Students' Visual Representation of Mathematics

Naci John C. Trance* · Roger B. Marapo[1] · Jonny B. Pornel[2]

Western Visayas College of Science and Technology, Philippines ·
[1]University of Saint La Salle, Philippines · [2]University of the Philippines Visayas, Philippines

Abstract: This paper takes another approach in assessing students' perception of mathematics. Instead of asking for verbal description of the students' perception of mathematics, we asked the respondents who were all college students to draw their perception of mathematics. This relatively new approach enabled students to take a second look of how they perceived math and, at the same time, explored students' creativity and provided a less austere appearance to mathematics which was taken usually in a more formal and severe manner. This approach of assessing students' perception of mathematics generated new information that could not be normally gleaned from other approaches like Likert Scale. Some drawings of mathematics of the respondents reinforced their math affect towards mathematics. For those who hated math, their drawings revealed so the same is true with those who loved mathematics. Examining the visual representations of mathematics and looking for commonalities, the researcher found a number of interesting themes that may shed some light to educators' understanding of students' math affect.

Key words: math affect, visual representation

Introduction

Governments around the world have recognized the vital role of mathematics in their scientific, technological, and economic development. Due to its importance, it has been integrated in every country's educational system from preschool to tertiary levels where no student could graduate without taking any mathematics courses. Performance in mathematics has been likewise considered as a highly significant qualification for employment and further studies (Githua & Ngeno, 2004).

However, there has been a widespread notion that mathematics is a relatively difficult subject. In fact, it has been the subject of investigations at international fora for decades, addressing the need for competency programs based on students' mental capacity and taking into account the nature of mathematics as a field of discipline (Coburn, 1989; Kroll, 1989; Jackson, 1992; Remillard, 1999; Lam, 2002).

Central to these inquiries is the concern on students' self concept of mathematics, specifically their confidence and self-esteem in learning new topics. Reyes (1984) described this self-concept as one's degree of confidence in knowledge acquisition. Harter (1996), on the other hand, noted the influence of one's experience on his/her self-concept: good experience results to positive self-concept while bad experience leads to negative self-concept.

The self-concept of mathematics is often times equated to perception of the same. A study of Pollak (1996) showed that educational experience has become the basis of perception among most people and that their experience on mathematics and recollection of it do not tend to be happy. Taylor (2011), through a study conducted by *Investigacian Psicopedagogica*, even believed that this self-concept is a dominant and essential predictor of general achievement as well as in language, arts, and mathematics.

Various studies have long been conducted on students' self concept of mathematics, with interview schedules and survey questionnaires as the widely used data gathering tools. These

*Corresponding author: Naci John C. Trance (nacijohn@gmail.com)
**Received on 31 July 2012, Accepted on 9 October 2012

tools have been criticized to have provided a relatively limited knowledge on one's self-concept since most respondents may have difficulties in expressing their ideas and some information may have been lost in the process when doing translation work or applying the Likert Scale (Clarebout, Elen, Leonard & Lowyck, 2007).

Responding to these criticisms, a number of researchers have suggested the use of visual representations. For instance, Eristi and Kurt (2011) highlighted that representations are helpful to students in expressing themselves in educational environments. Coming up with representations both entails a process and an environment that, when combined together, provide children opportunities to fully speak their minds (Hudson & Hudson, 2001).

Taking into account the issues raised above, this study aimed at determining the students' self-concept of mathematics through visual representations. Having known students' concept of mathematics, teachers are expected to provide an environment that maximizes learning with the use of appropriate strategies and pedagogies.

Specifically, this research sought answers to the following questions:

(1) What is the students' visual representation of mathematics? and
(2) What are their ideas when they think about mathematics?

Literature Review

The use of children's drawings in information gathering, clinical diagnosis, and intelligence testing has been very popular among behavioural and cognitive psychologists (Thomas & Jolley, 1998; Diem-Wille, 2001; Lange-Kuttner & Vinter, 2008). However, its value and use has yet to be fully explored within educational contexts (Russell, Haney & Bebell, 2004).

A number of studies have revealed various applications of drawings in the field of education. Clarebout, Depaepe, Elen, and Briell (2007) proposed that drawings can be used to identify nuances and ambivalences within a person's belief system. Harris, Harnett & Brown (2009) also suggested that drawings are helpful in studying and understanding student's conceptions. Wheelock, Bebell & Haney (2000) likewise mentioned that students with low performances and those with special needs may particularly benefit from expressing their viewpoints through drawings.

