

Students' Visual Representation of Mathematics

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Abstract

This paper takes another approach in assessing students' perception of mathematics. Instead of asking for verbal description of the students' perception of mathematics, the researcher asked the respondents to draw mathematics whatever they perceived it to be. This unusual approach forces the students to take a second look of how they perceive math. It also tap the students' creativity and gives a less austere appearance to mathematics which is taken usually in a more formal and severe manner. This approach of assessing students' perception of mathematics generates new information that cannot 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 gathered in this way and looking for commonalities, the researcher found a number of interesting themes that may shed some light to educators' understanding of students' math affect.

Keywords: math affect, visual representation

Introduction

Mathematics has been recognized by governments around the world because of its vital role in scientific and technological fields. In fact, it is integrated in every country's educational system. Particularly, in each level of education, students should expect to take mathematics courses. Moreover, it is an important qualification for employment and further studies (Githua & Ngeno (2004)). However, although mathematics plays an important part in both individual and social life, it is a common notion that mathematics is a difficult subject. Thus, it has been investigated at international level and programs for mathematics courses should be prepared based on the mental capacity of students and the nature of the mathematics course (Coburn (1989); Jackson, (Ed.), (1992); Kroll (1989); Lam (2002); Remillard, (1999)).

Self-concept in learning mathematics is often referred to confidence as well as self-esteem. Reyes (1984) defined these terms as being "how sure a person is being able to learn new topics in mathematics". Harter (1996) suggests that a global self-concept will be determined by the degree of importance that we assign to each of its components. If our judgments are satisfactory, then we obtain positive global self-concept; otherwise, we generate negative feelings which results to a negative global self-concept.

H. O. Pollak (1996) observed accurately that “the perception most people have for mathematics has been molded by their educational experience, and neither the experience, nor its recollection tends to be happy.”

According to Taylor (2011), a study conducted by Investigacion Psicopedagogica found that “academic self-concept powerfully and positively predicts both general achievement as well as that in language arts and mathematics.”

Studies investigating students’ conceptions as well as perceptions can be filled with complexity. In using verbal communications such as interviews and fora, most of the students are uncertain to talk. Also, with questionnaires, some information was lost in the process when applying Likert Scale. Hence, these techniques provide limited access to children’s thoughts (Clarebout, Elen, Leonard, & Lowyck, 2007).

One of the effective factors that help students to express themselves in educational environments is by pictorial representations (Erişti, Kurt (2011)). It constitutes a process that supports other teaching areas and provides an environment in which children can freely express themselves (Hudson & Hudson, 2001). For this reason, visual representation was used by the researchers to assess student’s perceptions of mathematics.

Having known what students’ conceptions as well as perceptions of mathematics are, corresponding strategies and pedagogies may be chosen by the teacher to create an environment for students’ optimal learning.

Literature Review

Customarily, behavioural and cognitive psychologists have used children’s drawings for purposes such as information gathering, clinical diagnosis, and intelligence testing (Diem-Wille (2001); Lange-Kuttner & Vinter (2008); Thomas & Jolley (1998)). In 2004, Haney, Russell and Bebell cited that “children’s drawings have seldom been analysed within educational contexts.” However, many changes have been made in the educational curricula to deal with other areas that were not covered before. As well, the focus of learning has been shifted from teacher-centered to learner-centered. More strategies arose and were developed in addition to the traditional way. Most of these strategies utilized games, drawings and many others which directly stimulate learners’ imagination, creativity and interest.

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) suggests that drawing would be useful in studying and understanding student’s conceptions. In addition, Wheelock, Bebell & Haney (2000) mentioned that students with low performances and those with special needs may particularly benefit from expressing their viewpoints through drawings. Furthermore, Thomas and Jolley (1998) have quoted some studies showing that “drawing pictures had helped children recall and express more detail about events they depicted.” Moreover, Diem-Wille (2001) noted that, “pictures, drawings, and metaphors show a person’s emotional state of mind much better than verbal definitions or descriptors”. This implies that drawings have great potential in accessing information about students’ affective experiences.

Mathematics has been commonly perceived as being unfriendly, rational, fixed and rule-bound (Willis (1989); McKnight & Cooney (1990); Leder (1986)) but is associated with strong, typically negative, emotion reactions; perhaps more so than any other subject area (Blum-Anderson (1992); Willis (1989); Williams (1988); Joffe (1984)). With these accounts, students’ descriptions of mathematics would be quite difficult to understand without some definite intellectual maturity. Similarly, students of different levels and courses perceived mathematics differently. With various attitudes, beliefs, creativity, experiences, maturity and reactions of students towards mathematics in consideration, it would be beneficial to use their visual representations of mathematics. This facilitates the collection of data and

understanding students' linguistic expressions and the things they failed to express verbally (Erişti & Kurt (2011)).

