non-routine problems that is, problems that cannot be solved through methods or formulas that are already known, and that require analysis, synthesis, and creativity [29], is now becoming increasingly important in the 21st century [30].

2.3. School-based assessment practices

Many developed countries (United Kingdom, Finland, New Zealand, and Canada) have successfully implemented the SBA [31]. SBA adopted mainly as a national education policy in Asia and in some developing countries, such as Ghana and Zambia [31], [32]. It encourages the implementation of formative and self-assessment in the classroom, as practiced in Finland [33]. Finland's assessment practice has contributed to reducing formal assessments and burden on teachers to provide students purely with standardized examinations [34]. Consequently, SBA provides opportunities for teachers tactilely engage in assessing each of their students. Interestingly, SBA is developmental in nature as it also emphasizes the assessment process from the beginning of the school year until the year-end. Thus, it could demonstrate the learning experiences gained by the students [31]. There is a link between SBA and continuous assessment, which is a type of assessment that has evaluation process implemented from time to time, involving certain tasks to measure the content of the lessons learned by students [31]. For example, in the Caribbean, internal assessments are usually described as SBAs whereby the main assessment activities include teacher assessment on assignments given to students according to the guidelines provided by the Caribbean examinations council (CXC) [31]. In a sense, the SBA in the Caribbean has continuous assessment features.

2.4. Practice of alternative assessment

The alternative assessment aims to address students' passive circumstances by replacing them with creativity, self-discipline, and choices and making students aware of their vision, beliefs and impulsiveness [35]. Alternative assessment also refers to the diversity of assessments that arise due to the shortcomings found in traditional or conventional forms of assessment [36]. Compared to traditional assessments, alternative assessment has the characteristics of constructive learning because it involves multiple assessment opportunities for students to demonstrate knowledge, skills and attitudes [37]. In mathematics education, there is a need and goodness to integrate the methods of alternative assessments that can efficiently assess the range of mathematical abilities of students [38].

Some countries in South East Asia also incorporate alternative assessments when assessing their students, for instance Indonesia. As neighboring countries, Malaysia and Indonesia share similar characteristics, including a general framework of references in history, culture, and religion [39]. Language constitutes a significant similarity between these two separate and independent countries. The Indonesian language and Bahasa Malaysia both use the Malay language [40]. Significant equality also occurs in the education system assessment in Malaysia and Indonesia, whereby both countries practice alternative assessment in mathematics education.

Alternative assessment can improve students' mathematic learning because it provides detailed information on the achievement of skills, understanding and knowledge of the lesson content without referring to achievement based on scores obtained through examinations [41]. Some alternative assessment techniques conducted in the Malaysian education system are: i) concept maps [41], [42]; ii) project work [41], [43]; iii) portfolio assessment documenting the overall learning process of students [44]; and iv) laboratory activities [45]. Indonesia also celebrates alternative assessment. Its educators are now aware that classroom assessment is a process because it involves students' learning progress and a medium for their successful learning [46].

2.5. The implementation of SBA in Malaysia

SBA is a form of assessment designed, administered, scored, and reported by subject teachers in accordance with the Malaysian Examination Syndicate guidelines [10], [47]. SBA is a holistic assessment of cognitive (intellectual), affective (emotional and spiritual), and psychomotor (physical), in line with the national education philosophy, primary school curriculum standards (KSSR), and secondary school curriculum standards (KSSM) [48]. Holistic assessment features are different from other assessments because: i) involve teachers' planning, identifying and developing assessment tasks that cater to students' ability; ii) enable the collection of several student performance samples within a period; iii) can be modified by the teacher to suit the teaching and learning goals of the assessed students; iv) can be implemented in the normal class; v) are carried out by the teacher; vi) involve active student participation, especially if self-assessment or peer assessment is used along with teacher assessment; vii) allow teachers to provide immediate and positive feedback on students; and viii) stimulate continuous assessment and coordination of teaching and learning programs [49]. Remarkably, SBA can be tailored to show a student's achievement whereby his scores will reflect what he had learned, rather than what he should learn [50].

