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RESEARCH ARTICLE

Indigenous Students' Images and Metaphors of Mathematics

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ABSTRACT

Images and metaphors have a significant impact on the mathematical knowledge of indigenous students. Several studies on indigenous education have found that indigenous students have very different ideas about learning mathematics. In this regard, research on images of mathematics and metaphors related to mathematics learning held by indigenous students is considered distinct and novel in relation to past research. The purpose of this case study is to investigate the mathematical images and metaphors in Pahang, Malaysia. A purpose-sampling technique was used to collect data digitally and descriptive analysis was performed on the responses of 31 indigenous students. The use of images and metaphors as constructions gives a glimpse into how students view themselves as mathematics learners and what they do while learning mathematics. Furthermore, images and metaphors help to construct meaning for abstract mathematical concepts because they connect to a variety of different senses. The findings of the study suggest that most indigenous students believe that knowledge of mathematics comes from the Creator. Humans, in particular, construct knowledge based on their reasoning, sensory experience, and guidance from the Creator. The results of the study could be used in the future to promote quality education for indigenous students.

Keywords: Images, Indigenous, Knowledge of Mathematics, Metaphors

1. INTRODUCTION

Over the last 50 years, research has consistently shown that student understanding and approaches to solving mathematical problems improve students' ability to learn, memorise and apply mathematics (Adnan et al., 2011; Singh, 2009; Teoh & Surubi, 2015). According to Howard and Perry (2005), understanding is vital because what is learnt with understanding can be applied flexibly and adapted to new contexts. Meanwhile, knowledge gained through understanding is useful in a constantly changing and unpredictable world. They also highlight and support the development of deep and integrated mathematical understanding, as well as the acquisition of mathematical abilities. Learning with understanding helps students develop confidence in their mathematics ability; therefore, conducting research on the aspects of thinking and cognition of indigenous students, especially among adolescents, in perceiving their

understanding of mathematical knowledge is important because these perceptions play a role in influencing their motivation and behaviour. In the same way, how indigenous students think about mathematics and how they learn mathematics may affect their future goals and academic goals.

Students' knowledge of mathematics can be identified using two elements known as images and metaphors. In this regard, issues related to one area of philosophy, namely the epistemological aspect, have to do with education and teaching methods. The epistemological aspect involves the study of the nature of mathematical knowledge, mathematical methods related to specific concepts such as truth, belief, and justification, and ways of knowing mathematics, especially in the context of limitations and the validity of various ways of knowing (Nik Pa, 2016). Therefore, studies on the images and metaphors of mathematics held by indigenous students are considered necessary to gain an understanding of this unique group of people. Correspondingly, any reflexion, idea, or conceptions formed by indigenous students on mathematical epistemology or the fundamental nature of mathematics have a direct effect on the mathematics education programme.

In Malaysia, only a few studies have involved indigenous student's enroling in higher education institutions as a case study to investigate the images and metaphors associated with mathematics learning. Although there are studies that use different data collection techniques for the same purpose, not all of the studies involved produce the same results (Sam, 1999). Therefore, this study aims to explore the images and metaphors of mathematics held by indigenous students at a higher learning institution in the state of Pahang. The results can reduce the research gap that exists for studies that choose different techniques. This study chooses the universal integrated perspective as the theoretical framework to enable the basic principles of images and metaphors to be explained in an integrated manner. In this context, a universally integrated perspective assumes that knowledge is constructed by active and creative participants, received from the outside or discovered from their environment through social interaction, and has ontological reality. Things that an individual prefers are considered subconscious mental processes that create imagination and intuition. Meanwhile, the universally integrated perspective considering the scope of epistemological questions is broad, both in the fields of religion and secularism. This is due to the Islamic worldview, which does not recognise the differences between these two fields (Syed Muhammad Naquib, 1995). Theoretically, this study is very interesting because it uses a certain philosophical approach to determine the variations in a learning situation. The information obtained can affect the pedagogical changes and improvements in teaching and learning mathematics held by indigenous students.

The terms 'images' and "metaphors" used in this study refer to one's personal representation of mathematics and mathematical learning. In general, these terms can include representations of graphics, space, and linguistics and can be related to one's beliefs, conceptions, and attitudes toward mathematics and mathematical learning (Osman, 2015). In this study, the selection of metaphors for written responses to a set of multiple-choice questions is influenced, at least in part, by their prior knowledge. Thus, it represents their individual histories in some way. Furthermore, the results on indigenous students' images and metaphors may provide information on the development of their conceptions of mathematics. Therefore, the study of these images and metaphors can serve as a knowledge component for the development of indigenous students' mathematics education programmes.

