Math is like...because...: A metaphor analysis of Filipino students' perceptions of mathematical operations

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Abstract
Recent research on learner centered education and qualitative inquiry in student cognition has indicated the importance of students' processing of different concepts as these are central in teaching and learning. In the abovementioned case, metaphor analysis can be attributed to the growth of applied linguistic research permeating in different domains of society. The present investigation is anchored in metaphorical analysis espoused by Lakoff and Johnson (1980) and attempts to draw the metaphorical images associated to different mathematical operations of grade pupils studying in a basic education institutions in the Philippines. Through systematic sampling, the data used in the analysis are drawn from journal entries of 35 students written in a span of three months. As will be presented, the investigation reveals the different metaphorical images associated to the four mathematical operations. Likewise, we intend to explore possible reasons for the aforementioned metaphorical associations. Moreover, useful implications for independent learning and using applied linguistic methods in improving students cognition are forwarded.

Keywords: Basic Operations, Independent Learning, Metaphor Analysis, Mathematics Education

1. Introduction

Learning mathematical operations is a basic skill that is needed to learn complex processes across selected subjects in the curriculum. Similar to real life situations, the importance of mathematical operations is greatly emphasized since these are needed for daily transactions. Given this reality, educational institutions invest resources in improving the teaching and learning of these processes since these constitute functional literacy in society. While research has greatly explored the difficulties of learning mathematical concepts, examining metaphors associated with learning mathematical operations remains a vibrant strand in the field (Font, Bolide & Acevedo, 2010). In addition, since both metaphors and mathematical concepts bear schematic representations of processes of association and learning, it is important therefore for researchers to examine the role of metaphors in developing (meta)cognitive development of learners in acquiring knowledge about mathematics.

In the case of the Philippines, research has been geared towards improving the teaching of mathematics by examining different aspects such as motivation and anxiety (Alday & Panaligan, 2013), language and comprehension of math problems (Bernardo, 2002) and socioeconomic factors and its relationship to education (Quimbo, 2003). While these investigations are notable in terms of the perspectives forwarded, there is a dearth of investigations (in the case of the Philippines) which explore learner's metaphorical associations with mathematical operations.

Initiated by Lakoff and Johnson (1990), metaphors are not only confined to the cognitive structuring of knowledge but also experience. Moreover, the use of metaphors in

understanding the world is built on the premise that schemas whether new or old are (re)structured in terms of the associations that people make as they get to experience new things around the world. In the case of education, metaphors are viewed as a potent pedagogical tool in helping understand complex constructs for teachers and learners (Saban, 2010). Ultimately, these studies point out that metaphors are no longer used simply as a figure of speech but already functions as a tool or device to measure cognitive abilities (Zheng & Song, 2010).

Given these points, this paper aims to identify the different metaphorical images learners associate with to describe mathematical operations and to determine the conceptual themes that emerge from these images.

2. Theoretical Framework and Research Questions

As regards using metaphors in teaching and learning, Font, Bolite and Acevedo (2010) investigated the different metaphors that were used to explain graphic representation of functions at high-school level, the awareness level of the teacher in using metaphors and the extent of monitoring his use of metaphors in the classroom. Moreover, it was found that different metaphors seen during the teachers' lessons were categorized as image schemas, path image schema, container image schema, part-whole schema, and object image schema.

Also, Huang & Ariogul (2006) & De Guerrero & Villamil (2002) also emphasized that metaphors are used by educators to show their thoughts, concerns and needs. For instance, Ahsan & Anjum (2012) investigated the relationship between Pakistani teachers' beliefs, perceptions and values to their teaching-learning situations and uses this to provide recommendations for teacher development programs in the future.

In terms of use of metaphors in analyzing students' understanding of mathematical concepts, Guner (2012) analyzed the metaphors used by Anatolian high-school and vocational students' in describing their attitude and learning experiences in mathematics. Moreover, the study also determined the metaphors used to describe both positive and negative attitudes towards math. It was found out that metaphors used varied according to the school attended by the participant. Emphasizing the cognitive benefits of metaphors in educational settings, Carter and Pitcher (2010) forward the notion that being aware of the metaphors teacher use in teaching helps educators see how useful metaphors can be in helping learners understand a concept. Further, as Shaw and Mahlios (2008) have demonstrated, the possibility of using metaphor generation activities prior to students' admittance to address the concern on students failing to adequately learn program concepts.

Given these points, the study is positioned from a constructivist position with the assumption that learners use metaphors for learning as it indicates an active engagement with inputs taught to them. Moreover, the investigation is anchored on the premise that learners constantly associate aspect of new learning through their familiar experiences, hence the use of metaphors. Given these insights in mind, the research attempts to answer two questions:

1. What metaphorical images do learners use to describe the different mathematical operations?

2. What conceptual themes can be derived from these metaphorical images?

3. Context of the Study

The investigation was conducted in a private basic education institution in the Philippines. Specifically, the institution is a Sectarian school exclusive for girls and has been in operation since 1962. Situated in the central business district in Metro Manila, the school is known to accommodate students from families coming from the upper middle class. The

institution implements its personalized education curriculum anchored on a constructivist and independent approach to learning where lessons highlight inductive teaching of concepts. Moreover, assessment in the institution entails the use of rubrics that qualitatively describe the progress of learners.