In addition, Thomas and Jolley (1998) have cited some studies showing that drawings assisted children to recall more and express vividly events they had experienced. Diem-Wille (2001) furthermore noted that visual representations like pictures, drawings, and metaphors are relatively accurate descriptions of a person's emotional state of mind and are better than verbal definitions. In other words, it can be said that drawings are equally appropriate tools in finding out students' affective experiences.

The perception that mathematics is unfriendly, rational, fixed and rule-bound has been documented very well (Leder, 1986; Willis, 1989; McKnight & Cooney, 1990). Studies have also associated it with strong, typically negative, emotional reactions than any other subject areas (Joffe, 1984; Williams, 1988; Willis, 1989; Blum-Anderson, 1992). Although these accounts may have some semblance of truth, it should be emphasized that the students' description of mathematics would be quite difficult to understand due to differences on their level of intellectual maturity, year level, and course taken.

Given these impediments, it would be beneficial to look into the ways that visual representations can supplement the data analysis. Eristi and Kurt (2011) shared that this process facilitates data collection and understanding students' linguistic expressions and the things they failed to express verbally. Hence, it is a relatively new approach of dealing with students' self-concept of mathematics.

In view of the above, the present study explored students' visual representations of mathematics along with their ideas of the same. This is a response to changes in educational curricula as well as in the shift on the focus of learning from teacher-centered to learner-centered that have paved the way to the utilization of games, drawings, and the like directly stimulating learners' imagination, creativity, and interest along with traditional learning methods.

Methodology

Research Design

This study utilized the one-shot survey. Data were collected using a researcher made questionnaire (see Appendix A) which was distributed to the respondents on the first day of class for the semester. Drawings generated from the questionnaires were expected to show the respondents' thoughts and perceptions of mathematics. The respondents were also asked to write an explanation of their drawing.

Participants

A total of four hundred twenty-five (425) students coming from Western Visayas College of Science and Technology (WVCST) and University of St. La Salle (USLS) participated in this study. Those who came from WVCST numbered to 221, were taking up BS Electronics Engineering, and from first to fifth year levels. On the other hand, USLS respondents consisted 204 students from three colleges: College of Arts and Sciences taking up BS Information Technology and BS Computer Science (all second year students), College of Business and Accountancy taking up BS Accountancy (second year students) and College of Nursing taking up BS Nursing (third year students). Table 1 shows the profile of the respondents.

Data Collection Procedure

We sought permission from respective college and university officials to conduct the present study. Questionnaire distribution and retrieval then followed. All questionnaires were checked to ensure that data gathered were complete. Coding was also done for both drawings and explanations to guarantee data integrity.

After which, these drawings were scanned, saved following their corresponding code and printed together with students' explanation. Each drawing was then placed in an envelope for data storing.

Data Analysis Procedure

Upon finishing the scanning, we opened the envelopes containing the drawings and grouped them according to themes. Often times, the major consideration was the commonalities found in each drawing which, when taken altogether, form a single idea. This process enabled the researchers to identify the themes given the ideas being illustrated in the drawings and, in turn, served as the basis for determining the appropriate strategies for mathematics teaching.

Results, Analysis and Discussions

There were five students who did not provide any drawing in the questionnaire. Thus, there were only 420 students' drawings. Some drawings had several ideas so they were counted separately. As such, it was possible that some drawings contained more than one idea about mathematics.

In general, we were able to come up with a list of figures or ideas found in these drawings. One concern during this phase was the difficulty in understanding some drawings, hence, labelled as 'others' (14.05%, 11.09%). Table 2 shows the frequency count and percentage distributions of

Table 1
Characteristics of the physics test for eleventh graders

Profile	Category	Frequency	Percentage (%)
Sex	Male	217	51.18
	Female	207	48.82
Course	BS ECE	221	51.28
	BS Information Technology	71	16.47
	BS Computer Science	54	12.53
	BS Accountancy	71	16.47
	BS Nursing	14	3.25
Age	16	26	6.16
	17	137	32.46
	18	132	31.28
	19	60	14.22
	20	31	7.35
	21	24	5.69
	22	6	1.42
	23	2	0.47
	24	1	0.24
	26	1	0.24
	28	1	0.24
	29	1	0.24

objects found in the students' drawings. There were two percentage distributions used: the first is based on the total number of students' drawings while the second is drawn from the total number of objects illustrated in the drawings.