This paper is organised as follows: The literature review related to this study is given in the next section, followed by the methodology of the study, the results, and the discussion. Finally, the article ends with a conclusion of the study, its limitations, and a recommendation for future work.

2. MATERIALS AND METHODS

Nowadays, studies of mathematical images and metaphors have gained widespread attention. These studies include the mathematical images and metaphors of adults (Osman, 2015) and students (Picker & Berry, 2000; Wong et al., 2007). Picker and Berry (2000) found that teachers are one of the key factors influencing student attitudes and beliefs about mathematics and mathematical learning. In addition, the differences in students' mathematical images and metaphors were found to depend on the methods of mathematics learning, students' mathematical learning experiences, and their evaluation of achievement (Wong et al., 2007). Yee (2017) found that among the majority of mathematical images and metaphors of problem solving given by students and teachers are journey, discovery, searching, building, visualisation, process, and partitioning. Erdogan et al. (2014) found that the most popular mathematical images and metaphors of mathematics given by prospective teachers are water, puzzle, ocean, sea, and riddle, while Latterell and Wilson (2017) found that half of the students majoring in elementary education viewed mathematics as an up-and-down process such as riding a roller coaster, and a quarter of them described mathematics as very difficult and unpleasant, like walking through a field of bombs. Furinghetti (1993) stated that mathematics is a peculiar field of study where learners may like or hate it, understand or misunderstand it, and everyone has a specific image or mental picture of it.

Meanwhile, Rock and Shaw (2000) pointed out that the learning process will be more challenging if the students' images and metaphors for mathematics show that they consider mathematics to be an unappealing subject. In other studies, Inan (2015) found that more than 90% of middle school students' drawings demonstrated positive mathematics characteristics such as functionality, numbers, figures, enhancing mental activity, enjoyable, rational science, and learning through effort. At the same time, Osman's (2015) research found that the drawings of more than fifty per cent of respondents demonstrated teaching mathematics as a teacher-centred teaching method. According to Schlimm (2016), metaphors help us to understand the concept of abstract phenomena. By observing and investigating the metaphors of mathematics held by mathematicians, we can see how they look and understand the nature of mathematics at a glance. Shaari et al.'s study (2011) found that indigenous students were interested in outdoor activities but lacked skills, making it difficult for them to master problem solving subjects. In addition to that, they were quickly bored and lacked learning skills. The learning process occurs only in school, and they prefer to work in the woods or help their parents earn a living.

The importance of the cultural background in mathematics learning has been widely recognised many years ago. Studies by Verner et al. (2013), Weldeana (2015), and Cimen (2014) showed that the cultural background might influence their mathematical thinking and, therefore, their performance in mathematics. Similarly, a study by Ezeife (2011) in Grades 5 and 6 classes of indigenous students in Ontario, Canada, showed that students performed significantly better when taught with a culture-sensitive curriculum compared to the regular curriculum. In comparison, Sicat and David (2016) found that the group receiving education in the same ethnic group performed better in mathematical computation skills compared to another group receiving education in a public elementary school. Their study also showed that teachers' concentration on the same tribe provides them with a clearer picture of the students' culture and limitations; thus, the transformation of knowledge could be much easier. According to Letsekha et al. (2014), the indigenous knowledge system of a tribe can be used as a basis for learning strategies. In addition, Prediger (2004) and d'Entremont (2015) affirmed the importance of including cultural backgrounds in teaching and learning mathematics strategies. Meanwhile, Ignas (2004) also suggested that there is a need to incorporate cultural practises, ideas, and beliefs into the mathematics curriculum. Previous studies focused on educators and students based on western perspective. Meanwhile, limited study focussing on local moulds involving

indigenous students. Thus, by studying the metaphors and images of mathematics held by indigenous students, the way they see and understand mathematics can be investigated. Based on this information, teachers, the district education department, the State Education Department, and the Ministry of Education can plan strategies or curriculum that can improve mathematics learning among indigenous students.

In this case study research design, an online form was used to investigate indigenous students' mathematical conceptions through their images and metaphors of mathematics. The participants in this study are indigenous student's enroled in several higher learning institutions throughout the state of Pahang. Due to the limited number of indigenous participants qualified to be a valid source of primary data, purpose sampling was used in selecting the most appropriate participants according to the research judgment. Students who have participated in various activities and experiences throughout their lives, including experiences in mathematical education, are more likely to exhibit specific images and metaphors related to mathematics in this context. The data collected from the participants through Google Forms was shared electronically. They were analysed quantitatively and qualitatively. Thirty-one indigenous students responded, and this figure is acceptable since not many indigenous students are studying at higher learning institutions in the state of Pahang. The online form was adapted from Osman (2012), consisting of four sections, the demographic profile, metaphors related to mathematics the sources of mathematics, and the nature of mathematics. The last part of the form entails an open-ended statement where the participants are required to complete the sentence, "Learning mathematics is like..." The responses in completing the sentence were also analysed by grouping them according to some common themes, as suggested by Latterell and Wilson (2017). In other words, thematic analysis was utilised to gather students' metaphors for mathematics learning.