The teaching of math in the school observes a concrete pictorial abstract approach that capitalizes on experiences of students to fully comprehend the complexities of different mathematical concepts/operations. Therefore, mathematical literacy is taught through concrete examples encountered in the daily life of students. In keeping with a personalized education framework, learners are introduced to basic lessons and depending on their progress proceed to more complex, abstract concepts through differentiated tasks which are appropriate to their level.

4. Methodology

This investigation employs a qualitative design to research since it aims to identify metaphorical images associated with the different mathematical operations (addition, subtraction, division and multiplication). Specifically, a case study approach was deemed appropriate for the problem investigated. The project had drawn data from diary logs written by grade 3 learners of the school since one component in actualizing individualized learning is to provide opportunities for reflection, engagement and independent learning. The diary entries of interest in this investigation were collected for a period of five months (July-November) since all the mathematical operations were tackled during the period of investigation.

With regard to the respondents in the case study, 35 grade 3 pupils were purposefully sampled for the project. Prior to proceeding with collection of data, the school administration and parent's consent were obtained. In collecting data, students were asked to give their insights/reflections/reactions after a lesson was tackled and these were elicited through writing prompts provided by the teacher. First phase of the data collection, the teacher-researcher provided the following prompts (as suggested by Saban, 2010).

(Mathematical operation) is like_____ because _____.

Further, students were given 10-15 minutes to write their metaphors on the different operations tackled in class. With regard to coding the data (second phase), each diary entry was encoded and given preliminary labels to determine the major thematic images associated to the different mathematical operations. Also, two raters were tapped to validate/confirm the images/metaphors identified (as suggested in Saban, 2010 and De Guerrero & Villamil, 2002). In addition, unstructured interviews were conducted with 5 students to strengthen the findings of the investigation.

5. Results and discussion

Table 1 presents the different metaphors associated by learners with the four mathematical operations namely; addition, subtraction, addition, and division. Moreover, the table also presents the different images that have observed from these metaphors. As can be seen, the four different mathematical operations have several metaphorical associations and corresponding images. The succeeding sections deal with each operation.

Table 1 *Summary of metaphors/Images used to describe mathematical operations.*

Operation	Image	Metaphor Used
Addition	Preparing Food	making cupcakes, making a pie, baking brownies, getting candies in a basket, eating apples, buying candy, ingredients of a cake
	Planting/Nature	Trees, flowers
	Daily Activities	Pouring Water, Depositing Money, Buying New Stuff, Making Gifts, Charging an iPhone, stacking bricks, Shopping
Subtraction	Eating	Cake, pizza, cupcakes, cookies, burger, donuts
	Taking away/Removing things	Getting out things from the bag, taking away stuff
	Time	Counting till the day ends, vacation time
	Movement	Running the opposite direction, moving away
Multiplication	Counting	Repeated addition, skipcounting
	Grouping things	Buying envelopes in several packs, buying pencils in boxes, sorting clothes in the closet
	Movement	Teleporting
	Food	Cookies (hard but good), Crackers
	Planting/Nature	Planting trees/flowers
Division	Counting	Repeated subtraction
	Eating	Soft cookies, Pizza

Food Metaphor

A prominent metaphor associated among the four operations is food. Specifically, the respondents saw processes related to food preparation (cooking, baking, mixing) as similar to addition. This may be attributed to the 'reproductive' property of addition as something more is produced. On the other hand, the food metaphor figures prominently as students associate subtraction with acts of consumption (eating). Moreover, the food metaphor seems to be applied in multiplication and division in terms of grouping quantities of food (slicing, packing bundles, putting in a container). interestingly, the food that is frequently associated with these metaphors are those favored by the respondents-mainly sweets. As Mika (of the respondents), when asked why subtraction is like eating cupcakes responds:

"I like eating sweets and eating is like subtraction, it gets less and less"
(translated from Filipino)

Based on this statement, it can be inferred that mental imagery that is not only familiar but also pleasant may be contributing factors to the prominence of food metaphors used by the students.

Movement Metaphor

Another prominent metaphor associated with mathematical operations is movement such as walking, running, teleporting, or going to another place. It would seem that the association may be attributed to the distance covered through the aforementioned actions. For instance, the metaphor "multiplication is like teleporting to another place" seems to elicit the notion that multiplication hastens travel. Similar to Font, Bolite and Acevedo's (2010) observation that teachers use path metaphors in explaining graph functions, the learners in our investigation see the application of mathematical operations in terms of traveling to a goal or destination. Likewise, the concept of motion associated with mathematical operations seems to reveal an associative property to what is concretely experienced by learners to something that is abstract.

