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A Comparative Investigation of the Mathematical Creativity of Filipino and Japanese Students

Lady Angela M. Rocena, Ma. Nympha B. Joaquin

Abstract

In order to produce individuals who can thrive in a society that is getting more and more digital, the education world deems it important to not only develop students' computational skills but their creative thinking skills as well. Previous studies have likewise given premium to mathematical creativity as its positive correlation to mathematical achievement has been observed. This link between creativity and achievement and the undeniable gap between the mathematical achievement of East and Southeast Asian students drove the present study to analyze the gap in the light of mathematical creativity. This research explored the mathematical creativity of Filipino and Japanese students in terms of fluency, flexibility, and originality. A matched sample of one-hundred forty Filipino and Japanese Grade 7 students participated by completing non-routine mathematical tasks in a researcher-made instrument which was content-validated, pilot-tested, and subjected to reliability testing. Statistical tests applied to the test results revealed that the mathematical creativity of the Japanese students is significantly better than those of the Filipino students. To substantiate the quantitative findings, classroom observations were conducted, and textbooks and modules were analyzed. Finally, the study's implications to mathematics teaching and learning were discussed.

Keywords: Mathematical creativity, Comparative study, Fluency, Flexibility, Originality

Introduction

There is a remarkable gap between the mathematics achievement of East and Southeast Asian students as evident in the results of the Trends in Mathematics and Science Study (TIMSS) over the years. For example, Japan has consistently scored significantly above the international average while its neighboring country in the southeast, the Philippines, is seen on the other end of the spectrum. Nonetheless, education agencies around the globe now push for mathematics education goals that go beyond academic achievement or achievement in standardized tests. To equip students to thrive in a digital society where one must have the capacity to contribute something that machines cannot offer, mathematics education moves beyond producing students who can apply formulas and perform calculations to developing students who can look at a problem from different perspectives and suggest multiple ways to solve it. Such skills in literature are called creative thinking skills. For instance, the United Nations Education, Scientific, and Cultural Organization (UNESCO) emphasize that developing critical and creative thinking in mathematics classes develop students who can contribute to the world's sustainability and socio-economic development in the future (UNESCO, 2012). In Asia, the working paper for the Southeast Asia Basic Education Standards (SEA-BES) in mathematics incorporates creativity in the common core regional learning standards (SEAMEO, 2016). The Japanese Course of Study in Mathematics also puts premium on mathematics lessons that promote creativity and exploration (Isoda, 2010). In the Philippines, the conceptual framework of mathematics education in the new K to 12 basic education curriculum aims to hone creativity (DepEd, 2016). An investigation of research studies from 1965 to 1980 revealed that mathematics achievement is positively correlated to mathematical creativity (Bicer et al., 2020). For instance, in a regression analysis, (Mann, 2005) found mathematical achievement to the most significant predictor of performance in mathematical creativity which means that students who have not sufficiently mastered mathematical knowledge and skills may be unable to exhibit mathematical creative thinking. Thus, in order to understand the mathematics achievement gap, and later on address it, one may look into the mathematical creativity of the students and explore how such creativity is developed in their respective countries. To the knowledge of the researchers, there is a dearth in literature discussing the differences in mathematical creativity between Filipino and Japanese students or any other cross-national studies at that. This paper aims to fill this dearth.

Mathematical Creativity

There is no clear consensus on the definition of mathematical creativity or even creativity itself (Haylock, 1997; Eric L. Mann, 2006; Sriraman, 2015). McGregor (2007) synthesized that creativity is often associated with divergent thinking (ability to come up with original ideas which by nature are unique), lateral thinking (thinking that sets out to explore or develop new perceptions), and innovative thinking (thinking that leads to new insights, novel approaches, fresh perspectives, and whole new ways of understanding and conceiving things). Creativity is often operationalized using the three core components that Torrance introduced in 1966. The three core components of creativity according to Torrance are: fluency, flexibility, and originality (Silver, 1997). *Fluency* refers to the number of ideas generated in response to a prompt; *flexibility* is the apparent shifts in approaches taken when generating responses to a prompt; and *originality* refers to the originality of ideas generated in response to a prompt.