2.6. The implementation of HOTS in Malaysia

The Malaysia Education Blueprint 2013-2025 is a 12-year strategic plan aimed at improving the quality of education as it is termed through a comprehensive transformation [51]. Ministry of Education (MOE) intends to list Malaysia in the top three groups in international assessments such as TIMSS and PISA within 15 years [51]. Through the Malaysia Education Blueprint, the MOE has devised an Education Curriculum Transformation Strategy that emphasizes HOTS regarding the thinking skills in Bloom's Taxonomy [52]. The four-level thinking skills imply the act of applying, analyzing, evaluating and creating. Incorporating HOTS in Malaysian classrooms is deemed important because the implementation of teaching and learning that does not focus on thinking skills has caused students to be less inclined to apply science or think creatively and critically in everyday life [53]. Some studies on HOTS implementation in Malaysia's primary and secondary schools [53]–[55] had indicated that adhering to the conventional teaching approaches and abstaining from encouraging students towards thinking independently and creatively, hindered their academic excellence.

Although thinking skills are the most important aspect in a progressive educational setting, teachers are more concerned about the content of their lessons than the knowledge of understanding how to teach effectively through HOTS application [56]. On the other hand, previous study reported a less favorable attitude among teachers towards implementing HOTS in the curriculum [54]. Similarly, the practice of thinking skills among 144 mathematics teachers was reported to be at a moderate level [55].

This study was carried out to determine the relationship between students' perception on teachers' application of HOTs in SBA (HOTS application) and students' mathematics SBA mastery level and students' mathematics achievement. The research questions are: i) What are the achievement profile and mathematics SBA mastery level of the 13 year-old students?; ii) What are the students' perceptions towards their teachers' application of HOTS in SBA scores?; iii) How do mathematics SBA mastery level scores and HOTS application scores contribute towards 13 year-old students' mathematics proficiency?; iv) What are the mathematics teachers' general perceptions towards SBA?; v) What challenges do mathematics teachers face when implementing SBA that incorporates HOTS? Thus, the hypothesis of this study is: SBA level and HOTS application scores do not contribute towards 13 years old students' mathematics achievement (H_o).

3. RESEARCH METHOD

3.1. Research design and procedure

The study employed an explanatory mixed-method research design whereby quantitative data collection preceded the qualitative data collection [57]. The quantitative data were obtained using questionnaires, while semi-structured, face-to-face interviews [58] were carried out with five purposively selected mathematics teachers. The interviewees' responses were jotted down by the researchers and also video and audio-recorded [59]. The relationship between the two variables, namely the score obtained by students through the implementation of critical thinking and assessment in SBA (Table 1) and the score obtained by students based on SBA, with student mathematics achievement. Both of these variables are important to get the big picture of the influence of both variables on student mathematical achievement. The percentage contribution of these two variables would show that teachers need to practice HOTS when conducting SBA and the score given by teachers to students through the implementation of SBA is also an indicator that can stimulate student mathematical achievement. In Malaysia, there has been no study done so far that specifically examine the influence of both variables on students' mathematical achievement in secondary schools since the introduction of SBA. Therefore, the findings within this study can serve as a reference for all mathematics educators that the role of teachers is important in applying HOTS in the learning process mathematics in the classroom.

3.2. The quantitative phase
3.2.1. Sampling
A total of 158 students (form one, aged 13 years old) were purposively selected to participate in this study which did not take into account gender and age factors. The participants had all taken a mathematics assessment in the current year. Their school, a cluster school of excellence established in January 1996, is located in the rural area of Northern Peninsular Malaysia. The rationale for the selection of 13-year-old form one students was because these students were not involved in national examinations in Malaysia. Based on the education policy in Malaysia, it is prohibited for any researcher or research involving students aged 15 and 17 who will sit for the national examination. On this basis, the researchers selected 13-year-old form one students to conduct this study.

3.2.2. Instrument
The 20-item questionnaire, adapted from critical thinking testing and assessment [60], measured the teachers' application of HOTS and SBA mastery level. After data from the teachers were obtained, standard statements by the form one students were recorded based on their KSSM mathematics assessment paper. Four experts, who determined the appropriateness of the items, validated the instruments with agreement scores. This validation process helped to ascertain that the items were measurable, clear, meaningful, and understandable in straightforward language [8]. Researchers developed interview protocol to obtain teachers' views about the implementation of HOTS in SBA. Table 1 presents 20 items questionnaire measuring critical thinking adopted and modified from the foundation for critical thinking press [60].

