The Competency of Science Teachers in Integrating Higher Order Thinking Skills in Teaching and Learning

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Abstract. The performance of an individual will increase if he has all the competencies required to carry out his duties and responsibilities. This survey study was conducted to identify the competency of science teachers in integrating Higher Order Thinking Skills (HOTS) in teaching and learning. The competency of science teachers is seen in three aspects based on the Iceberg Model which are knowledge, skills and attitude. 39 science teachers from 27 secondary schools in Besut district have responded to the questionnaire instrument disseminated in this study. Descriptive statistics were used to analyse the frequency and percentage of respondent profiles involved. Descriptive statistics were also used to obtain mean and standard deviation to determine the competency level of respondents in HOTS. Analysis shows the level of competency of science teachers in terms of knowledge and attitude is high. The skills aspect shows a moderate level. The study suggested that science teachers did not explore various strategies and approaches in implementing HOTS. The high level of knowledge and attitudes should be manifested through teaching and learning that combines different approaches, questions with various cognitive level and activities that challenge the students’ thinking. This study provides a room for improvement for science teachers in enhancing the quality of teaching and learning and nurturing HOTS in students.

1. Introduction

Thinking is a mental activity that occurs when processing information, building relationships, making decisions and generating new ideas. Humans think when solving problems, understanding situations and making plans. In the world of education, good thinking skills play an important role in producing creative, innovative and competitive students globally. Thinking skills is also one of the student aspirations outlined by the Ministry of Education (MOE) in the Malaysian Education Development Plan presented in 2013. The thinking skill emphasizes in the blueprint is Higher Order Thinking Skills (HOTS). HOTS is the ability to apply knowledge, skills and values in reasoning and doing reflection to solve problems, make decisions, innovate and create something new [1]. The MOE has taken the initiative to implement HOTS using a holistic and systematic approach. Curriculum, assessment and pedagogy are the three main elements of HOTS. While there are four supporting elements namely co-curriculum, community and private sectors, resources and capacity building. All of these elements have been detailed individually in an effort to inculcate and build HOTS among teachers and students [2].

These thinking skills should also be mastered by teachers. The role of teachers is not only a communicator of knowledge and skills, but also a resource and asset for building analytical, critical and creative thinking within students [3]. The TIMSS 2015 report shows that the science score has increased by 44 points after a declining performance in 2011. This has placed Malaysia at the 24th
rank out of 39 countries involved. However, the 471 score achieved was still below the average score and was not able to place Malaysia among the one-third above of all countries participated [4]. In addition to measuring student achievement in science subjects, this report also provides an overview of the effectiveness of teaching and learning of science in our country compared to other countries. It also opens up areas for improvement in science education in Malaysia including strengthening the role and effectiveness of teachers in teaching and learning science. The increase in the percentage of the elements of HOTS in the Malaysian Certificate of Education examination by 20% in 2016, 25% in 2017 and 30% in 2018 indicates that MOE is serious in ensuring that the students master the HOTS and prove it through written examination [5]. Changes in student assessment indicate that teachers should teach in different and various ways by focusing more on developing students' analytical abilities and not just remembering and understanding [6].

In implementing HOTS based teaching and learning, teachers need to make good preparations starting with identifying HOTS elements in the Learning Standards, designing explicit lesson objectives, planning activities that stimulate students’ thinking and being assisted by appropriate learning aids [2]. The use of thinking tools and mastery of good questioning techniques will guide students’ thinking from lower level to higher level. Collins states that, based on the Taxonomy Level, teaching thinking skills can be practiced structurally by teachers by designing questions in the classroom so that the questions asked are more directed and guided. Teachers also play a role in providing support and assistance to students, especially at the early stages of teaching before students can operate on their own [7]. Support in the form of appropriate and concrete examples such as diagrams, sketches, pie charts and graphs, showing the steps in solving problems are important for students to develop thinking skills in themselves. Undoubtedly, in the pursuit of these skills in students through the medium of teaching and learning, teachers become the backbone and frontline that serve as the basis and goals of the curriculum outlined by MOE [3].