We noted that most students draw a picture of mathematics as numbers (17.62%, 13.91%) and geometric figures and shapes (10.24%, 8.08%), suggesting that they perceived mathematics as purely operations on numbers together with figures.

Interestingly, there were also drawings that contained ideas like "Hard, Hate, Pain, and Load" when referring to mathematics (4.05%, 3.20%) indicating that some students viewed mathematics as a problem. Another observation is the inclusion of mathematics in daily conversations like when they buy some items, travel, and play ballgames.

Another way of classifying these objects was through the ideas they express of mathematics. Table 3 shows the categories/themes found in these drawings. It presents eight categories of perception of mathematics and the ideas or drawings that belong to each category.

Specifically, "Numbers and Operations" category includes all objects and ideas that relate mathematics to operation of numbers. "Geometric Figures" category, on the other hand, lists all objects and ideas pertaining to visual interpretation of mathematics such as

Table 2

Objects' Profile in the Drawings representing Mathematics

Objects/Ideas	Frequency	Percentage (%) (Base on the total number of students-respondents)	Percentage (%) (Base on the total number of objects in the drawings)
Numbers	74	17.62	13.91
Geometric Figures, Shapes	43	10.24	8.08
Arithmetic Operators	37	8.81	6.95
Question Marks, Underlines	33	7.86	6.20
Earth, Globe	28	6.67	5.26
Equations, Formulas, Functions	24	5.71	4.51
Every life Situations, Conversations	23	5.48	4.32
Graphs, Cartesian Planes	23	5.48	4.32
Hard, Hate, Pain, Load	17	4.05	3.20
Thinking Person	15	3.57	2.82
Tree	15	3.57	2.82
Calculator	12	2.86	2.26
Bulb	10	2.38	1.88
Book	9	2.14	1.69
Heart	8	1.90	1.50
Money	8	1.90	1.50
Road, Route, Way	7	1.67	1.32
Building	7	1.67	1.32
Mountains, Rice fields, Flowers, Sun	7	1.67	1.32
Maze	7	1.67	1.32
Star	6	1.43	1.13
Happy face	5	1.19	0.94
Blur, scratch	4	0.95	0.75
Checkered Board	4	0.95	0.75
Hierarchical	4	0.95	0.75
Grades	4	0.95	0.75
Process	4	0.95	0.75
Abstract (addition of parts)	3	0.71	0.56
Sports	3	0.71	0.56
Warning	3	0.71	0.56
Puzzle	3	0.71	0.56
Helping Hand	3	0.71	0.56
Clock, Hour Glass	3	0.71	0.56
Challenge, Magic Square	3	0.71	0.56
Stair	2	0.48	0.38
Subjects, other topics, other fields	2	0.48	0.38
Computer	2	0.48	0.48
Shades, Eye glasses	1	0.24	0.19
Kite	1	0.24	0.19
Measuring Instruments	1	0.24	0.19
Music	1	0.24	0.19
Tower	1	0.24	0.19
Codes	1	0.24	0.19
Dimensions	1	0.24	0.19
Multiplication Table	1	0.24	0.19
Others (Not Classified)	59	14.05	11.09

graphs, figures and shapes. The "Feelings or Emotions" category covers all students' positive and negative feelings towards mathematics. "Intrapersonal Relations" category consists of all everyday life situations.

"Nature" category, as the name denotes, consists all objects related to nature such as tree, mountains, etc. to show mathematics. "Tools" category comprises all things that students can use. This category includes computers, calculator, money and the like. The "Challenge or a Way to Success" category contains objects such as mazes and puzzles which tests students' intellectual capacity. It also includes routes, maps and stairs showing the way. The "Other" category consists of all objects that were not classified.