3. RESULTS AND DISCUSSION

Thirty-one participants were involved in the study, of which 22 (71%) were women and nine (29%) are males. The ages range from 19 to 23 years old. The distribution of the participants' concerns concerning religion is as follows: 12 (38.7%) Muslims, 4 (12.9%) Buddhists, and 15 (48.4%) with no religion or animism. Figure 1 shows that the participants' preferred metaphor for doing mathematics activity is solving riddles (80.6%), followed by doing exercises (22.6%), and only 3.2% perceived mathematics as performing a religious activity; however, no one perceived it as baking pizza. Thus, the participants regarded mathematics as riddles in which one needs to process all of the information available to obtain the correct answer. In this case, mathematics is considered to be a thinking process for indigenous students.

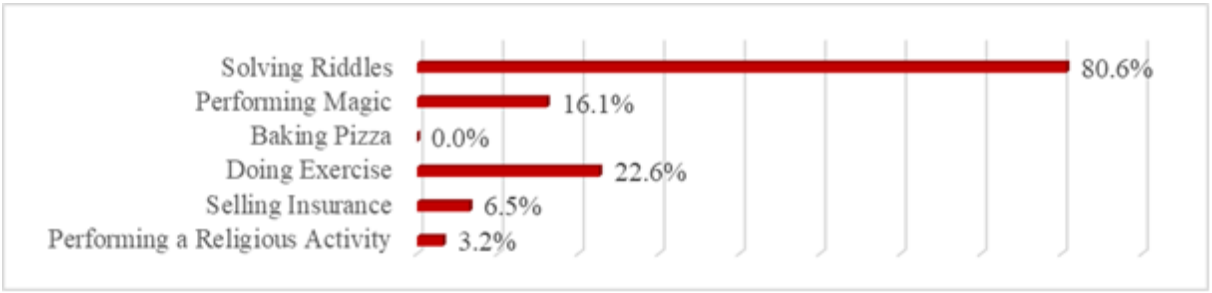

Figure 1. Activities related to mathematics

In terms of metaphors for the profession, as shown in Figure 2, businessman, banker, and engineer were the preferred choices with 74.2%, 71% and 61.3%, respectively. The participants

perceived that the professions that directly involve money are strongly related to mathematics and engineering, which are perceived to include the use of calculations in their professions.

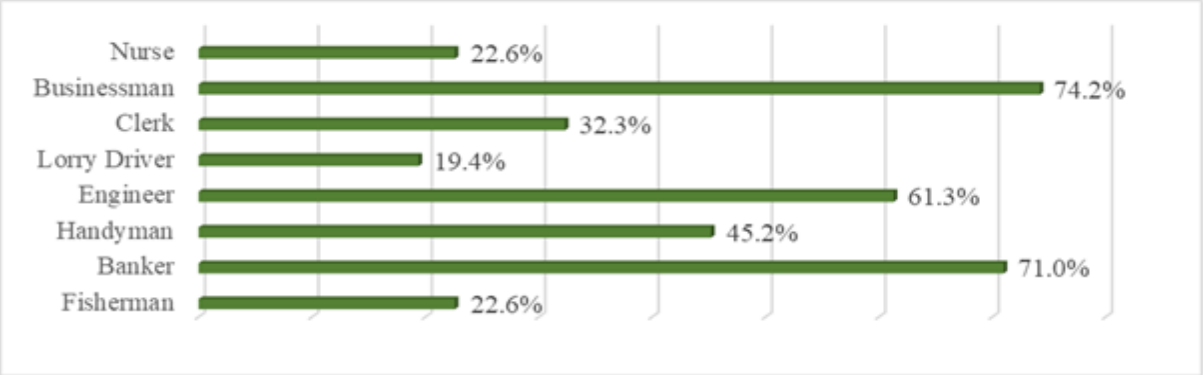

Figure 2. Professions related to Mathematics

An analysis of metaphors for mathematically related instruments is shown in Figure 3. The calculator was the best choice of the participants with a response of 93.5%, followed by a ruler (54.8%) and a pencil (48.4%). The participants' preferred choice of a calculator as the instrument related to mathematics is not surprising, since they rely heavily on calculators to solve their mathematical problems. Meanwhile, rulers and pencils are used to draw graphs and other graphical presentations.