In mathematics, creativity is observed in problem solving situations. Sak and Maker (2006) defined mathematical creativity as the ability to produce unique and mathematically correct solutions to problems by applying mathematical principles in various ways. Liljedahl and Sriraman (2006) differentiated mathematical creativity at two levels: professional and classroom level. At the professional level, mathematical creativity is the ability to produce original work that significantly extends the body of knowledge and the ability to open avenues of new questions for other mathematicians. At the classroom level, mathematical creativity is the process that results in novel and/or insightful solutions and the formulation of new questions and/or possibilities that allow an old problem to be regarded from a new point of view. For Bicer (2021), this definition of mathematical creativity implies that mathematical ideas or processes that students produce may be new to them but not necessarily new to the rest of the world. With this, more emphasis in put on the intellectual development of the student rather than on developing novel mathematical products. The relativity of the novelty of solutions produced relates to the notion of solution spaces that Leikin (2013) introduced. In school mathematics, the conventional solution space consists of solutions that are prescribed by the curriculum, while the unconventional solution space includes solutions based on strategies which are generally recommended by the curriculum. There is also the individual solution space which is a collection of solutions produced by an individual to a particular problem. These solution spaces also align with what Torrance observed in the nature of novelty of products: that the product does not have to be new to the whole society but new to the individual (Torrance, 1988 as cited in Yuan & Sriraman, 2011). Luria et al. (2017) also noted the same in the classroom level mathematical creativity. They concluded in their literature review that although students may not be formulating methods which are new to the whole field of mathematics, they may be creating novel solutions and ideas with respect to their own learning trajectories.

In view of mathematical creativity in the classroom level, Haylock (1997) characterized mathematical creativity of school children as overcoming content-universe and algorithmic fixations, and divergent production. Content-universe fixation is when a student's thinking is unnecessarily restricted to an insufficient range of elements that may be used to solve a problem. Algorithmic fixation is when students adhere to a previously learned algorithm even when such becomes inappropriate or inefficient. Haylock says that students exhibit creativity when they overcome content-universe and algorithmic fixations. Divergent production is when students are able to give many possible responses to open-ended tasks. Haylock further suggests that a student's creativity is limited by his/her experiences. The classical view of mathematical creativity is associated with giftedness while contemporary research reveals that mathematical creativity may be influenced by experience. Silver (1997) suggested that creativity may indeed be developed by increasing children's capacity in the core dimensions of creativity introduced by Torrance. Fluency is developed when students explore open-ended problems with many interpretations, solutions methods, or answers; flexibility is developed when students solve using many solution methods; originality is developed when students examine given solutions or answers then generate another that is different compared to what is given. Moreover, Silver noted that "creativity is often associated with long periods of work and reflection, rather than on rapid, exceptional insight" (p. 75).

Methodology

The present paper discusses the mathematical creativity of Filipino and Japanese students in terms of fluency, flexibility, and originality based on how Silver defined them. To execute the comparative research design, a combination of quantitative and qualitative research approaches was utilized, i.e., a test was conducted and statistical tests were applied to the results which were analyzed vis-à-vis textbooks/modules and class observations.

The Sample

One batch, consisting of 110 Grade 7 students from a school in the Philippines and one batch consisting of 160

Grade 7 students from a school in Japan originally participated in this research. To ensure the comparability of the two groups, Cattell and Cattell's (1959) Culture Fair Intelligence Test Scale 2 (CFIT2), a standardized IQ test which measures an individual's intelligence such that the influence of verbal fluency and culture is reduced as much as possible, was administered. The results were used to match the participants based on their IQ. Students whose CFIT2 results had no match were excluded from the analysis. In the end, 70 Filipino students and 70 Japanese students comprised the final sample included in the study.

The Instrument

Mathematical creativity was operationalized by the score in the fluency, flexibility, originality, and elaboration tasks (coined in this paper collectively as "Creativity subtest") of the Mathematical Thinking Skills Test (MTST), a researcher-made instrument whose framework was based on Joaquin's (2007) Mathematical Thinking Skills Test. MTST assesses students' mathematical thinking in terms of recall, basic thinking, critical thinking, and creativity. The topics covered in Joaquin's instrument were based on the Philippines' 2002 Basic Education curriculum. The present research's MTST was adapted to suit the present mathematics curricula of the Philippines and Japan. It covers topics on numbers and number sense which both Filipino and Japanese Grade 7 students have learned at the time of testing. MTST was content-validated by mathematics education experts from Philippines and Japan and was pilot-tested to 30 Filipino and 30 Japanese students. The reliability coefficient computed through the Cronbach alpha equation was .869 which means that the test questions have good internal consistency and that the test accurately measures the mathematical thinking of the students.