Methodology

Research design

This study uses a survey. Data were collected using a researcher-made questionnaire (see Appendix A). Contents depicted in the drawings were then examined for commonalities. The aim is to determine some interesting themes about students' math affect which may arise during the analysis of these drawings. With these themes, appropriate strategies can be chosen for teaching mathematics.

Participants

The respondents for this study were the students of the researchers for the first semester with a total of 425. There are two groups in consideration. The first group were 221 students coming from the College of Engineering and Architecture of the Western Visayas College of Science and Technology (from first year to fifth year) taking up BS Electronics Engineering. The second group were 204 students coming from three colleges of the University of Saint La Salle: 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.

Table 1
Respondents' Profile

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

Data Collection Procedure

The researcher-made questionnaires were distributed to the respondents at the beginning of the class for the first semester to avoid being influenced by their grades later on. The students-respondents were expected to depict in their drawings their thoughts and perceptions about mathematics objectively.

Data Analysis Procedure

Objects depicted in the drawings were determined. Then, some objects with similarities were combined to form ideas. An idea is a set that describes all of the objects illustrated. Commonalities were established before combining ideas. Having this process for several times, a number of themes were determined. These themes will be considered for choosing strategies suitable for mathematics teaching.

Results, Analysis and Discussions

There are five students who did not draw what they perceived mathematics is. Thus, there were only 420 students' drawings in consideration. Some drawings contain several ideas and they were counted separately. As such, some drawings contain two or three ideas reflecting what mathematics is all about. However, most of the objects in drawings show only one idea of mathematics. Table 2 shows the ideas as depicted in the students' drawings.

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

Table 2 shows two percentages: the first is based on the total number of students' drawings and the second is based on the total number of objects depicted in the drawings.

We note that most of the students draw a picture of mathematics as numbers (17.62%, 13.91%) and geometric figures and shapes (10.24%, 8.08%). These suggest that most students perceived mathematics as purely operations on numbers together with figures. These also entail that most of the experiences they have during mathematics were mostly of these objects. There were drawings that are difficult to understand and are labelled "Others" (14.05%, 11.09%). There were other significant ideas drawn about mathematics. Some of these were arithmetic operators, and question marks, both of which have percentages of at least 6% in both totals. One of the interesting ideas is the "Hard, Hate, Pain, Load" which constitutes to 4% of the total number of drawings. Hence, many students perceived that mathematics is not of big help for them; instead it adds up to their problem. We can also infer that these students were actually avoiding mathematics if they can. Some students have depicted mathematics to be ordinary conversations and other everyday life situations. These imply that students who have depicted these kinds of drawings happen to make use of mathematics in their everyday life. As such, buying in stores and to compute for the costs and having a change out of the money they paid to the vendor, travelling in cars and shooting the ball to the basket were some of the ideas found in the drawings.

Classifying further the ideas form, several categories/themes were determined. Specifically, ideas discussing similar notion of mathematics were combined. Positive and negative feelings such as love and hate were also combined into one category/theme name "Emotions or Feelings". Table 3 shows the categories found in the students' drawings.

Table 3
Categories of Mathematics as Drawn by the Students

Categories/Themes	Drawings/Ideas	
Numbers and Operations	Numbers	Multiplication Tables
	Equations	Magic Square
	Codes	Infinity
	Dimensions	Arithmetic Operators
	Process	Grades
	Abstract (parts)	
Geometric Figures	Circles, Squares	Cubes, Spheres
	Triangles	Cartesian Planes
	Graphs	

Feelings or Emotions	Love	Hate
	Happy face Heart Bulb	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
	Tree Mountains Sun	Flowers Rice fields
Mathematics as Tools	Calculators Computers Tower Food	Money Books Shade, Eye Glasses Measuring Instruments
	Maze Star Kite Roads Way Buildings	Puzzle Challenge Hour Glass, Clock Route Hierarchical
Others		

Based on Table 3, eight categories/themes were determined including a category corresponding to other objects that were not classified. A profile of these categories/themes is shown in Table 4.