Table 4 shows the frequency count and percentage distributions of identified categories in mathematics. It reveals that most students

Table 3

Categories of Mathematics as Drawn by the Students

Categories/Themes	Drawings/Ideas	
Numbers and Operations	Numbers Equations Codes Dimensions Process Abstract (parts)	Multiplication Tables Magic Square Infinity Arithmetic Operators Grades
Geometric Figures	Circles, Squares Triangles Graphs	Cubes, Spheres Cartesian Planes
Feelings or Emotions	*Love* Happy face Heart Bulb	*Hate* Pain, Hard, Load Blur, Scratch Checkered Board Warning Question Mark, Underline Thinking Person Devil
Intrapersonal Relations	Globe, Earth Sports Helping hand	Everyday Life Situations Conversations Music
Mathematics as Nature	Tree Mountains Sun	Flowers Rice fields
Mathematics as Tools	Calculators Computers Tower Food	Money Books Shade, Eye Glasses Measuring Instruments
Mathematics as a Challenge or a Way to Success	Maze Star Kite Roads Way Buildings	Puzzle Challenge Hour Glass, Clock Route Hierarchical
Others		

Table 4

Profile of Categories of Mathematics as Drawn by the Students

Categories/Themes (Mathematics as)	Frequency	Percentage (%) (Base on the total number of students-respondents)	Percentage (%) (Base on the total number of objects in the drawings)
Numbers and Operations	151	35.95	28.54
Geometric Figures	65	15.48	12.29
Feelings or Emotions	99	23.57	18.71
Intrapersonal Relations	58	13.81	10.96
Nature	25	5.95	4.73
Tools	35	8.33	6.62
Challenge or a Way to Success	42	10.00	7.94
Others (Not Classified)	54	12.86	10.21

provided drawings that consider mathematics within the numbers and operations category (35.95%, 28.54%), followed by feelings or emotions category (23.57%, 18.71%), and geometric figures category (15.48%, 12.29%).

Figures 1 to 7 present the students' visual representations of mathematics as classified according to abovementioned categories. These are number and operations, geometric figures, feelings and emotions, nature, a form of interpersonal relations, tools, and a challenge or way to success.

Lastly, Table 5 presents ideas that students associate with mathematics by major themes. It shows that these ideas supplement the interpretation of drawings and can serve as basis for determining students' self-concept of mathematics. These ideas are also crucial to the formulation of teaching approaches and strategies to maximize learning among the students.