The Creativity subtest consists of open-ended tasks which test fluency, flexibility, and originality. These tasks are guided by Silver's discussion of these dimensions of creativity in the classroom setting. Fluency is practiced when students explore open-ended problems with many interpretations, solutions methods, or answers so in the fluency tasks, the students were asked to write as many examples of a given concept. The responses were scored based on the number of correct examples given. The rubric for checking this task set a benchmark of the number of answers in which a student may be considered fluent. The first task is to list as many numbers between 1 and 3. There are 19 typical answers (whole numbers and numbers up to the tenths place: 1.1, 1.2, …, 2, 2.1, …, 2.9) for this task based on the results of pilot testing. If a student was able to list a 20th number, that number would have two decimal places. This demonstrates fluency in terms of the density of numbers. Thus, the highest score was given if a student was able to list at least 20 numbers. The second task is to list as many pairs of integers whose sum is –12. The perfect score was given if the student was able to list at least 7 pairs. There are 6 typical answers based on the results of pilot testing: {0, -12}, {-1, -11}, {-2, -10}, {-3, -9}, {-4, -8}, and {-5, -7}. If a student was able to list a 7th pair, that pair would have at least one positive number. Giving a pair of differently signed numbers resulting to a negative sum demonstrates fluency in terms of addition of integers.

Flexibility is exhibited when students solve using many solution methods. In the flexibility task, a problem (see Figure 1) was given, and the students were tasked to write as many solutions as they can to correctly solve the problem. The responses were scored based on the number of different sensible solutions coming from different points of view or using different techniques. A solution is considered entirely different if it demonstrates a different thinking process. Variety of solution caused by properties of operation is not considered entirely different.

In a laboratory, one bacteria sample was cooled to a temperature of –51°C while another to –76°C. What was the temperature difference between the two samples? Show as **many different solutions** to this problem as you can think of.

Figure 1. The Task on Flexibility

Originality is developed when students examine given solutions or answers then generate another that is different so in the originality task, the students were presented with a problem and a solution to it, and they were required to give an alternative solution that is entirely different from what was given. The problem is presented in Figure 2. In the given solution, the number of yellow marbles and the number of blue marbles were first computed and then subsequently subtracted from the total number of marbles. A solution is considered entirely different if it demonstrates a different thinking process. The rubric for checking considered whether the solution is "entirely different" or not from one that is already given.

Kim has 210 marbles. One-fifth of his marbles are yellow, and $\frac{1}{3}$ are blue. The rest are green. How many green marbles does Kim have? Show a solution that is **different** from what is shown below. You may use illustrations, if necessary.

$$210-\left(\frac{1}{5}\times 210\right)-\left(\frac{1}{3}\times 210\right)=N$$

$$210-42-70=N$$

$$168-70=N$$

$$98=N$$

Kim has 98 green marbles.

Figure 2. The task on Originality

Note that the novelty of the ideas in the tasks was not scored based on all the responses of all the students but based only on the individual solution space. As Torrance observed, the product does not have to be new to the whole society but new to the individual (Torrance, 1988 as cited in Yuan & Sriraman, 2011; Luria et al., 2017). With this, more premiums are put into the individual intellectual development rather than on the production of a new product (Bicer, 2021).

There were two tasks on fluency, and one task each on flexibility and originality. The maximum point given in each of the fluency tasks is 2 while the maximum point given in each of the flexibility and originality tasks is 4, so the highest possible score for the Creativity subtest is 12. In the all rubrics for scoring the students' responses in the Creativity subtest, sample responses in each point category were provided. These sample responses were derived from the responses in the pilot test.

The Creativity subtest was originally written in English. It was translated to Nihongo before pilot-testing in Japan and the accuracy of the translation was validated by Japanese professors. The Japanese students answered the test in Nihongo. The Filipino students answered the test in English since the medium of instruction and assessment for Grade 7 Mathematics is English. However, the Filipino students were free to write their answers in Filipino or English.