2. Problem statement

In the context of science education that aims to increase the level of scientific literacy among students, ability to use science and skills to solve problem and make decisions based on values [8], the use of science learning approaches such as constructivism, inquiry-based learning, problem-solving or project-based learning, mastery learning, contextual learning, scientific research or experimental STEM approaches, are able to expose students with an optimal opportunity to train themselves in mastering HOTS. HOTS include critical thinking skills to evaluate ideas logically and rationally, creative thinking skills to create something new and valuable, critical thinking skills and thinking strategies, a structured and focused way of solving problems [9]. Nurturing these skills to a student is certainly not an easy task for an educator.

To stay relevant, science teachers must be equipped with the necessary knowledge and skills in order for achieving what is outlined in the curriculum effectively in the classroom. In addition to being competent in the areas of knowledge and skills, science teachers should also be able to address issues related to the quality of teaching and learning Science [10]. In the analysis to see the factors of deterioration of student participation in science stream, a study on teaching strategies found that science and mathematics teachers still practice traditional teacher-centred and lecture-based teaching and lack of injecting noble values. The teaching is also exam-oriented rather than developing thinking and constructivism skills. The study also found that teaching experience affects the pedagogical knowledge and content that a teacher has. New teachers rely heavily on sources of reference and are unable to solve complex problems as well as having misconceptions among them [11]. Teachers’ weaknesses in mastering concepts and teaching strategies will give implications towards students’ learning.

A qualitative study examining the implementation of HOTS by science teachers was also conducted. Findings of a study reported that science teachers’ perceptions of HOTS differ from teaching experience. Science teachers with more than 5 years of experience show a better understanding of the concept of HOTS compared to less than 5 years of experience science teachers [12]. On the whole, however, the perception and definition of the HOTS expressed by the science teacher still does not meet the definition of HOTS as defined by the MOE. The same study also looks
at the implementation of HOTS by science teachers in teaching and learning. Unexpected findings reported when implementation of HOTS by more experienced teachers are limited to textbook sources compared to inexperienced teachers who use various techniques and strategies to implement HOTS in the classroom [12].

In the survey of science teacher questioning techniques, they found that science teachers tend to ask lower-level questions (78.42%) to convergent cognitive-level knowledge questions that require very simple answers, one word or phrase [13]. The findings of the research involving science teacher trainees show that there is a significant relationship between the level of creativity or skills of the science teacher and the ability to generate open-ended and cognitive-oriented questions [14]. A qualitative study of physics teacher questioning techniques found that the skills of questioning of physics teachers are still at a moderate level [15]. A study conducted to identify the training and skills that science teachers have in assessing students’ achievement and found that the skills in fostering critical and innovative thinking as well as creativity in students’ learning and subsequently implementing HOTS in students are weak [6]. Measuring the level of competency of science teachers in implementing and integrating HOTS in teaching and learning is seen as something that is still relevant to be studied to ensure that science teachers are competent in planning and implementing teaching and learning that guides the students' thinking.

3. Theoretical framework
Saedah and Mohammed Sani state that an individual’s performance will increase if the individual has all the competencies required to perform the tasks and responsibilities entrusted to him. For individuals who are teachers, competencies include personal, professional and social related matters [3]. These include mastering the subject matter and related theories, classroom management and the ability to adapt to the situation and environment [16]. Competency in this study is based on the Iceberg Model adapted from Spencer & Spencer which covers three key components of measuring teachers’ competence levels of knowledge, skills and attitudes [17]. These components have been illustrated by Hay McBer in the Iceberg Model where knowledge and skills are visible and easy-to-learn components while personal personality traits are attitudes that are difficult to see and develop but contribute the most to one’s competency [18].

The component of knowledge is the ability of individuals to equip themselves with continuous knowledge to improve their performance effectively. In the context of this study, this component refers to the knowledge of teachers in HOTS which includes principles, concepts, curriculum, pedagogy and assessment. For the skills component, it refers to the ability of individuals to use and apply the knowledge and skills gained to well-performed a task in achieving the desired goals. The teacher's HOTS knowledge is applied in the form of skills used in teaching and learning. The components of personal characteristics are attitudes and behaviours that need to be understood and practiced. Teachers' attitudes towards HOTS are assessed through the personal views and practices of teachers in HOTS. The measurement of these three components will give insight to the level of competency of science teachers in implementing HOTS in teaching and learning as a whole.