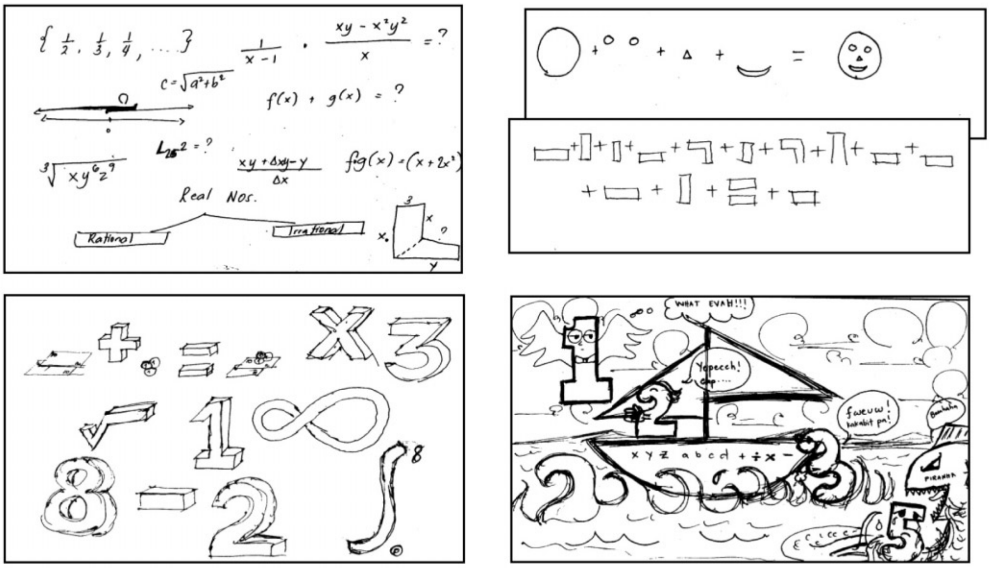

Fig. 1 *Mathematics as Numbers and Operations*

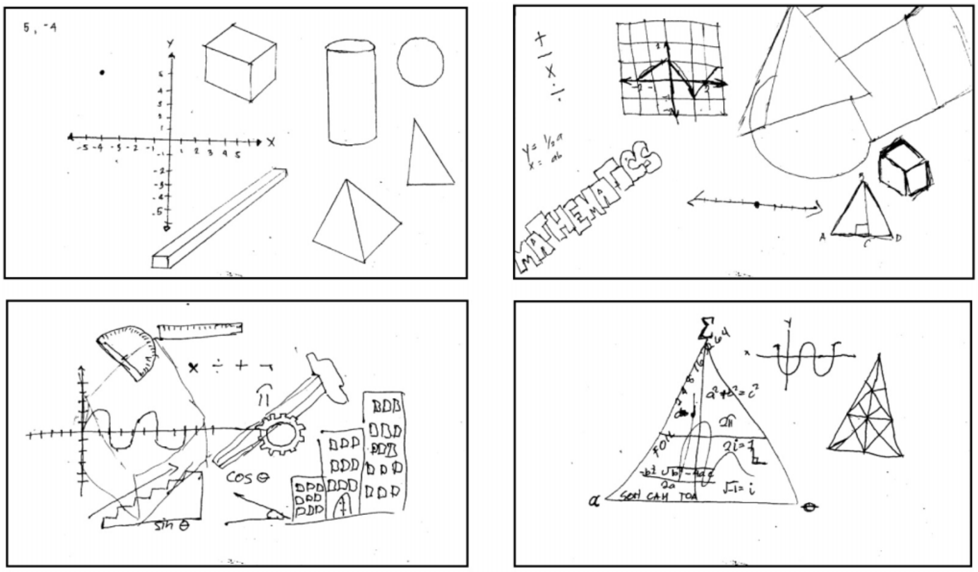

Fig. 2 *Mathematics as Geometric Figures*

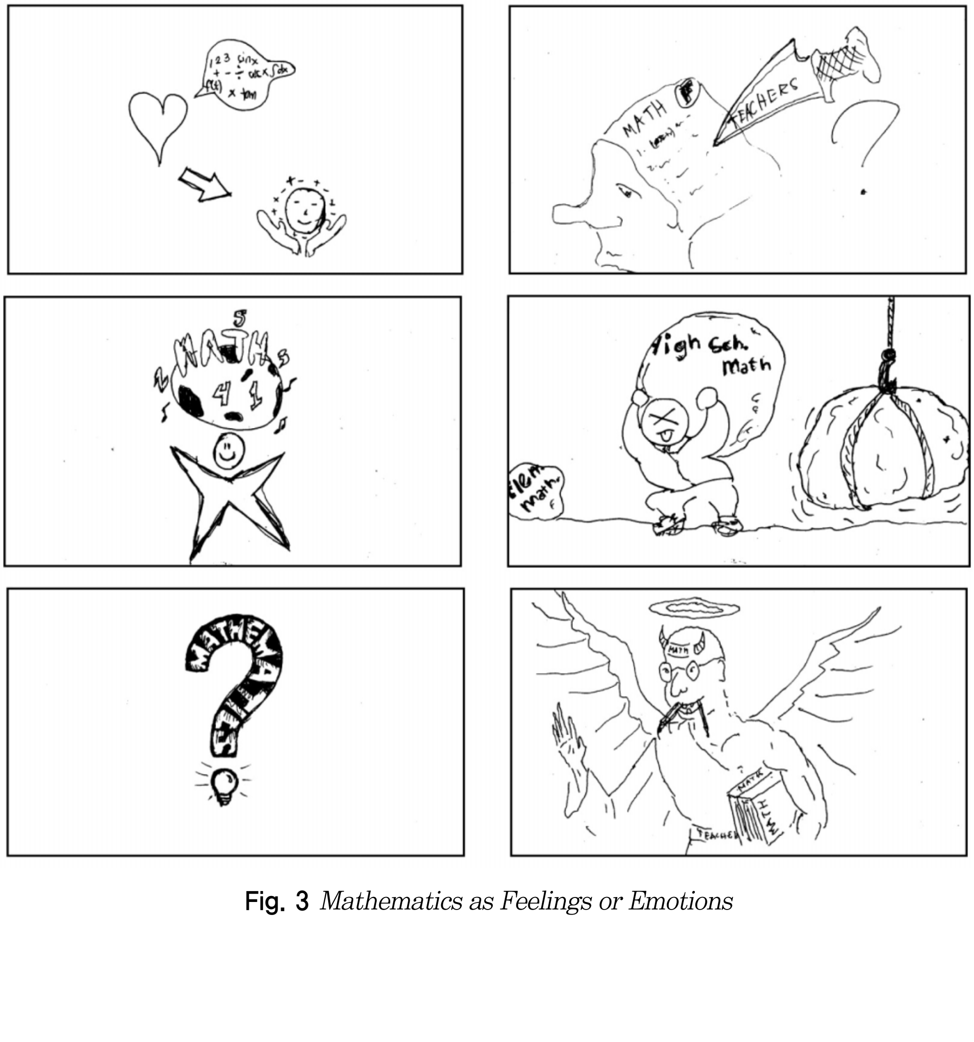

Fig. 3 *Mathematics as Feelings or Emotions*

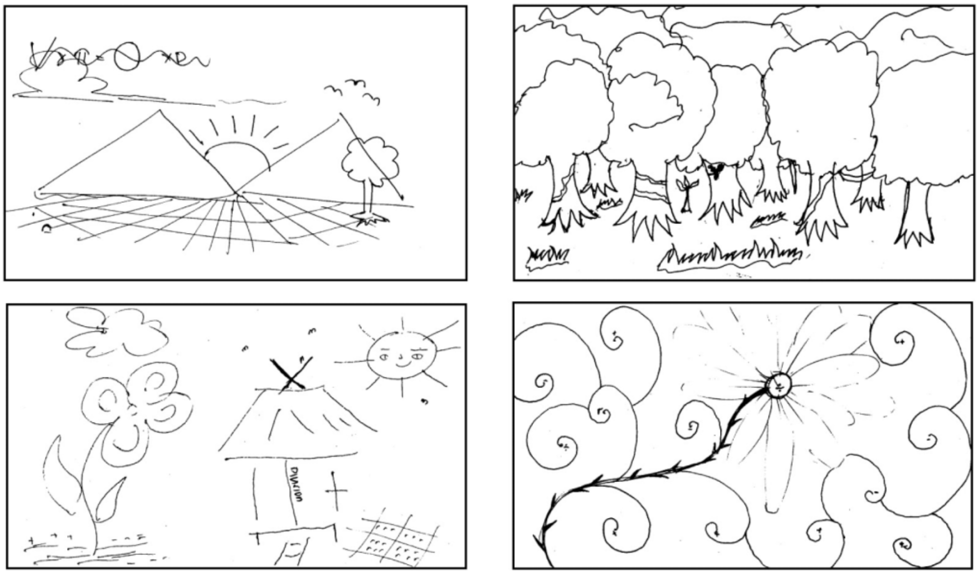

Fig. 4 *Mathematics as Nature*

Fig. 5 *Mathematics as Intrapersonal Relations*

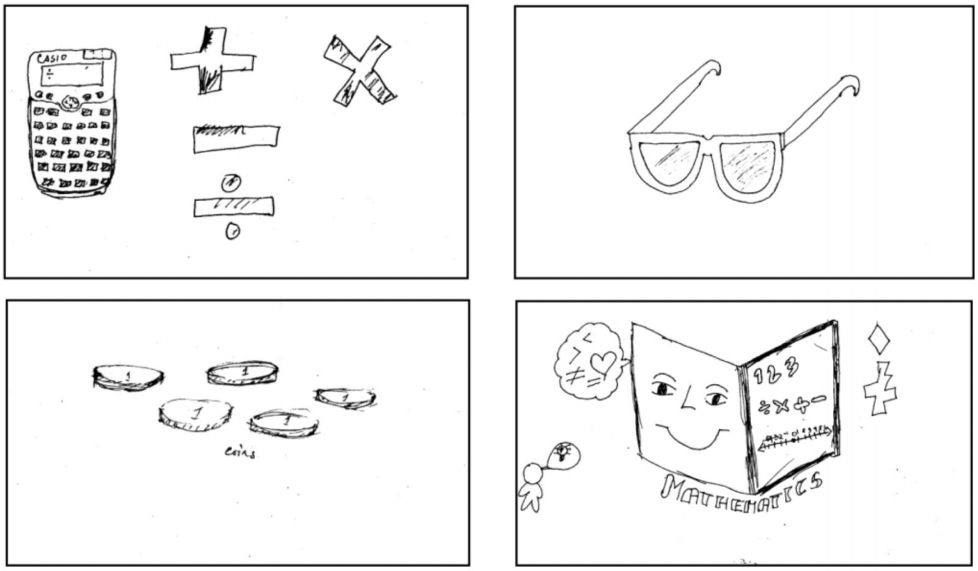

Fig. 6 *Mathematics as Tools*

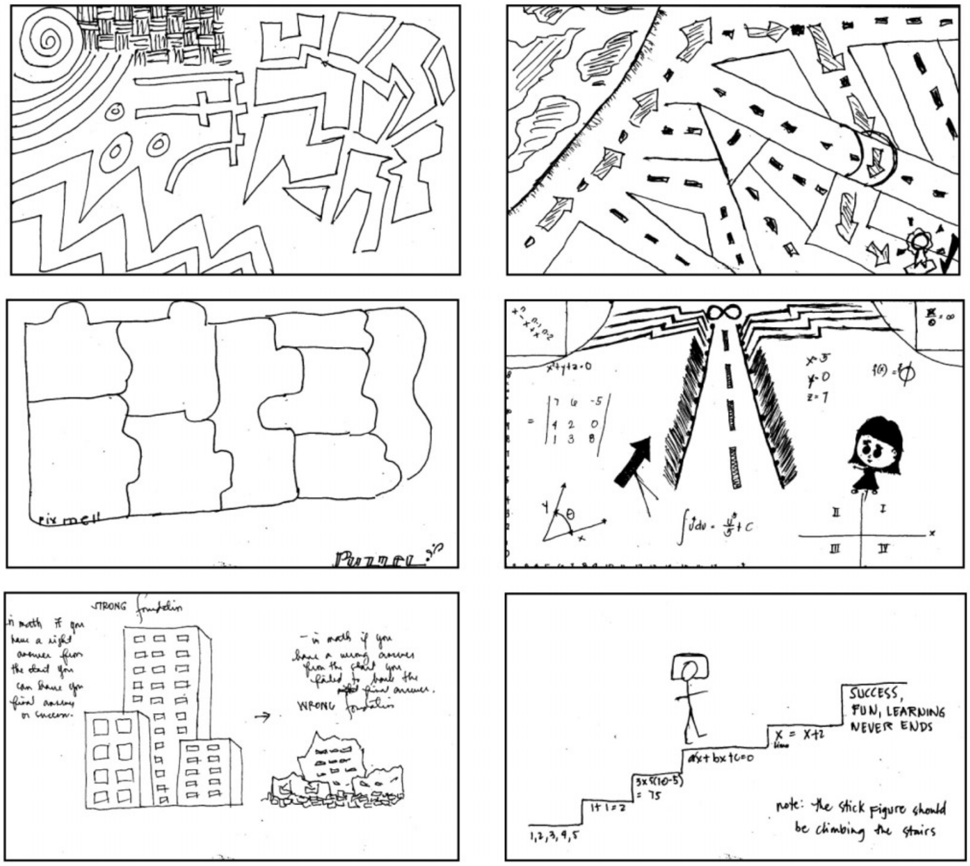

Fig. 7 *Mathematics   Challenge or Way to Success*

Table 5

Ideas Associated with Mathematics by Category

Categories/Themes	What the students are thinking when they were asked to draw mathematics?
Numbers and Operations	Most students illustrated mathematics as numbers and operators. These imply that students see mathematics as purely operations on numbers and don't have any relation with other aspects of life. Other students have depicted mathematics as a grade. This entails that no matter what they have experience with mathematics, they will either passed or failed it.
Geometric Figures	Students see mathematics as concrete objects such as circles, squares and graphs. This shows that students may have an inclination to spatial and visual things and processes. They try to represent situations related to mathematics into tangible or real objects. However, these students were similar to the first category because they have not seen the true essence of math.