Classroom Observations and Textbook/Module Analysis

Literature suggests that creativity is limited by a student's experiences (Haylock, 1997; Silver, 1997). In this regard, classroom observations and analysis of textbooks/modules were conducted to provide possible explanations to the results of the Creativity subtest. Two class periods of Grade 7 Math classes in the Philippines and Japan were observed. The observation focused on the mathematical discourse in the classroom and how creativity was promoted in the classroom activities. In the Philippines, each period is 60 minutes long. The second half of the second period was allotted for a mastery game, so there were no discussions. In all, around 80 minutes of classroom discussions were observed from the Philippines.

In Japan, each period is 50 minutes long. Although two classes were observed, only 20 minutes of the first class were permitted to be observed. So, around 70 minutes of classroom discussions were observed in Japan. The classes were videotaped for accurate referencing during data analysis. Textbook and module excerpts on the same topic (fraction, a topic in number sense) were collected from both countries. These were analyzed by surveying for evidence of mathematical creativity in terms of promotion of fluency, flexibility, and originality. General observations were also noted.

Data Analysis

Descriptive statistics (mean and standard deviation) were applied to to provide baseline information about the students' mathematical creativity. To determine significant group differences between the scores of the two groups, t-test for dependent samples was executed. Then the solutions were scrutinized to substantiate the quantitative analyses and provide further evidence of the students' creativity. For triangulation purposes, mathematics textbook and module excerpts were collected and analyzed and so are the mathematics classes observed.

Limitations

This paper presents a portion of a more encompassing study on the mathematical thinking of Filipino and Japanese students in the numbers and number sense domain; thus, the tasks in the Creativity subtest are delimited to problems involving numbers and number sense alone. Moreover, the present study, albeit being cross-national, is a small-scale comparative research so the small sample size limits the generalizability of the results.

Findings

The Japanese students' score was higher and less varied (*M* = 9.26, *SD* = 2.3) than the Filipinos' (*M* = 6.41, *SD* = 2.5). Dependent samples t-test was run at .05 level of significance and the computed p-value was less than .001 which means that the Japanese students scored significantly higher than the Filipino students.

Fluency

Fluency is exhibited when students generate multiple answers to a problem. The fluency tasks in the Creativity subtest required students to provide multiple answers. Table 1 shows the results on these tasks.

Table 1. Results of the Fluency Tasks

Fluency Task 1			Fluency Task 2		
	Filipino	Japanese		Filipino	Japanese
Listed more than 19 numbers	61%	67%	Listed more than 6 pairs	53%	88%
Listed up to 19 numbers	29%	23%	Listed up to 6 pairs	27%	0%
Listed no correct number	10%	10%	Listed no correct pair	20%	12%

As shown in Table 1, more Japanese than Filipino students were rated fluent (got the highest score) in both items. Interestingly, there is little difference between the results of the two groups in the first task. This means that the fluency level of the two groups on the density of rational numbers does not differ much. Turning to the second fluency task, substantial difference between the scores of the Filipino and Japanese students can be observed. This implies that Japanese students are more fluent in terms of addition of integers than the Filipino students.

Apart from an evidence of fluency, success in this task also demonstrates a break from a content-universe fixation. Students who were able to list numbers with digits beyond the tenths place value in the first task shows that they have overcome the limited set of rational numbers with only one digit in the decimals place. Students who listed pairs of positive and negative numbers show that they have overcome a fixed notion of using same-signed numbers in addition. As seen in the results, more Japanese students have overcome content-universe fixation in the second task.

The second fluency task is rather computational in nature. One may suggest that Japanese students might have been given more opportunities to master their computational skills than their Filipino counterparts. However, the opposite was observed in the mathematics classes as well as the textbook and module excerpts gathered. In the mathematics classes observed, only 2 to 3 practice exercises were given to the Japanese students while around

10 were given to the Filipino students.

Moreover, in the Filipino textbooks, 15 to 20 exercises were found at the end of each lesson, while only 5 to 10 in the Japanese textbooks. It appears that there is a factor contributing to the exceptional computational fluency of Japanese students that goes beyond the walls of the school. This might be attributed to the *juku* or “cram school”. Because of the high-pressure testing culture of the Japanese society, parents send children to *juku* as early as primary school. Japanese students attend *juku* almost every day after school, and there they answer mastery exercises and learn about the easiest ways to compute. Japanese teachers acknowledge that *juku* compliment classroom discussions – while mathematics classes in Japan are designed to develop creativity, the role of *juku* is to teach efficiency and mastery (O’Donoghue, 2014).