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

With Table 4, most of the determined categories/themes have percentages greater than 10% for both totals. The category “Numbers and Operations” includes all objects and ideas that relate mathematics to operation of numbers. “Geometric Figures” category includes all objects and ideas pertaining to visual interpretation of mathematics such as 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 connotes, involves all objects related to nature

such as tree, mountains, etc. to show mathematics. “Tools” category comprises of 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.

Below are examples of figures corresponding to each category/theme. The drawings may contain figures showing strong characterizations as well as emotions for loving or hating mathematics. Also, some of the drawings may contain objects pertaining to more than one category/theme.

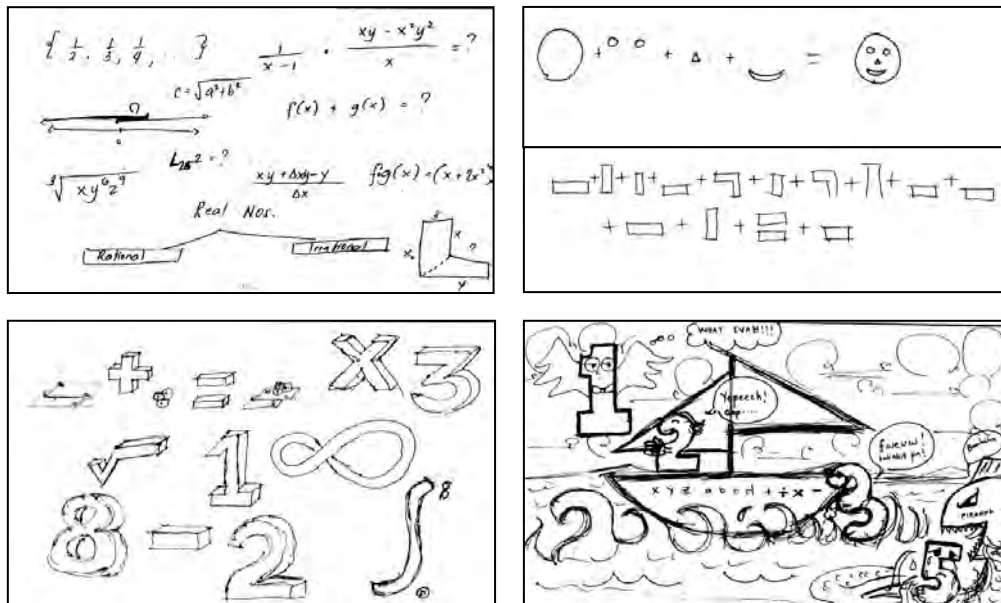


Figure 1. Mathematics as Numbers and Operations

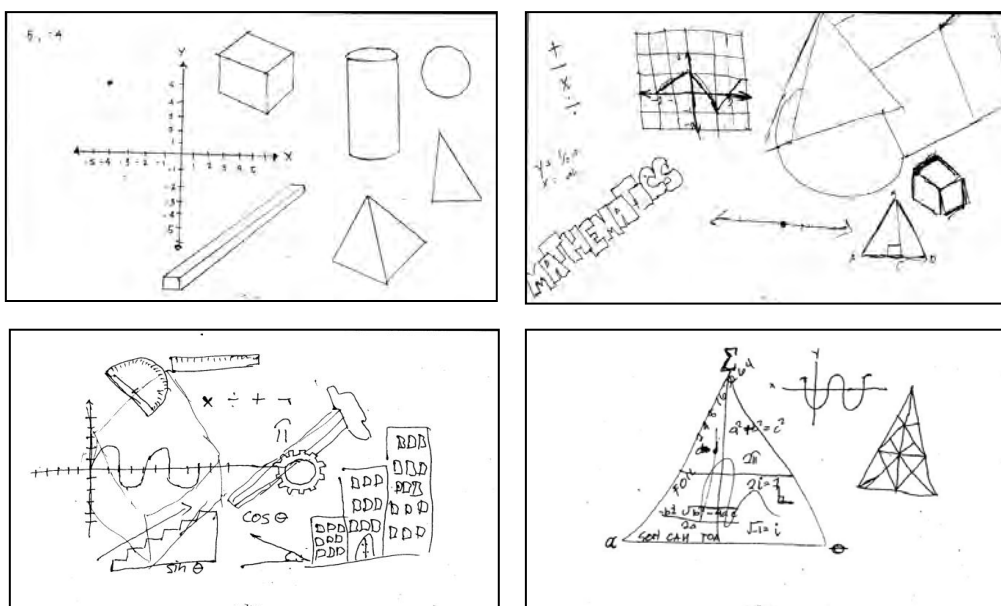


Figure 2. Mathematics as Geometric Figures



Figure 3. Mathematics as Feelings or Emotions

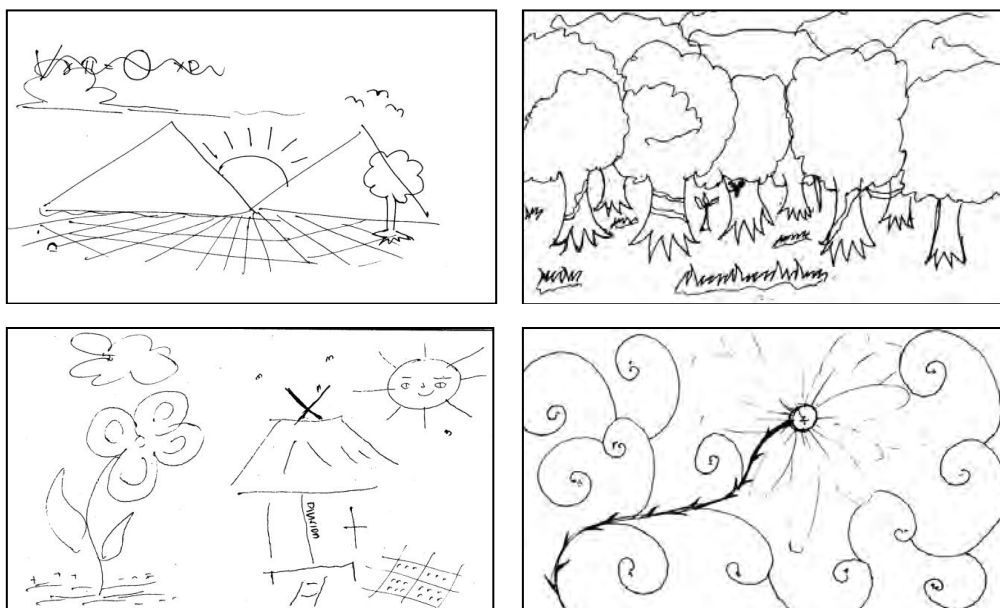


Figure 4. Mathematics as Nature



Figure 5. Mathematics as Intrapersonal Relations