Feelings or Emotions	Most students illustrated mathematics as a question mark. This connotes that they have seen math as problems which needs to be solved. Some students love it. Others hate it. Some drawings depicted that loving mathematics will results to a happy and enjoyable world. Others demonstrated mathematics as a load to be carried which gets bigger and bigger as they advance to the next level of education. Another student portrayed mathematics as a dagger pointing his/her head. Still, another student showed mathematics as an angel-and-devil-like teacher carrying a book and having a lecture. This suggests that these students have difficulties with mathematics. Also, one reason they hated mathematics was their teachers.
Intrapersonal Relations	Drawings show that mathematics is essential to their everyday life. As such, we use mathematics in conversations, in buying some items in a store, in playing basketball, and in any thing around the world. These entail that students are more receptive to real-life problems and situations when learning mathematics. These also imply that students have lived and have related mathematics to their own lives.
Nature	Students' drawing depicting mathematics as nature suggests that these students want mathematics to be taught in a kind and lovely manner. The calmness of nature proposed that they don't want to rush on learning mathematics. Everything to be learned has its own place and time. They tend to learn in their own pace.
Tools	Students think that mathematics is merely a tool to be developed and used. A drawing of calculator or any other devices suggests that mathematics is important and should be learn without exemptions. As such, students understand that mathematics is needed and is required in getting a job with a higher pay. With these, students are amenable to any strategy the teacher will use. However, teachers should take note that these students may not reflect mathematics in their lives.
Challenge or a Way to Success	These students depicted mathematics as the only means for them to succeed. Thus, these students have focused towards learning mathematics. They tend to be interested in any topics in mathematics. They tried to challenge themselves with any difficulty incumbent of mathematics. Hence, they are also amenable to any strategy the teacher will use.
Others (Not Classified)	These students illustrated mathematics as an object that cannot be identified or fall into the categories above. These students need more attention because they are seeing mathematics as a foreign object with no known significance.

