Force field analysis on higher order thinking skills (HOTS) airtime in Malaysian mathematics classroom

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Introduction

Amongst the goals of the Malaysian National Education Development Plan (2013-2025) is the emphasis of thinking skills amongst teachers and pupils, specifically on teaching about thinking. This has been implemented using various tools in the hope that our pupils will be able to think using Bloom's taxonomy (1956) and Anderson and Krathworl's (2001) work. As teachers introduce the concept of how to think by using all levels of questions, this preliminary modest study on HOTS airtime, a colloquial expression, which the researcher defined as the proportion of time devoted to asking questions in the classroom in order to develop thinking among pupils, is explored.

Force field analysis is akin to surveying the strengths and weaknesses, the opportunities and threats that are present, which must be taken advantage of or overcome. In the field of Physics, the idea of a force field explains why objects in the physical universe move or fail to move because of the counteracting forces that push them back to the status quo or push them forward. Some people described them as inhibitors and accelerators.

Therefore, for this study the researcher sought to use a tool devised by School Inspectorate and Quality Assurance, Ministry of Education, i.e., the Quality Standards of Malaysian Education (SKPM, 2010). SKPM was used as the instrument to ascertain the kinds of accelerators that could increase HOTS airtime and the inhibitors that frequently constrain improvement. Moreover, all teachers are familiar with SKPM as it is mandatory to be used by all Malaysian schools in the assessment of the teaching and learning process based on a directive from MOE. Ideally, SKPM is used by all schools as a guide and self-review to assist teachers in their learning and teaching process.

HOTS airtime has been identified as a research issue. The researcher scrutinized all the twelve aspects in SKPM concerning accelerators and inhibitors. Three mathematics classes were selected where HOTS airtime was observed and analysed based on SKPM. The accelerators were compared and ranked to determine which one was ranked highest and lowest in the force field analysis. This exploration was done to contribute to the pursuit of knowledge on how Malaysian teachers who traditionally engage in teacher-centred approach with strong emphasis on examination carry out the mandated HOTS teaching and learning process as well as to seek out those who were successful in implementing HOTS. Thus, the researcher hopes to identify the accelerators that encourage HOTS airtime and analyse the strength of its contribution.

Literature review

Hiebert and Wearne (1993) as well as Klinzing, Klinzing-Eurich and Tisher (1985) observed that teachers rarely asked "higher-order" questions even though these had been identified as important tools in developing better pupils understanding. Mathematics

teachers ought to view questions from within the context of the kind of instruction that takes place in the classroom and in relation to the mathematical context. This is relevant as research by William (1999) showed that rich questions promote thinking and standard mathematical tasks could be opened up for exploration with skilful teacher questioning (Lampert, 2001). Since questions were a way that teachers used to bring pupils around to the correct mathematical concepts and procedures through the "negation of meaning for necessary condition of learning" (Voight, 1992, p. 43), it was important to emphasize teachers' questioning as a critical part of a teacher's work. The act of preparing and asking a good question is cognitively demanding because it requires considerable pedagogical content knowledge and it necessitates that teachers know their pupils well. The preparation of a teacher based on her teaching record is ranked as the top accelerator in HOTS airtime.

Resnick (1987) emphasized that mathematics should not be recall of information nor mere application of concepts or knowledge to familiar situations and context, thus the researcher rank pupils' active interaction as the next accelerator which required pupils to work outside the familiar. This is in congruence with Senk, Thompson and Beckham's (1997) suggestion that HOTS involve solving a task where the solution requires applying an unknown algorithm, with justification, explanation or proof required and where several correct answers are possible.

The third accelerator refers to the resources available such as textbooks and thinking tools that may foster high level of cognitively complex task as recommended by Stein and Lane (1996). Igbaria (2013) stressed that textbooks contribute greatly to pupils' creative thinking. Furthermore, the MOE has advocated Malaysian teachers to use Kestrel's eight thinking tools (i.e., defining context, describing qualities, comparing and contrasting, classifying, part-whole relationship, sequencing, cause and effect, and using analogies) to encourage interactions and thinking.

Research problem

The researcher sought to observe and rank the accelerators and inhibitors for HOTS airtime in the mathematics classroom based on the SKPM.

Methodology

The researcher observed three mathematics classrooms as part of her professional duties being a trained mathematics school inspector in Sarawak, Malaysia. The researcher is a trained mathematics teacher who has taught for 17 years in secondary school mathematics as well as a school inspector who has undergone various professional trainings organized by MOE and inspected more than 200 schools in Malaysia for more than eight years. The selection of the schools was determined based on locations and primary-secondary schools ratio. The teachers were chosen randomly with the requirement that they were teaching mathematics during the time of inspection. No other observers or evaluators were involved due to financial and manpower constraints. The purpose of the observation was to ascertain if the accelerators encourage HOTS airtime amongst the pupils. Hence, three female mathematics teachers, Doris, Hafi and Lau (pseudonyms) were interviewed and observed. Their teaching records and pupils' work were also inspected.