Flexibility

Flexibility is the ability to give multiple solutions to a problem, and these solutions should come from different perspectives. In the flexibility task of the Creativity subtest, a problem was given and the students were tasked to write as many solutions as they can to correctly solve the problem. The problem required the students to find the temperature difference between -51°C and -76°C. Table 2 presents the percent of students from both groups who were able to give 1 solution, 2 solutions, and more than 2 solutions, regardless of computational errors. Almost half (47%) of the Japanese group were able to generate more than 2 solutions. This is very far from the only 7% of the Filipino group who were able to do so.

Table 2. Results of the Flexibility Task

	more than 2 solutions	2 solutions	1 solution	no/wrong solution(s)
Filipino	7%	31%	19%	43%
Japanese	47%	33%	17%	3%

Common solutions that were given by both Filipino and Japanese students are presented in Figure 3. This answer shows three different solutions: subtracting the smaller number from the bigger number in order to get the difference; getting the difference of two similarly-signed numbers by getting the difference of their absolute values; getting the absolute difference between two numbers since it does not change even when the numbers are interchanged.

Student F-19 | Student J-97

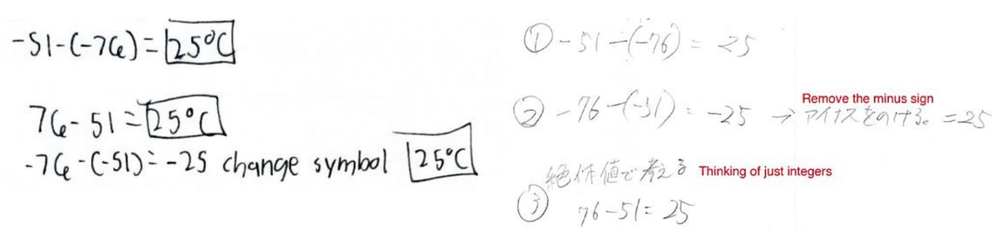


Figure 3. Solutions in the Flexibility Task and common to both Filipino and Japanese Groups

Another solution common to both groups is a visual one – drawing a number line and then manually counting the units between -76 and -51. Being able to provide these meaningful solutions means that a student has a good grasp of knowledge and skills on integers, subtraction, and absolute value. Moreover, these solutions which demonstrate different thinking processes exhibit creativity in terms of flexible thinking.

Interestingly, five Filipino students, in their attempt to provide multiple solutions, played around with numbers and operations in order to generate what they believed was the correct answer. However, such solutions are meaningless in the context of the problem. An example of this is presented in Figure 4.

Student F-44

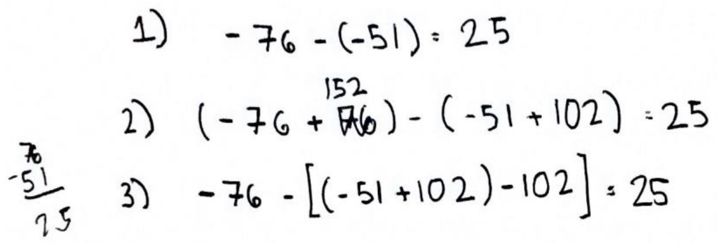


Figure 4. Examples of Irrelevant Solutions found in the Filipino Group

In the second and third solutions given by the Filipino student in Figure 4, one would wonder about the relevance of 152 and 102 to the problem. As there were no explanations provided by the student, it was assumed that these numbers were intentionally chosen and arranged in a number sentence to generate the correct answer which is 25. But these numbers are actually irrelevant to the problem. Clearly, the student only gave one meaningful solution, and this does not exhibit flexible thinking.

Now there were some solutions that can only be found in the Japanese group. One of these is the use of reference numbers. Reference numbers are used instead of the original given to make calculations easier. Example of this is presented in Figure 5.