Table 1. HOTS items during SBA implementation

No	Items	1	2	3	4	5
1	Think to understand the content of mathematics lessons					
2	Get good grades by understanding the content of mathematics lessons					
3	Explain about high -level thinking (in a way I can understand) in mathematics					
4	Explain why a mathematics lesson needs to be studied for example the purpose of assignments, activities, topics, tests					
5	Identify problems or issues clearly in the mathematics lessons content					
6	Find relevant information to answer questions in mathematics content					
7	Understand the main concepts in mathematics lessons content					
8	Learn how to apply mathematical content in everyday life					
9	Learn how to summarize the mathematical information learned					
10	Learn how to distinguish between assumptions, conclusions or implications in mathematics lessons content					
11	Think about mathematics lessons content					
12	Learn how to ask questions related to mathematics lessons content					
13	Evaluate things more clearly in learning mathematics					
14	Think of ways to make a decision more accurately in mathematics					
15	Identify something that happens in a mathematical operation in more depth					
16	Think with a more logical mind when solving mathematics problems					
17	Think about a mathematical operation that happens, more fairly					
18	Learn how to distinguish what I know and what I do not know about a mathematics lessons content					
19	Think about mathematics in an angle I disagree with					
20	Think about mathematics using intellectual discipline					

3.2.3. Reliability
A pilot study, to establish the instrument's reliability, was carried out. It had yielded a high reliability value (.932) using Cronbach alpha that approximated as 1.00 [61]. The semi-structured interview protocol used to obtain teachers' data, had also undergone the validity and reliability processes. Five experts in the field of qualitative research were appointed to review the appropriateness of this interview protocol.

3.2.4. Data analysis
Descriptive analysis (percentage) was used to answer the first and second research questions, while multiple regression tests were used to answer the third research question. The purpose of the regression test was to identify the contribution of the SBA mastery level and HOTS application scores towards the mathematics achievement profile of the form one students [62]. On the other hand, the content analysis approach was used to analyze the interview data [57].

4. QUANTITATIVE FINDINGS

4.1. SBA mastery level and mathematics achievement profile of form one students

Table 2 shows the students' SBA mastery level, where 94 students (59.5%) reached level 5, indicating their ability to: i) develop and use models for complex situations; ii) identify constraints and make specific assumptions; iii) apply suitable problem-solving strategies; iv) work strategically using in-depth thinking skills and reasoning; v) use various suitable representations and display in-depth understanding; vi) reflect on results and actions; and vii) conclude and communicate with explanations and arguments based on interpretations, discussions and actions. On the other hand, 58 students (36.7%) reached level 4, which indicated their ability to: i) use explicit models effectively in concrete complex situations; ii) choose and integrate different representations and relate to real world situations; iii) be flexible in using skills and reasoning based on deep understanding; and iv) communicate with explanations and arguments based on interpretations, discussions and actions. Only six students (3.8%) reached level 3, a stage that indicated their ability to: i) perform procedures that are stated clearly, including multi-steps procedures; ii) apply simple problem-solving strategies, interpret and use representations based on different sources of information; iii) make direct reasoning; and iv) communicate briefly when giving interpretations, results and reasoning.

Table 3 shows the students' SBA mastery level in mathematics, in which 20 students (21.7%) obtained grade B (credit), 40 students (25.3%) obtained grade E (minimum level) and 14 students (8.9%) obtained grade F (below minimum level). The number of students who obtained grades C (good) and D (satisfactory) were the same, which was 42 (25.3%). According to these results, no form one students had achieved grade A (excellent) in mathematics.

Table 2. Students' SBA mastery level in mathematics

SBA mastery level	*f*	%
3.00	6	3.8
4.00	58	36.7
5.00	94	59.5
Total	158	100.0

Table 3. Mathematics achievement grade

Grade	Grade Interpretation	*f*	%
B (70-84)	Credit	20	12.7
C (60-69)	Good	42	26.6
D (50-59)	Satisfactory	42	26.6
E (40-49)	Achieved minimum level	40	25.3
F (01-39)	Has not reached the minimum level	14	8.9
Total		158	100.0

4.2. Students' perception of teachers' application of HOTS in SBA scores

In this study, students evaluated their mathematics teachers' application of HOTS in SBA. The results of descriptive analysis on the items that measured the application of HOTS by teachers in SBA mathematics showed that the number of students who gave the high scores to the HOTS application was greater. Next, there were three items that obtained the highest scores, namely: i) understand the main concepts of the mathematics content; ii) how to think about the mathematical operation more systematically and iii) learn how to differentiate what I know and what I do not know about the contents of mathematics; (n=140, 88.61%). The other items that obtained the highest scores were: i) think in order to understand the mathematics content; ii) get good grades by making relevant exercises to understand the mathematics content; iii) think how to make an accurate decision in math (n-139, 87.98%). Meanwhile, one item which was 'to think about mathematics in an angle that I disagree', received a low score (n=69, 43.67%).