4. Research objectives
Many recent literature studies have examined teachers’ readiness, competency and professionalism in various areas. But the study of competencies for teachers in science is still unclear. Based on this phenomenon, the research aims to measure the level of competency of science teachers as well as analysing the strengths and weaknesses of science teachers in implementing HOTS in teaching and learning to ensure that science teachers are competent and proficient. The extent to which the implementation and integration of HOTS in science learning can be measured and analysed for better empowerment and improvement processes can be carried out. Therefore, the objectives to be achieved in this study are to;

- identify the competency level of science teachers based on the knowledge aspect in integrating HOTS in teaching and learning;
- identify the competency level of science teachers based on the skills aspect in integrating HOTS in teaching and learning;
identify the competency level of science teachers based on the attitude aspect in integrating HOTS in teaching and learning.

5. Methodology

5.1. Research design
Research design is the plan or strategy for conducting the study [19]. This study is a quantitative study using the survey method in the form of questionnaire instrument. The choice of survey study is to enable a generalization to be made from a sample of studies that represent the population [20]. A survey method is suitable for measuring respondents’ view of an issue, measuring their achievements and attitudes and practices [21]. Therefore, the survey method is suitable for measuring the level of competency of science teachers in this study. The study population selected were science teachers at 27 secondary schools in the district of Besut who are teaching science, physics, chemistry and biology subjects. Sample selection is a simple random sampling. A total of 39 respondents responded to the questionnaire distributed.

5.2. Instrument
The use of questionnaires is most appropriate for quantitative studies for the purpose of obtaining accurate data for analysis [22]. This study uses questionnaire instruments used in the study by Norfariza Mohd Radzi and Nur Fadhillah Muzammil [23]. The questionnaire was adapted with permission. The justification of choosing this instrument is that the construct of the items matches what the researcher intended to see which are knowledge, skills and attitudes. This instrument has received expert validity in terms of the content and language. This instrument has also been tested the reliability through a pilot study with the Cronbach Alpha index calculation as a measure. For the knowledge items in HOTS, the reliability value is 0.921. Similarly, the items of skills and attitude in HOTS with reliability values of 0.940 and 0.903 were also high. The questionnaire comprises four sections. Section A is for demographic which included gender, age, academic qualifications, teaching experience, attendance of HOTS workshop and major subjects taught. Section B deals with teachers’ knowledge of HOTS. Section C is to obtain information on teachers’ skills in implementing HOTS. Section D looks at teachers’ attitudes towards HOTS. The measurement scales used in this study are the 5-point Likert Scale.

5.3. Data collection
Researchers have collaborated with Besut district high school teachers to online-distribute the questionnaires to science teachers in their schools. Through the disseminated instrument, the researcher informed that all information shared by the respondents is confidential and will be used for research purposes only. In addition, the researcher also stated that the findings of the study were not to measure individuals or organizations, but to look at the overall science education phenomenon in order to implement improvements in the future. Within three weeks of the dissemination of the questionnaire, two reminders were made by the researcher to ensure that the purpose of the distributed questionnaire is achieved.

5.4. Data analysis
Descriptive methods were used to analyze the data in this study. Frequency and percentages are analyzed in Section A, which is demographic information to view the distribution of respondents by gender, age, academic qualification, teaching experience, attendance of HOTS workshops and major subjects taught. Section B, Section C and Section D are analyzed by looking at the mean values and standard deviations to measure the level of competency of science teachers in terms of knowledge, skills and attitudes in implementing HOTS. The mean values obtained are interpreted into three levels namely low, moderate and high by dividing the 4 intervals in the 5-point Likert Scale applied to the three desired levels. Each point carries a value of 1.33. Table 1 shows the interpretation of mean scores as used in the study of Sumarni Lapammu and Zamri Mahamod [24].
Table 1. Interpretation of mean score

| Mean Score   | Mean Level |
|--------------|------------|
| 1.00 to 2.33 | Low        |
| 2.34 to 3.67 | Moderate   |
| 3.68 to 5.00 | High       |

