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An Investigation of Students' Perceptions of Doing Mathematics

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Please Note:

RCML History

The Research Council on Mathematics Learning, formerly The Research Council for Diagnostic and Prescriptive Mathematics, grew from a seed planted at a 1974 national conference held at Kent State University. A need for an informational sharing structure in diagnostic, prescriptive, and remedial mathematics was identified by James W. Heddens. A group of invited professional educators convened to explore, discuss, and exchange ideas especially in regard to pupils having difficulty in learning mathematics. It was noted that there was considerable fragmentation and repetition of effort in research on learning deficiencies at all levels of student mathematical development. The discussions centered on how individuals could pool their talents, resources, and research efforts to help develop a body of knowledge. The intent was for teams of researchers to work together in collaborative research focused on solving student difficulties encountered in learning mathematics.

Specific areas identified were:

1. Synthesize innovative approaches.
2. Create insightful diagnostic instruments.
3. Create diagnostic techniques.
4. Develop new and interesting materials.
5. Examine research reporting strategies.

As a professional organization, the **Research Council on Mathematics Learning (RCML)** may be thought of as a vehicle to be used by its membership to accomplish specific goals. There is opportunity for everyone to actively participate in **RCML**. Indeed, such participation is mandatory if **RCML** is to continue to provide a forum for exploration, examination, and professional growth for mathematics educators at all levels.

The Founding Members of the Council are those individuals that presented papers at one of the first three National Remedial Mathematics Conferences held at Kent State University in 1974, 1975, and 1976.

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AN INVESTIGATION OF STUDENTS' PERCEPTIONS OF DOING MATHEMATICS

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Garnering different kinds of data from students about their perceptions of mathematics helps teachers, teacher leaders, districts and researchers better understand students' perceptions. In this study, we investigate and compare students' perceptions of doing mathematics from samples of students from the United States, China, and Fiji. We administered the Draw Yourself Doing Mathematics instrument developed by Bachman, Berezay, & Tripp (2016) to students at three grade levels in China, Fiji, and the United States of America. Statistically significant differences among perceptions in the three countries and the three grade levels were observed.

At a very young age children are encouraged to draw in order to develop their fine motor skills, stimulate their brains, and cultivate their creativity. Whether drawing lines and circles or drawing a picture of where a child lives, each picture tells the viewer something about the child (Farland-Smith, 2012). Borthwick (2011) shares that "psychologists and art therapists have used drawing for years as a way of gathering information about emotional and psychological aspects of children" (p. 38). As upper elementary, middle, and high school students are still developing their vocabularies and means of expression, using drawings to empathize and gage their perception of a situation can be very effective (Aguilar, Rosas, Zavaleta, Romo-Vázquez, 2016, Finson, Beaver, & Cramond, 1995, Weber & Mitchell, 1996). In support of this assertion, Briell, Elen, Depaepe, & Clarebout (2010) state, "drawings may provide a unique and valuable route of expression even for the older participant who might find it difficult to express such abstract beliefs in verbal or written words articulately" (p. 662) showing that drawing is a valuable tool to gain insights into students' worlds in the all grades.

In addition to drawings being viable tools for assessing students of varying ages they have also been used to inform researches about students' perceptions across cultures. Several studies have been done internationally with students as participants. Some examples include Mexico (Aguilar et al., 2014), England (Borthwick, 2011), Belgium (Briell et al., 2010), Canada and Australia (Chamber, 1983), as well as Finland and Russia (Räty, Komulainen, Skorokhodova, Kolesnikov, & Hämäläinen, 2011). However, only two of these studies compared drawings across cultures. Räty et al. (2011), comparing students' drawings of intelligence in Finland and Russia, found "cross-nationally shared" (p. 17) elements. Similarly, when comparing the drawings of French speaking versus English speaking Canadian students, Chambers (1983) found the drawings to be "very much alike" (p. 262). Therefore, drawings can be a good source of data for exploring perceptions across cultural lines. In this study, we used drawings to investigate the following research questions:

RQ1: What are the differences, if any, among students in the same grade level in the United States, Fiji, and China in perceptions of doing mathematics as measured by the "Draw Yourself Doing Mathematics" instrument?