4.3. Students' perception of teachers' application of HOTS in SBA scores

Overall, data analysis results in Table 4 show that both predictor variables were significant, namely the application of HOTS in SBA by teachers (β=.30, t=4.06, P<.05) and the SBA mastery level of students in mathematics (β=.28, t=3.86, P<.05). Overall, the two predictor variables accounted for 19.6% (r=.443) variance change in the mathematics score F (2, 155)=2463.437, P<.05.

Table 4. Multiple regression test

Independent variable	R	R²	F	Unstandardized B	Coefficient Std. Error	Standardized Coefficients Beta	t	Sig.
Constant	.443	.196	18.058	8.712	8.003		1.089	.278
HOTS application in SBA by teachers				5.094	1.254	.297	4.064	.000
SBA mastery level				6.263	.1.621	.282	3.863	.000

5. QUALITATIVE FINDINGS

Three mathematics teachers from the school were purposively selected and were interviewed by one of the researchers. The researchers had developed a set of interview questions based on literature and face validated by three qualitative research experts within the university. Some of the interview questions were: i) What is SBA to you?; ii) How do you apply HOTS in the mathematics SBA?; iii) What challenges do you experience in applying HOTS in the students' assessment? The interviews were transcribed as verbatim before the data was analyzed [58]. Table 5 provides a brief profile of these teachers.

Table 5. Profile of mathematics teachers interviewed in the study

No.	Teacher	Gender	Teaching experience (years)
1.	MT1	Male	36
2.	FT2	Female	21
3.	FT3	Female	15

5.1. Teachers' general perception of SBA

MT1perceived SBA as the tool that determined students' level of acquisition and competence in the topics learned. MT1 added that teachers would be able to identify areas in which students found most difficult.

> *"SBA measures students' level of acquisition and competence. Usually, teachers will plot each student's level of achievement according to topics. Sometimes we tell students about their performance. When we teach, we can see where they are facing difficulties. When we walk around the class when they are doing their work, or when we check their exercise books, we can know what they have not understood."* (MT1)

MT1 further hinted that student can be made to know their performance, and if they were still performing below the accepted standards, teachers must resort to alternative strategies to help them improve. One such strategy is by taking advantage of 'peer teaching':

> *"Teacher must let students know their achievement in each topic learned. When they have not achieved according to pre-set standards, we need to assist them. We must use different techniques or teaching strategies, maybe by including peer teaching."* (MT1)

Seemingly, FT2 had a similar perception of SBA as MT1. She talked about 'modules' and 'workbooks' when describing SBA. Commercial workbooks were referred to when selecting items or questions as exercises for her students:

> *"…we mathematics teachers don't have the time to sit together to discuss. The students have a diversity of knowledge. So, we teachers decided on using just one workbook (module). We will first discuss and then select the module to be used."* (FT2)

Interestingly, FT2 expected her students to write notes during mathematics classes:

> *"I asked them to get used to writing notes… to absorb concepts. That's why I continue to inculcate these things when they are in Form One."* (FT2)

FT3 likened the SBA to using worksheets as well as involving the construction of concrete materials:

> *"For assessment purposes, I will give questions based on worksheets. If needed, I will ask my students to build models… the solid geometric models."* (FT3)

5.2. Challenges when implementing SBA that incorporates HOTS

The three teachers reportedly faced unique challenges when implementing HOTS-incorporated SBA. For instance, MT1 found his students' inability to establish links between the current topic and the previously learned topics, as one of the challenges. MT1 explained:

> *"Sometimes these students cannot link… they cannot relate things that they have learned with the exercises that we gave them. But when we do the exercises in class with them, they can solve the questions. But in exams, they forgot. They can usually do topical tests because this type of assessment is still new. But in the long run, like in end of year exams, we can see that they don't remember what they have learned."* (MT1)

Hence, MT1 had decided to teach the topics in a slightly different way that included re-teaching the basic concepts underlying the topic being taught.