Student J-48

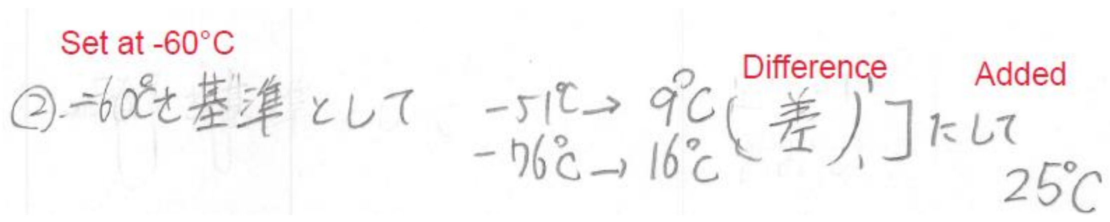


Figure 5. A unique Solution found in the Japanese Group: Use of Reference Numbers

Another solution that was found in the Japanese group and not in the Philippine group is decomposing the numbers according to place value (see Figure 6). The solutions presented in Figures 3 and 4 demonstrate a good grasp of numbers, the meaning of difference, and practical applications of properties of operations.

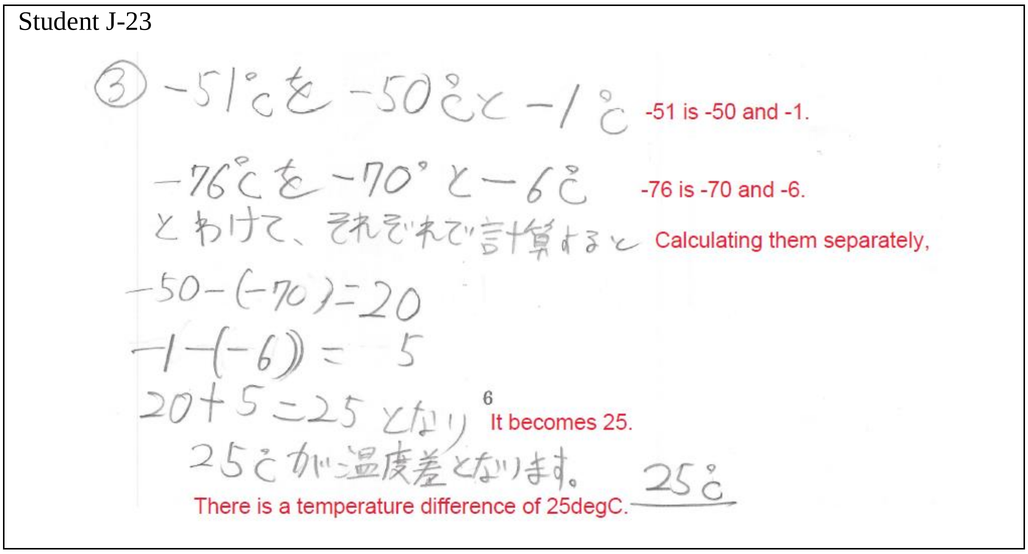


Figure 6. A Unique Solution found in the Japanese Group: Decomposing Numbers

The ability of the Japanese students to come up with different and unique solutions may be traced from how mathematics classes are conducted in Japan. In the class observations, the researchers remarked a common routine. First, the teacher poses a new problem, then the students were given ample time to reflect and discuss with their seatmate possible solutions to the problem. After some minutes, the teacher convenes the class and then asks some students to explain their solutions. The teacher strategically chooses the students so that solutions from different perspectives are presented to the whole class. This routine is aligned with the observations made by TIMSS researchers in their Videotape Classroom Study (Stigler et al., 1999). In the Philippines, the observed classes involved review of the previous lesson, whole-class discussion, and practice. In the whole-class discussion, the teacher guided the students through the development of mathematical concepts by asking a series of scaffolded questions. The questions were directed to the whole class, and the teacher called out some students to answer. Incorrect answers were processed while correct answers were emphasized. In contrast to the Japanese set-up, intentional discussion of multiple solutions to problems was not observed.

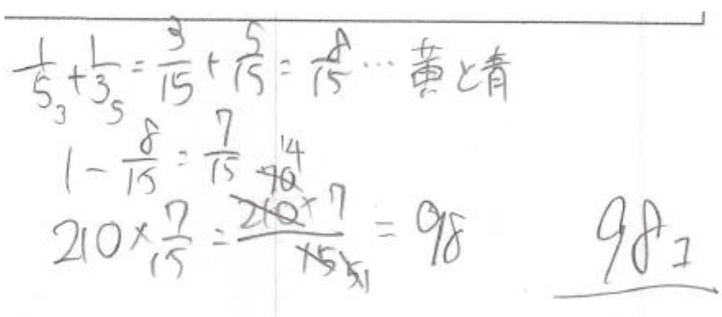
Flexible thinking is also found to be promoted in the Japanese textbooks. The Japanese textbook follows a problem-based approach, mimicking the students' classroom experience. A problem is presented, and the whole discussion is anchored to the problem. In most lessons, multiple solutions are presented after the problem. This shows that Japanese students are exposed to multiple solutions not only in classroom discussions but also through their textbooks. Some lessons in the Filipino modules also contain a word problem at the beginning of the lesson, but the discussion is not sustained throughout the lesson. The word problem only serves as an introduction. Moreover, only one solution is presented, usually the method that is easiest computationally.