RQ2: What are the differences, if any, among students from different grade levels from the same country in perceptions of doing mathematics as measured by the "Draw Yourself Doing Mathematics" instrument?

Related Literature

The study presented here further develops Bachman, Berezay, & Tripp's (2016) *Draw Yourself Doing Mathematics Test* in which students enrolled in a traditional introductory collegiate mathematics course as well as students enrolled in a course pairing mathematics and dance completed drawings at the beginning and conclusion of the semester. The samples were openly coded for affective elements indicating students' perceptions of doing mathematics. Numerical values were assigned to these open codes which were used to score each sample. Bachman et al.'s (2016) results comparing pre and post test scores of the students between classes showed the course to be effective.

The *Draw Yourself Doing Mathematics Test* heavily relied on the work of Chambers' (1983) and Finson et. al. (1995) *Draw a Scientist Test* assessing children's stereotypical beliefs of scientists by asking them to simply draw what they believed a scientist looked like. Farland-Smith's (2012) *Development and Field Test of the Modified Draw-a-Scientist Test and Draw-a-Scientist Rubric* extended Finson et. al.'s (1995) research by combining the drawings aspect with an additional set of questions asking for additional information about a student's drawing. This additional information eased the scoring process for the appearance, location, and activity categories.

Research involving students' drawings has been extended into Science, Technology, Engineering, and Mathematics (STEM) fields since the work of Chambers (1983). For example, Thomas, Colston, Ley, DeVore-Wedding, Hawley, Utley, & Ivey (2016) developed a rubric for assessing fourth and fifth grade students' knowledge and understanding about the work of an engineer. Some extensions into the branch of mathematics parallel Chambers (1983) and Finson et. al. (1995) such as assessing high school students' and adults' images of mathematicians (Aguilar et al., 2016; Rensaa 2006). However, others diverged from the original test extending the applications of drawing to include assessing the affective elements present as collegiate students draw themselves doing mathematics (Bachman et al., 2016), primary students' perceptions of and attitudes towards their mathematics lessons (Borthwick, 2011), as well as preservice teachers' mental models of mathematicians doing math (Wescoatt, 2016).

Using drawings as a data source has also been extended more generally in education (Briell et al., 2010; Räty et al., 2011; Weber et al., 1996). Drawings are a way to allow students to naturally express their perceptions of experience that involve learning and growing in a new knowledge, such as mathematics. As a data source, drawings are considered to be similar to text and frequently coded in the same way text is coded (Weber et al., 1996). For this reason, we chose drawings as a way to inquire about students' perceptions of doing mathematics.

Methodology

Participants

This study took place in three different countries: The United States of America, China, and Fiji. The participants were students from grades 5, 8, and/or 10/11 who were taking mathematics courses in that grade. Table 1 shows the number of participants from each country and their respective grade levels. Each participant submitted only one drawing.

Procedure

Drawing upon the work of Bachman et al. (2016) we gave the participants the prompt "Draw yourself doing mathematics. Don't worry about the quality of your drawing. Just sketch what comes to mind." The authors partnered with teachers who wanted to better understand their students' perceptions of doing mathematics. With the oversight of the first author, the teachers administered the prompt to their students without a time limit. Teachers distributing the assessment in all countries were instructed that all samples should remain anonymous. Teachers were instructed to inform participants that they were able to include words to explain their drawings, but that a drawing must be present. Following implementation, drawings were collected and numbered. Any drawings that did not have a viable sketch were thrown out to prevent bias in the analysis. Such drawings included those that did not have any people, usually only math figures, in them. Once all drawings were numbered and vetted, the rubric was applied to the remaining drawings.