Findings

Doris taught a Year 3 (9 years old) class. Her topic was estimating and calculating mass of objects. She used various weighing machines as an introduction to her lesson. Her lesson plan explained the steps that would engage and elicit responses from her pupils. First, Doris asked her pupils to compare the weights of two of their classmates, "Let's guess the weight of Ani and Betty. Can you compare? Who is heavier?" Next, she asked them to guess the weight of a third pupil.

The learning activity was student-centred and pupils happily participated in paired learning. Doris engaged her pupils using various strategies to increase HOTS airtime such as games and music to increase pupils' interaction. Doris used questions such as "Are you sure?" and "If 1kg is 1000g, what about 500kg, how many grams is that?" However, although the lesson was fun, Doris did not engage her pupils to ask questions as they were merely confirming the answers of their peers in their "think-pair-share" activity. Doris facilitated the learning but did not utilise pupils' wrong answers as an opportunity to correct their misconception. As Cazden (2001) emphasized on classroom discourse such as wait time in teacher-pupil interaction so that pupils will be probed to search for alternatives, Doris did not successfully explore probing questions nor check for accuracy and understanding in their fully-charged mathematics classroom discourse.

Hafi who taught in a rural secondary school was not trained in mathematics but as there were not enough mathematics teachers she was asked to teach the Form 2 (14 years old) pupils. Hafi's lesson plan had five objectives, which were too ambitious for her one-hour mathematics class. She could not complete her lesson. Hafi unknowingly used questions and a sense of uncertainty to stir the pupils' interest and curiosity. Hence, when pupils were challenged on how to construct perpendicular lines, they tried various methods to get the correct answer. Pupils were engaged in the lesson and used all kinds of references to confirm their answers. As Hafi moved around to check for pupils' understanding and misconception, those who were uncertain about their strategies eagerly sought her help. She demonstrated how to solve part of the problem and the pupils followed up with their own attempts to construct the lines. However, as Hafi did not plan her lessons with appropriate HOTS questions, she did not engage or probe her pupils in HOTS. When pupils were asked to explain their solutions to their peers, she did not probe them to think deeper or encouraged other pupils to ask questions. Although social interactions were happening, Hafi was not able to challenge pupils to find answers or create unique ways of presenting the information that they discovered.

Additionally, Hafi did not plan her questions carefully although the problem she posed could be answered at various levels according to the pupils' conceptual understanding. Some pupils were challenged to find other alternatives in constructing the perpendicular lines. Interestingly, those pupils stumbled into a new question worth exploring, "Which method was better and why?" Nonetheless, in this class from the rural school, HOTS airtime was not accomplished successfully as Hafi has very low confidence in carrying out the lesson. Her emphasis on single-step answers did not challenge or motivate pupils to be creative.

Lau, a secondary school teacher in the town area has taught for more than twenty years. She was given a class filled with intelligent and inquisitive Form One (13 year

olds) pupils. She started her lesson with detailed lesson plans as she used open questions to extend learning. Lau encouraged the pupils to find the relationship between the radius and circumference of a circle. They were given a big rubber band and a string, and asked to apply their prior knowledge to this new and challenging situation. Each group was instructed to synthesize a range of mathematics concepts such as determining the center of the circle, measuring the radius and circumference to confirm their answers. Next, Lau asked the pupils to compare their answers from the two methods that they have used against using the formula circumference = $2\pi r$. Although several pupils looked anxious and uncertain in using this exploration process, most of the pupils found it challenging, interesting and meaningful as they interacted in their groups to successfully put their mathematical understanding into solving everyday problem.

From the researcher's observation, Lau has successfully incorporated HOTS in her classroom discourse (airtime) by probing and engaging pupils to think of alternatives in measuring the circumference of the circle. Her active feedback loops that assist learning as mentioned by Black and William (2004) showed that these social interactions that used cooperative groups managed to facilitate pupils seeking and accepting different opinions while checking for accuracy and understanding. The entire 80 minutes of classroom discourse showed that pupils were on-task. Lau guided the pupils to ask probing questions to clarify each other's thinking, as this was a part of formative assessment (assessment for learning) (Black & William, 2003).

In her reflection, Lau shared her satisfaction on how the lesson went and enthusiastically planned on how she could increase everyday problems such as calculating the volume of cement needed to build a circle using information from the required radius and height.

Discussions

The observation from this modest study confirmed that the teachers who were deemed to accelerate HOTS airtime have adequate prior preparation of HOTS questions before class.

Teachers' preparation

Observations of the teachers' preparation and self-reflection (SKPM 2010, p. 80) revealed that only Lau and Doris have adequately prepared the questions that they wanted to ask. They have sought to ensure there were adequate opportunities of learning whereby even misconceptions and challenges faced were used in the teachers' efforts to continuously engage their pupils in the process of learning. These HOTS airtime were deemed the most critical aspect in the mathematics classroom, as these were the opportunities that wrong concepts could be addressed and corrected.