6. Findings

The profiles of the respondents involved in this study have been analysed. Data indicated that more than half of the respondents were female (f=27, 69.3%). The demographic survey by age group analysis showed that the majority of the respondents were at 30 to 39 year-old (f=20, 51.3%) while the minority of the respondents were between the ages of 40 and 49 (f=4, 10.2%). The findings also showed that 96.9% (f=38) of the respondents in the study consisted of science teachers with academic qualifications of the first degree. The respondents consisted of the average of 5 years of experience teachers (f=14, 35.9%) followed by 7 to 10 years of experience teachers (f=13, 33.3%). The minority of science teachers who responded were among the very experienced teachers (f=5, 12.9%). Subsequent findings discuss teachers' exposures to HOTS workshop. Analysis suggests that the majority of science teachers had attended the HOTS workshop (f=32, 82.1%). The final analysis in the demographic was related to the major subjects taught in the school. Majority are teaching science subject (f=22, 56.4%). The rest are divided between 3 pure science subjects which are chemistry, biology and physics.

6.1. The science teachers' level of knowledge in HOTS

Analysis shows the highest mean value of 4.565 (sd=.471) which is the knowledge of respondents regarding cognitive level in Low Order Thinking Skills (LOTS). This was followed by cognitive levels knowledge in HOTS with a mean value of 4.156 (sd=.824). Both mean values suggest that respondents' knowledge of the Bloom's Taxonomy Level is high. This is followed by a high level of mean for understanding the concept of HOTS, identifying 4 level of HOTS in curriculum documents, knowledge of preparing lesson plans and teaching aids and planning the implementation of HOTS in T&L. The high level of knowledge is indirectly associated with the majority of respondents who have attended HOTS workshops. The mean values of the knowledge of the HOTS based learning strategies and approaches suggest an overall lower level. These mean values suggest that respondents are less familiar with the diversity of strategies and approaches in HOTS based pedagogy. Respondents' knowledge of the use of thinking tools in enhancing HOTS is expected to be at a high level with the highest mean recorded by knowledge of the usage of mind maps and i-THINK maps. For assessment items, although the mean value proposes knowledgeable respondents on the general criteria of the HOTS question (m=3.906, sd=.752), a moderate level of knowledge is suggested for how the HOTS item is constructed in the assessment (m=3.594, sd=.809). This finding suggests that the workshop related to HOTS attended by the respondent did not emphasize enough on the construction of the HOTS items. Overall in terms of knowledge, the mean value suggests a high level of knowledge for science teachers in integrating HOTS in teaching and learning (Table 2).

6.2. The science teachers' level of skills in HOTS

Referring to data collected, for items of the use of HOTS verb in the curriculum, the mean level suggests high proficiency in the usage of apply, analyze and evaluate. Whereas moderate level is suggested for the verb of create (m=3.594, sd=.756). High level skills are also suggested in planning the implementation of HOTS in T&L and to provide HOTS-based teaching plans. This may be explained by the documents of the Curriculum Standard and Assessment provided by the MOE for the
convenience of teachers in planning daily teaching. In terms of the provision of teaching materials based on HOTS, a moderate level is proposed based on a mean of 3.625 (sd=.761). The mean values obtained for the learning strategy items suggest a moderate level for all items suggested that the respondents are less likely to explore new strategies in teaching and learning. For thinking tools using mind mapping, the use of mind maps recorded the highest mean value of 3.750 (sd=.672) compared to i-THINK maps, graphic organizer and questions and questioning technique. For the last item, namely the construction of HOTS items in the assessment, a moderate mean level has been suggested. Overall in terms of skills, mean values suggest a moderate level of teachers' skills in implementing HOTS in teaching and learning (Table 2).

6.3. The science teachers’ level of attitude in HOTS
In terms of attitude, the findings indicate that respondents were less concerned with the latest issues related to HOTS based on the lowest mean scores for the item (m=3.531, sd=.567). However, the mean value also suggests that respondents are very concerned about the importance of applying these skills in T&L (m=4.031, sd=.897). In addition, a high level of mean is recommended for teachers’ willingness to learn the HOTS learning approach and implement the teaching using HOTS. Overall in terms of attitude, the mean value suggests a high degree of teachers’ attitudes in implementing HOTS in teaching and learning (Table 2).