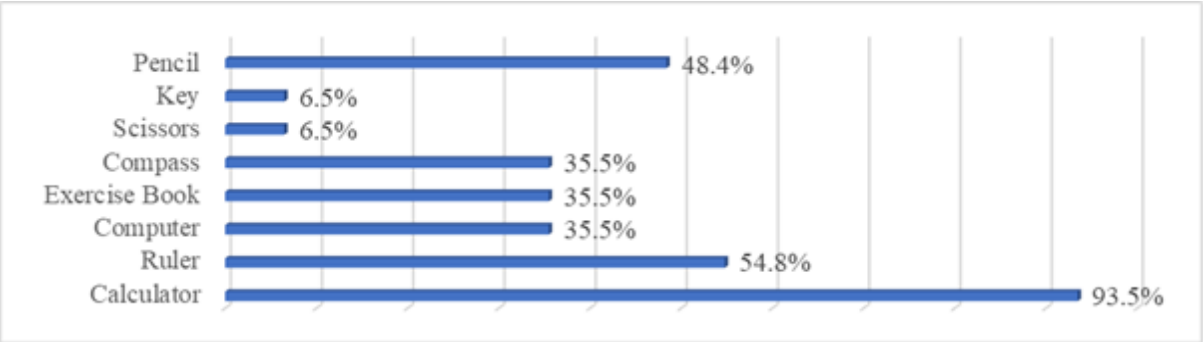

Figure 3. Instruments related to Mathematics

Numbers, mathematical formulas, and graphs (93.5%, 64.5% and 64.5% respectively) were the top choices of participants on the metaphors related to mathematical elements, as shown in Figure 4. Again, this finding is expected, since mathematics is all about numbers as perceived by most people. Naturally, the learning experience in mathematics will make them choose numbers, graphs, and formulas since these are the most related elements to learning mathematics.

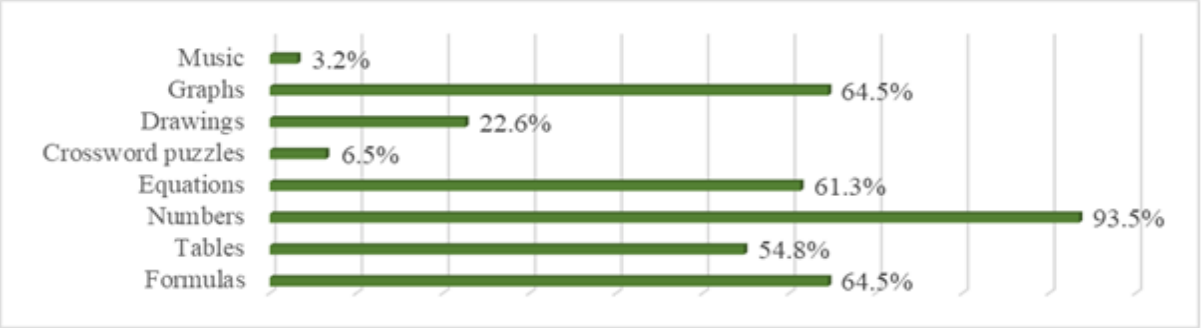

Figure 4. Elements related to Mathematics.

The responses about the sources of mathematics are based on the statements shown in Table 1. The highest percentage is for Statement 3. The participants believe that mathematical knowledge originates from the Creator and individuals construct it based on their thinking, experience, and guidance.

Table 1. Sources of Mathematics

Statement	Percentage		
	Agree	**Strongly Agree**	**Total**
1. Mathematical knowledge is part of universal knowledge and individuals discover it through their sensory experiences	51.6	6.5	58.1
2. Mathematical knowledge is part of universal knowledge and that knowledge is inherent in an individual's thinking	45.2	12.8	58.0
3. Mathematical knowledge originates from the Creator and individuals construct it based on their thinking, experiences, and guidance from the Creator	38.7	25.8	64.5
4. Mathematical knowledge does not originate from the Creator, and individuals construct it based on their thinking and specific experience	22.6	6.5	29.1

The participants' perceptions of the nature of mathematics were obtained through five questions, as shown in Table 2. The highest percentage is the perception of the value of mathematics, which is 71% of the participants agree that mathematics is very valuable. On the truthfulness of the mathematics, 51.6% of participants agree that mathematics is true in some situations.