In the three classes observed, there were very few high level questions (SKPM 2010, p. 85) which could be used to obtain creative and innovative ideas and approaches, evaluate and synthesize the decisions and justifications given, as well as to analyze and apply the information in a new situation, as advocated by Benjamin Bloom and Tracy Anderson (Anderson & Krathworl, 2001, p. 67-68). Moreover, none of the teachers showed that they were competent to rephrase or clarify questions (SKPM 2010, p. 85) by asking pupils, "Are you trying to say…?" or "What is your opinion about …?" This is related to the teachers' inability to present their lessons in a confident, clear and

accurate manner, which ought to be related to current issues and their surroundings across curriculum using diverse resources. Furthermore, in Hafi's class, due to her inexperience and lack of pedagogical content knowledge, she was not able to adequately probe her pupils for ideas and alternatives in the construction of perpendicular lines.

Pupils' involvement

Secondly, the pupils' active involvement as seen in all the classes (SKPM 2010, p. 77) was evidenced by their responses, further elaborating on their explanation, debating the answers given, interacting intellectually, defending their answers in a confident manner. The works done by Lau's pupils were of high quality (SKPM 2010, p. 79), which demonstrated that effective learning has taken place whereby they were able to present their works to their peers in a creative, innovative and critical manner.

Learning resources

All the teaching activities observed provided rich learning experiences in terms of resources that were fun, thus encouraging collaboration and interdependence among students. Teaching was student-centred (SKPM 2010, p. 81) and the teachers have adapted resources that encouraged inquiry, were problem-based as well as promoted collaborative and cooperative learning.

However, this accelerator could be inhibited if teachers are not able to stir the personal interest of their charge or prepare a conducive environment for igniting their curiosity. Some teachers like Hafi could be incompetent or already in their comfort zone thus will not work to purposely provoke a situation whereby incomplete instructions and information were used to prompt pupils to think through real-time situations. As many teachers consider HOTS to be something new there could be inertia or resistance based on the researcher's observation. Moreover, teachers are very familiar with the examination-oriented ways of teaching, which emphasized low-level single-step solutions hence the status quo for many teachers will be challenged. Thus, pupils may not be able to progress effectively further and deeper in their learning process.

The teachers were also not able to use educational resources effectively (SKPM 2010, p. 83) with the appropriate levels of their pupils in their interactive airtime between pupil-pupil, pupil-teacher and pupil-resources.

Limitations

The researcher acknowledged the limitations of this study as observation is based on a short period of time, which only encompassed the official time of classroom discourse with no follow-up observations done and the limited number of samples. Moreover, the number of observers was limited due to financial and manpower constraints. Nonetheless, this exploratory study has been attempted with the ardent hope that it will trigger more in-depth, well-developed and financed studies.

Conclusion

As Ubben and Hughes (1992) sounded the warning quoting Lewin (1961) that a body at rest will only "move in the direction of the unbalancing force" (p.137), it is imperative that the HOTS airtime should not be "frozen" due to the counterbalancing of plus and minus forces. Hence, in eliminating forces such as teacher's inexperience, apathy and over-reliance on textbooks as the only educational resource, developing new forces or

affecting the power of existing forces such as collaborations of teachers, using HOTS assessments, active involvement and interactions as well as detailed and focused lesson plans will unfreeze the current situation thus creating a new state of equilibrium.

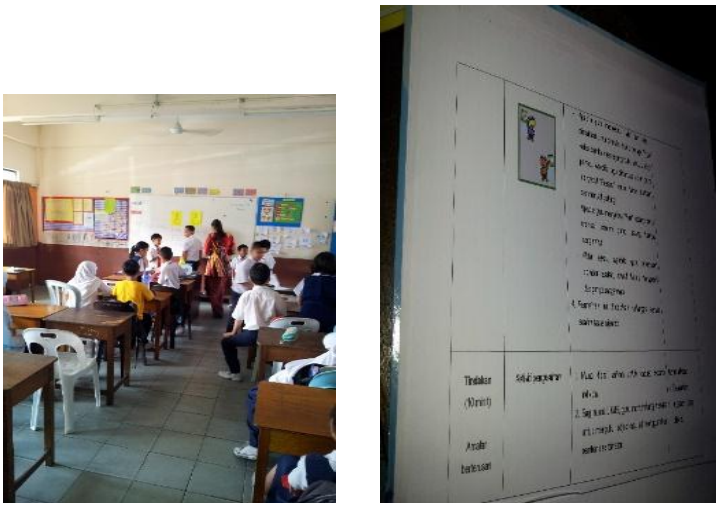

Figure 1. Interaction in Doris' class and sample of Doris' lesson plan

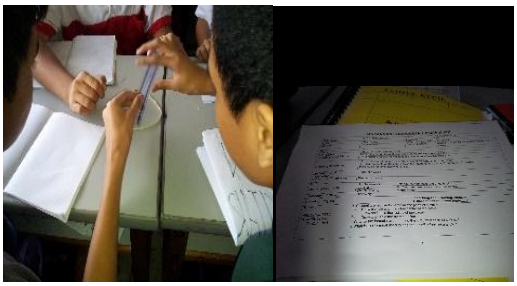

Figure 2. Engaged exploration as planned by Lau

Figure 3. Hafi's class –explanations by teacher and pupils

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