Daily Activities Metaphor

As regards mathematical operations as "daily activities" several metaphors have been cited by the learners. For example, shopping, depositing in banks, packing things in groups are some metaphors indicated by the respondents. As mentioned in several studies, daily activities appear to be a familiar source domain for learners to make sense of the target domain as certain aspects of the daily activities are similar with mathematical operations (Amiripour, Amir-Modify and Saharan, 2012; Shaw and Mahlios, 2008; Lakoff & Johnson, 1990).

Counting

When it comes to metaphorical associations with multiplication and division, a common response given by the respondents is that these operations is a form of counting (skip counting, adding or subtracting many times). The findings suggest that students build understanding based on what they have experienced as taken from the different levels of understanding (Schwarz and Fischer, 2006). The data also suggests that the metaphors associated with multiplication and division are closely associated with addition and subtraction leading to the notion that processes related to counting serve as scaffolding concepts for young learners to concretize more complex mathematical operations (Amiripour, Amir-Modify and Saharan, 2012). As seen in this category, metaphors do not only provide an opportunity for understanding a particular concepts but is also a tool to map out progressions of difficulty/simplicity in learning through scaffolding.

Given these recurring images from the data, it can be said that the metaphors generated by the students are practical, highly contextual yet personal interpretations of abstract mathematical concepts (Zhang & Song, 2010). As Valdez (2012) emphasizes, the use of metaphors does not only provide conceptual (mis) understandings of mathematical concepts through familiar practices, habits or objects encountered real life but provides interesting engagements with these concepts. Similar to teachers, the students' use metaphors serves as a strong connection between their classroom experience and their physical world (Huang and Ariogul, 2006).

Another interesting observation is that the respondents provided emotional associations with their metaphors that depict mathematical operations. For instance, "division

is like eating soft cookies", "subtraction is like shopping" are not only associated to the act of doing mathematical operations, but they claim that these are "easy" to do and "enjoyable". On the other hand, some have also expressed negative emotions with mathematical operations in terms of difficult activities such as "subtraction is like counting the days before vacation". This metaphor may be interpreted as a manifestation of their current state of experiencing stress due to studies. The findings reveal another interpretation to the data as learners do not only look at mathematical operations as mechanical processes but also generate emotional attachments to them. Similarly, Benesch's (2012) work on academic emotions can be helpful here as she believes that much learning does not only entail constant (re)interpretation of inputs but also require emotional investments on the part of the learner.

Overall, though the respondents may be considered as young learners, it can be deduced that despite problematic articulations of mathematical operations from the perspective of teachers, their interpretations of these constructs can be interpreted as an active process of restructuring knowledge to help them make sense of new learning experiences. As Schwarz and Fischer (2006) have observed, in order for a learner to fully understand an abstract concept, s/he should be able to relate or make representations of what they hear from lectures and what they read from texts. Learners need to make sense of this concept through construction and reconstruction of ideas by relating these concepts to their personal experiences and activities.

6. Conclusion/Implications for Teaching

Taking the findings as a whole, the metaphors associated with the different operations seem to have similarities. Specifically, the respondents closely associate addition, subtraction, multiplication and division as food. In the food metaphor, processes such as sharing, eating, cutting (or other synonyms) or cooking suggest the various ways how people make use of food in their daily activities. In the same vein, the nature metaphor also suggests that organisms observed have the capacity to actualize the different mathematical operations as learners associate it with growth, reproduction and death (in the case of cutting trees/flowers). This can also be observed in daily activities engaged by the learners such as shopping, moving, manipulating objects since to some extent mathematical operations are at work.

In light of these findings, several directions for research and practice may be pursued by educators and researchers. First, the use of metaphors among young learners provide meaningful insights on where the students are at in terms of learning mathematical concepts which may be far different from educational institutions' expected outcomes for learning. This therefore poses greater challenges in closing the gap between addressing learning needs of students and attaining expected competencies expected of learners at a specific level. Second, with the emphasis of process and contextualized teaching of mathematical concepts, researchers may want to examine students' strategies in regulating learning content through the use of metaphors since may serve as catalyzing agents for independent learning. Third, an important dimension in learning is students' affective or emotional associations with the course/subject. Perhaps seeking metaphors that articulate these emotions may help teachers manage not only the cognitive load of the lessons they teach but as well as the emotional loads these lessons carry for students. More importantly, as demonstrated in this investigation, the use of metaphors provides a reflective tool for students which in turn may help teachers to reflect on maximizing opportunities for them to collaboratively explore mathematical concepts. Overall, this investigation hopes to spark constructive debates on the functions of metaphors as it contextualizes learning across the curriculum.

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