The first two authors of this research are native USA citizens and have studied the education systems and cultures of China and Fiji. Their study of these systems included travelling to China and Fiji, interacting with students, teachers, and education professors as well as visiting schools. Unlike the USA and Fiji, China does not have English as its primary language. Therefore, prior to coding, drawings from China which contained any language or symbols other than English were interpreted by two linguistic and cultural experts. Both of these experts are native Chinese, have lived in both the United States and China, and speak both Chinese and English fluently. The text in these drawings was translated into English and any cultural references were explained to the first two authors.

To ensure fidelity of rubric coding, the first two authors conducted meetings for the purpose of establishing within-group interrater agreement. The first two authors independently coded 10.40% of the data (31 of 298 drawings) with samples that were chosen using a random number generator. The expected minimum for interrater agreement is $r_{wg} = .9$ (James, Demaree, & Wolf, 1993). Interrater agreement exceeded this minimum as $r_{wg} = .9355$.

Instrument

The *Draw Yourself Doing Mathematics Rubric* was adapted from the coding process of Bachman et al. (2016). This rubric uses a seven point Likert scale to assign a numerical value to each drawing. These numerical values also have corresponding categorical values: severely negative, negative, unpleasant, neutral, pleasant, positive, and extremely positive. The assignment of a specific numerical and categorical value is determined on a set number of positive and negative components within the drawing. The presence of negative components, Confusion, frustrations, overwhelmed, question marks, frowns, etc., correspond to lower scores of three or two. Expletives, statements of hate or other intense negative emotions or actions acquire the lowest possible score of one. The presence of positive components, smile, positive thought bubble, indication of understanding, etc., receive scores of five or six depending on the frequency of the components. Similarly, elations, statements of love, and other intense positive emotions or actions, receive the highest score of seven. Through these categorical values, we establish the degree that participants positively or negatively perceive doing mathematics. Evidence for the numerical and categorical value of the drawing is recorded as well as any additional comments pertinent to the sample. The above mentioned criteria were analyzed within and across the three different countries.

Data Analysis

Excel was used to produce relative frequency histograms of rubric scores for each of the six classes. Minitab was used to compute basic descriptive statistics for each class including sample size, mean, median, interquartile range, and standard deviation. 95% confidence intervals for the means and medians were also computed.

RQ1 and RQ2 are testing for evidence of a higher average positive perception level in a specific class than in another versus a null hypothesis of no difference. Therefore, we are using a series of one-tailed two sample tests. Since the underlying distribution of scores is inherently ordinal in nature, the non-parametric Mann-Whitney test for difference in median was used as the primary test. The Mann-Whitney test does not have any normality assumptions on the underlying distribution. However, since all but one of the subgroups have sample sizes larger than 30 and the distributions of individual scores were examined to be mound shaped, the distribution of mean rubric scores is close enough to a normal distribution to be approximated well by a normal curve. This satisfies the assumptions for a *t*-test, thus one sample *t*-tests were used to provide corroborating evidence of a positive difference in mean. An alpha level of .05 was used for all hypothesis tests.

Results

Summary statistics for each class are tabulated in Table 1.

Table 1: Summary Statistics for Rubric Scores by Country and Grade Level

Country	United States			Fiji		China
Grade	5	8	10-11	5	8	8
Sample Size	18	52	44	39	37	108
Median	4.5	4.0	4.0	4.0	4.0	3.0
	[4.0, 5.0]	[4.0, 5.0]	[4.0, 4.0]	[4.0, 5.0]	[3.0, 4.0]	[3.0, 4.0]
Mean	4.6	4.3	3.8	4.2	3.5	3.2
	[4.2, 5.0]	[3.9, 4.6]	[3.4, 4.3]	[3.9, 4.6]	[3.1, 4.0]	[3.0, 3.5]
IQR	1	1	2	1	2	2
Standard Deviation	0.85	1.21	1.61	0.99	1.26	1.35