Table 2. Nature of Mathematics

Survey question	Perception on mathematics	The highest percentage	
		Percentage	**Remarks**
How often do mathematics change?	Dynamism	35.5%	Always changing
How true is mathematics?	Truthfulness	51.6%	True in some situations
Can mathematics be presented concretely?	Concreteness	32.3%	Can be presented concretely, maybe can be presented concretely and unsure
Is mathematics originated from human beings?	The origin	35.5%	Produced by human being, and some produce by human being
How valuable are mathematics?	The value	71.0%	Very valuable

More than half of the participants (67%) viewed mathematics as a thinking process in this study. The statements that fall into this theme are summarised as follows: Learning mathematics is like solving a problem, a mental exercise for your brain to think creatively, playing a game you must focus on, and solving puzzles or riddles. The next theme that emerged from the responses is that learning mathematics is a struggle (27%), indicating that mathematics is difficult. Some statements that fall into this category are summarised as follows: Learning mathematics is like being caught in a trap, solving something in a complicated situation, and a never-ending story whenever you get an incorrect answer.

The new theme found in this study is related to learning mathematics as a journey (6%). The statements are summarised as follows. Learning mathematics is like the life journey of a human being, searching for a solution to life problems that require patience and strategy and learning in our own daily life. The findings of this study on metaphors in learning mathematics are consistent with the results reported by Osman (2020). Based on the findings, the calculator

collected only 0.6% of the responses, while the materials that obtained the highest responses were board (55%), pencil (46.9%) and book (21.3%). The type of participants may contribute to the difference in results, where, in the context of indigenous students in this study and the Diploma students in Osman (2012), calculators are considered students' best friends of students in learning mathematics. Regarding the profession related to mathematics, the businessman is the most preferred choice (74.2%), which is consistent with the results indicated by Osman et al. (2020). Meanwhile, in contrast, the Osman (2012) participants preferred the bank manager profession (95%). Nevertheless, both groups chose a profession that involves money transactions, and these results are relatively related to Inan (2015).

The analysis of the source of mathematics is shown in Table 1, which explores the holistic conception of mathematics in terms of whether the participants have a Creator-orientated perspective or a Material-orientated perspective. The finding shows that most of the participants agreed that knowledge of mathematics comes from its creator. This knowledge is constructed by humans on their thinking, their sensory experience, and guidance from the Creator. This is followed by the statement that mathematical knowledge is part of universal knowledge and that people discovered it through their sensory experiences (58.1%). The third choice is that mathematical knowledge is part of universal knowledge and this knowledge is inherent in an individual's thinking (58%). This implies that mathematics originates purely from the mental ability of humans. The least preferred statement is that mathematical knowledge does not originate from the Creator and individuals constructed it based on their thinking and specific experience (29.1%); this finding is consistent with Osman (2012).

Kittay (1991) argued that metaphors do not just have a literal meaning but more than that as they also have a specific cognitive meaning. Thus, the study of images and metaphors in this study merely provides some surface information on a subject. At the same time, in considering the complexity of understanding a concept or educational phenomenon, any model, image, or metaphor formed about that phenomenon is inadequate (Pirie, 1988).

4. CONCLUSION

In conclusion, the results of this study align with the results of previous studies related to images and metaphors of mathematics. Based on the findings, the images of mathematics held by diploma students are mostly focused on the physical aspect, the study found that the images of mathematics held by secondary school students focus on practical experiences. In the context of indigenous students, the images and metaphors of mathematics are relatively narrow and shallow because their perceptions of the source, nature, and reality of mathematical knowledge are at the level of normal human consciousness. In this situation, the indigenous students' understanding of mathematics is based on logical and empirical methods. Thus, an implication from this study shows that mathematics teachers need to have a deeper understanding of the mathematics teaching model from the local mould to guide students to become quality and balanced students in various aspects. In this case, a deep understanding of a phenomenon will be achieved not only through the strength of rational thoughts, practical experiences, and the use of scientific methods alone, but also by meeting every demand of knowledge and civilisation as well as attaining a high level of spiritual consciousness. In addition, every deep understanding begins with a spiritual being guided by faith and piety towards the Creator. Without this, everything is just a material achievement. In short, the practise of teaching and learning mathematics among indigenous students has yet to involve the process of human change in achieving self-actualisation or, in other words, self-awareness. In this case, self-awareness is closely related to awareness of the relationship between man and the Creator, other human beings, and nature. What has been discussed in this study raises questions for further studies; for example, what forms of impression have led to the situation in which indigenous

students make representations of images and metaphors related to mathematics and mathematical learning? However, it cannot be denied that the information obtained through online questionnaires regarding images and metaphors owned by indigenous students can provide a partial view into their conceptions of mathematics and mathematical learning in a specific cultural context.

Declaration of Interest
The authors declare that there are no conflicts of interest.

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