Table 2. The competency of science teachers in integrating HOTS

| Aspect of Competency | Mean (m) | Standard Deviation (sd) | Mean Level |
|----------------------|----------|-------------------------|------------|
| Knowledge            | 3.826    | 0.252                   | High       |
| Skills               | 3.434    | 0.180                   | Moderate   |
| Attitude             | 3.672    | 0.181                   | High       |
| Overall              | 3.672    | 0.209                   | Moderate   |

7. Discussion
This study aims to look at the level of competency of science teachers based on three aspects which are knowledge, skills and attitudes in implementing HOTS in teaching and learning. Based on the proposed mean value, the science teacher's competence for knowledge aspects is high. The sample of science teachers involved as respondents has a clear knowledge and understanding of the concepts of HOTS underlined by KPM as an ability to apply knowledge and skills to solve problems and make decisions. The science teachers are able to identify the cognitive level for HOTS and be able to distinguish it from LOTS. In addition, science teachers are aware of the planning and implementation of HOTS based teaching and learning, the diversity of the HOTS approach strategies, the use of thinking tools and the subsequent development of HOTS items in assessment. The knowledge and mastery of good concepts by teachers influence the way they are developed in teaching [25]. The high level of the knowledge indicates that science teachers are constantly developing their capabilities and professionalism with the majority of respondents having attended HOTS workshops. This is also the result of MOE's initiative and efforts in empowering HOTS through the drafting of the HOTS curriculum, the HOTS awareness campaign, the distribution of HOTS teaching aids, ongoing professional development training as well as the production of HOTS application handbooks distributed to schools [4]. With high level of knowledge and understanding, teachers are capable of producing effective teaching because knowledge and understanding influence how a teacher acts, makes decision and applies teaching practices in the classroom [26]. Similar findings are reported in the study involving Islamic education and mathematics teachers in high school [21] [27].

In terms of skills, moderate levels of competence are found in science teachers. Skill refers to the ability of individuals to use and apply knowledge. Therefore, high levels of teachers' knowledge competency need to be demonstrated through the skills observed. In order to enhance thinking skills and ensure that teaching and learning in the classroom can be carried out creatively and effectively, a teacher must have skills in a variety of strategies appropriate to the content of the teaching [28]. The
mean values of the skill aspects suggest that science teachers do not tend to explore various strategies and approaches in teaching. Exam-oriented practices do not provide a conducive environment to create a culture of teaching science and enhance science literacy in a meaningful way that can further develop students' thinking skills [8]. Teachers need to emphasize student-centred teaching strategies as well as applying the technology and digital elements to produce meaningful learning in the classroom [11]. Learning science that is prevalent in the laboratory should give science teachers the opportunity to be more versatile, creative and innovative in executing T&L that stimulates thinking and builds student minds. The use of real material and the appropriate approach, assisted by the use of thinking tools will produce a meaningful T&L session and will indirectly apply HOTS in students. The finding of a moderate level of skills is also supported by other researchers in different field of subjects [23] [29] [30]. These studies indicate that teachers do not possess the skills of integrating HOTS into teaching besides lacking of various methods and strategies for implementing HOTS. Teachers also expressed difficulty in asking high-level questions to students.

The aspect of attitude also shows a high degree of competency in science teachers. The willingness to learning the HOTS approach and implement the HOTS based teaching demonstrates the positive attitude and high commitment of science teachers in applying these skills in teaching and learning. Science teachers are also positive about this skill as the aspirations outlined in the blueprint and take importance note of nurturing this skill to their students. The element of personal characteristics seen through attitude is an important component that supports the knowledge and skills components that shape an individual's competency. The mean value proposed in this aspect gives a positive impression of the competency of the science teachers as a whole because attitude is the heartbeat that plays a major role and affects the knowledge and skills of an individual [3]. A person's tendency to act either positively or negatively toward an object, situation, or person is reflected in attitude [31]. Attitude can also affect one's behaviour, effort taken, interest and awareness in doing something [32].

8. Conclusion
Overall, referring to Table 2, this descriptive study has suggested a moderate level of competency for science teachers in implementing HOTS in teaching and learning. High level of knowledge and positive attitude need to be justified through the skills applied in the classroom. Science teachers need to execute a T&L session that combines a variety of approaches, addresses diverse cognitive levels and complex questions and plans activities that challenge students' thinking. Science teachers also need to be smart and creative in addressing the challenges of implementing HOTS so that it can be effectively applied to students through the T&L process and eventually increasing the quality of education in our country.

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