> *"It is easy when we teach topics that are related. For every topic that I teach, I will go down to the very basics if necessary. For example, when teaching 'Angles', I have to go back to what has been covered in Form One."* (MT1)

Students' prerequisite knowledge is vital before proceeding to teach new mathematics topics in the classroom, as mentioned by MT1:

> *"When it comes to students' prerequisite knowledge… I have to go back to (refreshing) Form One (topics) to check their knowledge. I teach the Form Three students."* (MT1)

MT1's colleague, MT2 was concerned with her students' inability to obtain correct answers due to incorrect mathematical operation procedures and sequences. She had attributed this issue to her students' maturity level. To her, the matured students were better in their way of thinking:

> *"The maturity of students… During their mathematical learning in primary school, they needed to do calculations when solving problems. They were used to just doing calculations. But now they must know what to write. They were not matured enough in doing this. For example, the operations for addition, subtraction, multiplication, and division, (they must know) the ones they needed to do first and be put in brackets. Instead, they simply solved the problems from the beginning till the end without the right skills. The matured students were able to know the ones that must first be put in brackets… (that was) multiplications needed to be solved first and so on. When we asked them to transfer word problems from statements to mathematical sentences, not all of them could do it because of their ways of thinking. They did not want to understand the problems given to them."* (MT2)

MT2 reported a challenge in translating the assigned topics within the mathematic curriculum to fit the students' cognitive maturity level as well as their mathematics proficiency. She suggested for a need to relook at the organization of some topics within the mathematics curriculum. According to her, related parties should revise some of the contents according to students' cognitive development:

> *"The arrangements of the topics and the ways some topics were combined. There was no need to include geometric in algebraic elements because there was confusion. We should have started with mastering the lower skills first before moving to the higher levels. Honestly for me, in mathematics, all the basic skills should be completed at the primary school level. There was no need to ask weird questions. When the students were in secondary schools, we can use questions along the lines of, for example "Aminah worked for half an hour in sixty minutes. Her sister used half the time that Aminah has spent". We emphasized things like that."* (MT2)

Students' inability to memorize multiplication tables was another challenge faced by MT2 who believed that students who know their multiplication tables by heart are in a better position to solve sums and problems efficiently:

> *"The multiplication tables were not in their heads. When they entered secondary schools, they faced problems. When I asked the number of factors for six, they only saw one times six, they didn't see two times three."* (MT2)

MT2 believed that the ability to memorize multiplication tables could support students' learning of advanced mathematics. She also mentioned that during her school days, she had written the multiplication table beginning for one (1x1=1, 2x1=2, 3x1=3, … 1x12=12) until the multiplication table for 15.

> *"They didn't know multiplication tables. When we were in schools, we wrote one until fifteen. So, when we reached number thirty-six, we could already see six, and see three times twelve. We could already see the pattern. I don't know why I could not get this from them. If they had it, then it would have been easy for them to understand additional math."* (MT2)

The third teacher, MT3 faced a different challenge related to students believing that mathematics was a difficult subject to learn, a belief that remained even when they were given simple sums to solve:

> *"The students found it difficult to accept what we teach …because they always thought mathematic questions as difficult even if the question was easy. I have this student whom I gave an easy question to solve, and yet he still came back to me with a wrong answer. He used working procedures that I did not teach. They were not logical at all."* (MT3)

Nevertheless, she did not feel disheartened but instead, had felt that the experience had allowed her the opportunity to change her teaching approach. MT3 explained:

> *"Once, I had given the students quite easy questions but they had thought about them in a difficult way. That was their problem. So, I changed the way I teach. I examined their cognitive levels first, and stressed more on imparting basic mathematical concepts. I could see changes among the students. I told my students that if they understood and acquired the basic concepts, they could solve any questions."* (MT3)

For these mathematics teachers, implementing SBA that incorporated HOTS opened up various challenges, something that they attested to firsthand. Presumably, these challenges can be supported through pedagogical workshops in which trainers guide teachers through the obstacles of managing SBA within various contexts of mathematical classroom environment.

6. DISCUSSION

There was an astounding difference between SBA mastery level, mathematics achievement and HOTS application scores. On average, the students' SBA mastery level was 5, reflecting the continual student development in using models for complex situations and identifying constraints to make specific assumptions. At a glance, SBA might have encouraged students to apply suitable problem-solving strategies using in-depth reasoning and various suitable representations. It has been found that SBA could easily help students reflect on results and communicate based on interpretations, discussions and actions. However, the mathematics achievement profiles in this study showed that 40 students (25.3%) had achieved the minimum level (grade E), while 14 (8.9%) others had not (grade F). Although laden with numerous concerns, scores based on teachers' application of HOTS in SBA were high, indicating that a common trait shared by most teachers was the necessity for teaching problem-solving skills during mathematic lessons. This should be the cognitive skill that students should improve on as they progress forward in their mathematic achievement. This conjecture was confirmed via a regression testing, in order to answer the second research question.