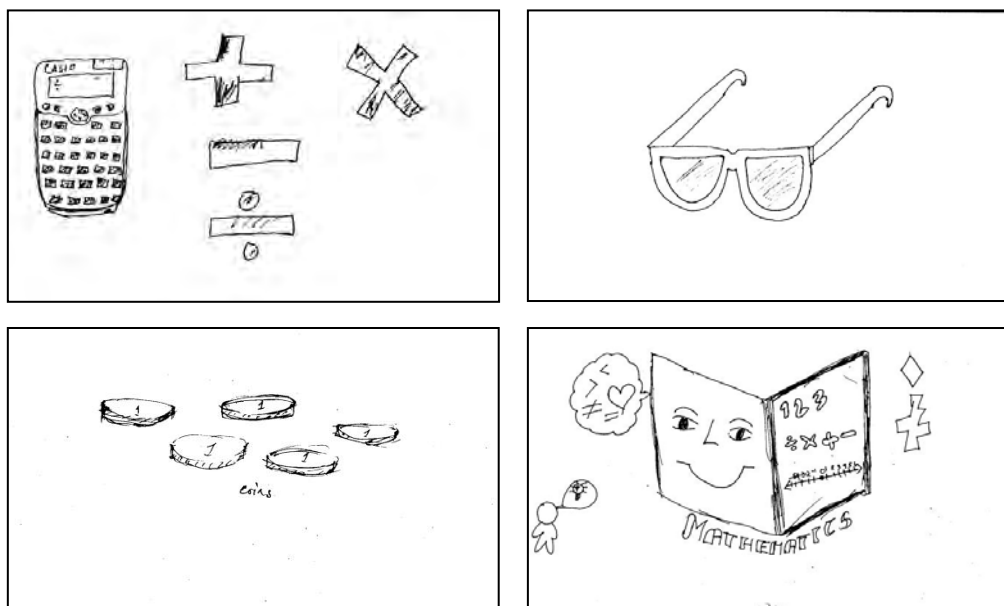


Figure 6. Mathematics as Tools

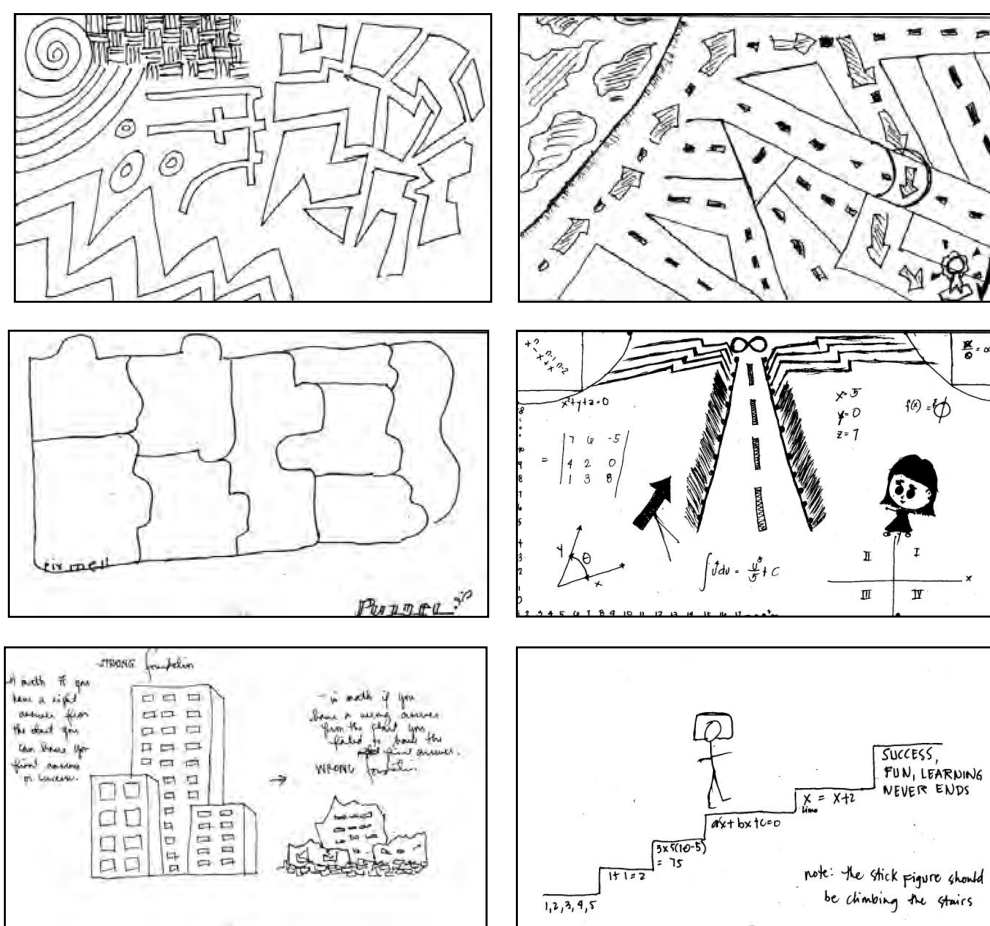


Figure 7. Mathematics – Challenge or Way to Success

The drawings shown from figure 1 to figure 7 speak for themselves. Drawings in each category/theme have depicted objects with commonalities.

Table 5 suggests some ideas or things the students are thinking about mathematics.

Table 5

Categories, Students' thinking

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.

Using the information in Table 5, teachers can possibly determine what students view and perceived mathematics. It can also help teachers to prepare approaches as well as activities that will enhance or stimulate students' interests towards mathematics. Aside from these, teachers may suggest some innovations in the teaching of mathematics.

Conclusion

The students-respondents have various perceptions of mathematics as depicted by their drawings. Most of the drawings illustrated mathematics as numbers and operations. Geometric figures and shapes also appear in many of the drawings. Classifying the drawings, eight categories or themes were determined. One interesting theme is the feelings or emotions portrayed in the drawings when some students were asked of mathematics. For those who have hated it, they have voiced out their negative emotions through their drawings. Other students hated mathematics because they hate their teachers. For those who loved it, they have sketched that the world will be happy with mathematics. There is a category which includes some drawings that were not recognized to fall into other categories. These need further attention as it might lead to understanding of these students' perceptions of math.

Pictorial representation clearly provides students an avenue to reflect the things they learn, see, and experience about mathematics. It also allows students to freely transfer their thoughts, feelings, and imaginations. On the other hand, while it is impossible to determine and learn students' perceptions of mathematics, drawings have allowed students to concretize their conceptions, their communications and their perceptions (Cox (1992)). This provides 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 questions truthfully. We assure you of the confidentiality of the information you gave us.

Draw mathematics in the box provided below.

A large, empty rectangular box with a thin black border, intended for a respondent to draw mathematical concepts or diagrams.