RQ1: The data provided evidence that for the same grade level, perceptions of doing mathematics in the United State are higher than those in Fiji and those in Fiji are higher than those in China. This is evidenced by the mean scores of both the fifth grade participants: United

States 4.6 and Fiji 4.2, and the eighth grade participants: United States 4.3, Fiji 3.5, China 3.2. However, hypothesis tests had to be performed to determine if these differences were statistically significant. Table 2 provides the *p*-values for tests for significance of differences in center for the four possible pairings of data groups at the same grade level. From the *p*-values from the Mann-Whitney tests, we see that eighth-grade US participants scored significantly higher than their counterparts in either Fiji ($p = 0.004$) or China ($p = 0.000$). US fifth graders vs. Fiji fifth graders produced a *p*-value of 0.112, and Fiji eighth graders vs. China eighth graders produced a *p*-value of 0.098. Therefore, these pairings were not significantly higher at this grade level.

Table 2

One-tailed Hypotheses Tests Pairs of Subgroups

Groups Compared	Mann-Whitney (*p*-value)	*t*-test (*p*-value)
US 5 vs. Fiji 5	0.112	0.099
US 8 vs. Fiji 8	**0.004**	**0.004**
Fiji 8 vs. China 8	0.098	0.112
US 8 vs. China 8	**0.000**	**0.000**

On the other hand, at the eighth-grade level there is enough evidence to support the conclusion that participants in the United States have more positive perceptions of doing mathematics as measured by this instrument than their counterparts in either Fiji or China.

RQ2: Note that in Table 1 there is data from three different data groups from the United States; grade 5, grade 8, grade 10-11. The mean rubric scores for these three data groups are as follows: US 5=4.6, US 8=4.3, US 10-11=3.8. We also have data for two data groups from Fiji; FJ 5=4.2 and FJ=3.5. This, along with a visual inspection of the histograms from each country in Figure 1, suggests that older students' perceptions of doing mathematics were more negative.

We now examine the results of the Mann-Whitney tests found in Table 2 to determine if the data indicates significant support to reach this conclusion. The data gives evidence that US fifth grade participants have significantly more positive perceptions of doing mathematics than US tenth-eleventh grade participants ($p = 0.022$). Fijian fifth grade participants also have significantly more positive perceptions about doing mathematics than the Fijian eighth grade participants ($p = 0.007$). However, the comparisons of US fifth grade participants to US eighth grade participants ($p = 0.188$) and US eighth grade participants to US tenth-eleventh grade participants ($p = 0.053$) is not statistically significant.

In the case of US participants, there is enough evidence to support the conclusion that participants in the fifth grade have more positive perceptions of doing mathematics as measured by this instrument than participants in the tenth-eleventh grade. Similarly, there is enough evidence to support the conclusion that Fijian fifth grade participants are more positive about their perceptions of doing mathematics as measured by this instrument than Fijian eighth grade participants. Although there is some evidence to suggest that US fifth grade participants also have more positive perceptions than eighth grade participants, and US eighth grade participants have more positive perceptions than tenth-eleventh grade participants, the evidence provided here is not strong enough to reach that conclusion.

We note that if two-tailed tests had been used in each of the analyses above, the p-values would have been twice as large. However, the analysis of the data would not lead to different conclusions. Similarly had t-tests been used instead of Mann-Whitney tests no differences in conclusion would have been reached.

Discussion

The data for the study was gathered from a convenience sample of students at schools which were familiar to the first two authors. These samples are small and not representative of the countries as a whole. Our use of the country names in this article is only for the purpose of categorical necessity and are not used to imply that these results are indicative of students in each nation as a whole. Due to the space limitations of the proceedings we would like to note that we plan the following topics for discussion during the presentation. Further thoughts on data results and its implications about student's perceptions, benefits of the assessment for teachers and teacher leaders, and further study. Additionally, several drawings from each category will be shared during the presentation as it was not feasible to place these pictures in the proceeding. Lastly, we will also share our seven-point Likert scale rubric.

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