The regression test showed that teachers' application of HOTS in SBA and students' mastery level of SBA were the factors affecting school's mathematics achievement, although these predictors' contribution scores were rather small (19.6%). This would enable future discussions on the construction of assessment by teachers. It was also revealed that assessment was closely linked to the learning activities curated by teachers. Therefore, good assessments must focus on the creation of exciting challenges for students that require solving on their end [8], [63]. Consequently, the implementation of SBA requires teachers' classroom skills that conform to the principle of constructive alignment model, which refers to the continuity between assessments, teaching, learning activities, and learning outcomes in each teaching session [64].

During the implementation of the SBA, it is the responsibility of the teacher to design the assessment and ensure that the learning outcomes and activities have a positive impact on students' mathematical understanding and achievement. However, an analysis of the interview data with the teachers indicated evidence of a mismatch between learning outcomes and assessments. This is an issue because assessments should be in line with learning outcomes [4], [65]. Furthermore, students should be allowed to explore and structure meaningful learning through educational activities [65]. Nevertheless, the findings showed that the mathematics teachers did not construct learning activities and assessments according to their students' ability and background. Due to time constraints, the teachers preferred to choose materials from mathematics workbooks available in the market for classroom activities and assessment purposes.

Importantly, the interview data showed that the teachers perceived SBA as assessments based solely on test items at the end of the day. They had all mentioned the use of workbooks, modules, and selected test items from the workbooks. There seemed to be confusion among the teachers as to the definition of modules. According to them, a module could mean the selection of one of the workbooks that are available in the market. This 'workbook' serves as the module to determine materials for classroom assessments. According to students' ability and achievement level, SBA allowed teachers to modify learning and assessment activities [50], [66]. Students should actively participate in assessments [49] as they can be conducted as self-test or with a colleague under the guidance of a teacher. Nonetheless, teachers need to have the appropriate skills to design and construct their learning materials, adding layer upon layer of meaningful objectives as students' progress through various cognitive levels.

The findings were consistent with an earlier study [63] who found that English teachers lacked the knowledge and skills in conducting oral SBA English assessments. Similarly, when multitasking came into play, the teachers in this study lacked the skills to design assessments tasks that were aligned with mathematic learning activities. Thus, future initiatives should include re-training teachers and empowering them with different teaching methods to assist with SBA's implementation, goals, and intentions. Early interventions in students' cognitive development will reap enormous long-term returns in mathematic learning outcomes. A similar recommendation was made, with emphasis on SBA training and review based on the existing implementation system [63]. When incorporating HOTS in SBA, the teachers faced students' inability to link the current topics with previously learned ones. Between 5% and 8% of school children experienced some form of memory or cognitive deficiency that can interfere with their ability to learn concepts or procedures in one or more mathematics domains [67]. To overcome this, learning activities that meet the underlying need of students must be designed by teachers [68]. A meaningful learning experience can help connect the present content with that is being studied in the future [69]. In fact, brief question-and-answer sessions and discussions are formative forms of assessments applied by mathematics teachers to stimulate HOTS in SBA.

The challenges in applying HOTS in SBA had a positive effect on teachers' pedagogical approach in a sense that they could devise a new strategy for meeting the needs of students and teach topics in alternative ways. Some of the efforts made by the teachers included re-teaching the underlying concepts of the topics taught to ascertain that student had mastered the appropriate prerequisite or basic knowledge of mathematical concepts before learning new topics. This study also found that the teachers realized the inability of their students to understand the correct procedures of performing mathematical operations and sequences to accurately solve problems. Besides, the teachers believed that maturity was an important factor affecting the students' ability to solve HOTS problems. Switching up their teaching techniques is part of the teachers' bid to boost student achievement and ease their learning [70]. For instance, they often try to change their students' negative perception towards mathematics to seeing mathematics as an easy subject to learn. Notably, it has been found that the negative perceptions towards mathematics can be changed by the use of effective teaching techniques [71].

7. CONCLUSION

The application of HOTS in SBA mathematics lessons can contribute to the improvement of students' mathematics achievement. However, efforts to train mathematics teachers on designing and implementing meaningful learning activities should be carried out from time to time by the Ministry of Education of Malaysia, the State Education Department, or the District Education Office. Additionally, teachers' understandings of HOTS and their capability to perform assessments that integrate HOTS should also be enhanced. The assessment tools should not be limited to written tests only, but can also be in coursework, project, discussion, and games. Teachers' challenges when implementing mathematics assessments that incorporated HOTS presumably can be lessen by having any meaningful learning activities. The injection of fun learning elements in the teaching and learning processes could probably hold students' attention and bring about their favorable perceptions towards mathematics.

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