CONCLUSION

In this study, we have found out that most students visually represented mathematics as numbers and operations (17.62%, 13.91%), geometric figures and shapes (10.24%, 8.08%), and arithmetic operations (8.81%, 6.95%). We have also come up with eight categories or themes when we further grouped these visual representations based on the ideas they denote, with the number and operations (35.95%, 28.54%), feelings or emotions (23.57%, 18.71%) and geometric figures (15.48%, 12.29%) as the top three most drawn categories. Lastly, we were able to validate these visual representations by soliciting students' description of the same highlighting areas for interventions to fully maximize learning.

Our findings have agreed with the existing literature. Among others, we share the same result with a number of researchers that mathematics is unfriendly, rational, fixed and rule-bound has been documented very well (Leder, 1986; Willis, 1989; McKnight & Cooney, 1990) and that is often associated with strong, typically negative, emotional reactions than any other subject areas (Joffe, 1984; Williams, 1988; Willis, 1989; Blum-Anderson, 1992).

Another equally significant finding is the usefulness of visual representations. Through these, we were able to document students' self-concept of mathematics as accurate as we could. This was our response to the call for more appropriate research tool in exploring the said concept (Clarebout, Elen, Leonard & Lowyck, 2007).

The process of having visual representations has enabled us to identify nuances and ambivalences within a person's belief system as Clarebout, Depaepe, Elen, and Briell (2007) did. At the same time, it has opened new ways of looking at these nuances and ambivalences suggesting the fact that drawings assisted children to recall more and express vividly events they had experienced (Thomas & Jolley, 1998).

Furthermore, we are of firm belief that these drawings have served as somehow accurate descriptions of the students' emotional state of mind, hence, are very helpful in studying and understanding self-concept of mathematics (Diem-Wille, 2001). This idea supports the findings of Eristi and Kurt (2011) when they wrote that visual representations supplement the text when verbal expressions are insufficient.

We have also similar observations with Harter (1996) when processed the data gathered according to themes. It is prevalent that one's experience influences his/her self-concept: good experience results to positive self-concept while bad experience leads to negative self-concept. Both students' visual representations and the corresponding explanations provide ample evidence on what they felt when being asked about mathematics.

In fact, Thomas and Jolley (1998) asserted that coming up with representations both entails a process and an environment that, when combined together, provide children opportunities to fully speak their minds. This is to say that drawing their concept of mathematics provides students a more flexible way of expressing themselves regardless their academic performance and learning disabilities.

However, we have yet to explore more this possibility in future studies. Our study has excluded this type of analysis and, perhaps, entails a different research question. Thus, we could not certainly claim that drawings have assisted those with low performances and special needs in expressing their views as shown in the findings of Wheelock, Bebell & Haney (2000).

Nevertheless, we have substantially shown that children's drawings are useful in information gathering within educational contexts. In our study, students have been provided with an avenue to reflect the things they learn, see, and experience about mathematics. The process has allowed them to freely transfer their thoughts, feelings, and imaginations.

On the other hand, while it is impossible to fully determine and learn students' perceptions of mathematics, we have come to the conclusion that drawings have allowed students to concretize their conceptions, their communications and their perceptions (Cox (1992), providing researchers another means of determining students' perceptions and views.

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Appendix A

Name (optional) ______________________________________ Age:__________ Sex: _____________
School __________________________ Course ________________ Year ________ Section _________

To the respondents:

Please answer the following statements/questions truthfully. We assure you of the confidentiality of the information you gave us.

Draw mathematics in the box provided below.

Why did you draw such?

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