Originality

Originality is the ability to generate a unique yet meaningful solution to a problem. In the originality task of the Creativity subtest, the students were presented with a problem and a solution to it and they were required to give an alternative solution that is entirely different from what was given. A solution is considered entirely different if it demonstrates a different thinking process. Variety of solution caused by properties of operation is not considered entirely different.

Figure 7 showcases sample solutions that are considered entirely different from what was given. The solution of Japanese student J-45 is considered entirely different because instead of deliberately computing for the number of the yellow and blue marbles, it demonstrated the idea of getting the fraction of green marbles. The same is true for the solution of Filipino student F-04. The combined number of yellow and blue marbles was computed not by getting the number of each but by solving for the fraction of marbles that correspond to both of them and then subtracting it from the total number of marbles afterwards. Both solutions demonstrate a thinking process that is different from that of the given solution.

Student J-45



Student F-04

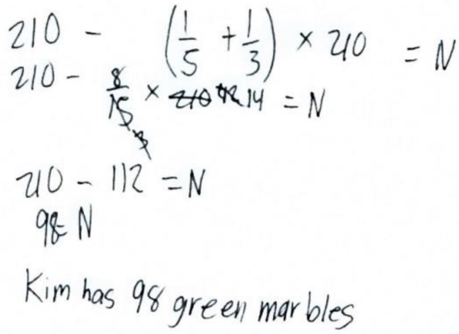
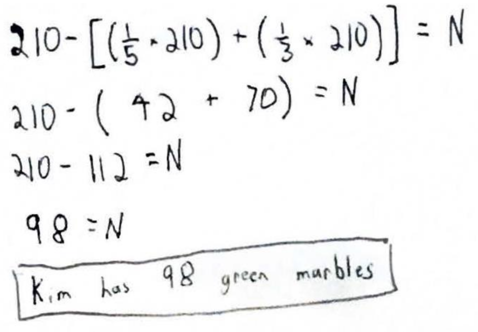


Figure 7. Sample Solutions in the Originality Task which are entirely different from given

Figure 8 presents sample solutions that were not considered entirely different from the given. In the solution of Filipino student F-12, the number of yellow and the number of blue marbles were computed separately which is the same with the given solution. The only difference is that instead of subtracting one by one, the sum of the blue and yellow marbles was computed and then subtracted from the total number of marbles. This is a variation caused by the distributive property of multiplication over addition. This can also be seen in the solution of Japanese student J-24. At face value, it looks a lot different because it made use of the division concept of fraction (e.g., dividing 210 by 5 instead of getting one-fifth of 210), but in fact, the thinking process involved in solving the problem was the same, i.e., find the number of yellow and blue marbles first and then subtract afterward.

Student F-12



Student J-24

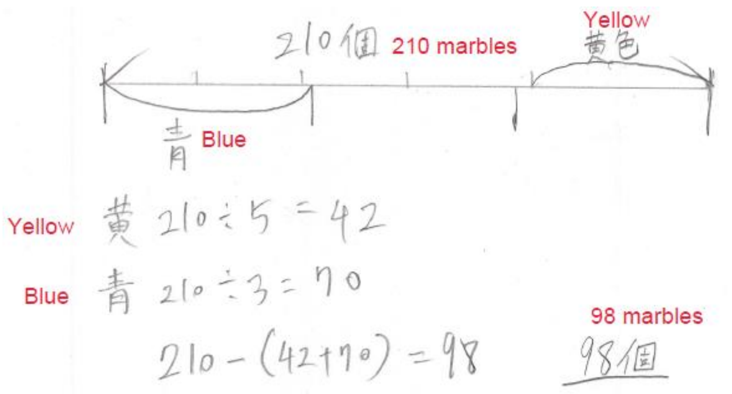


Figure 8. Sample Solutions in the Originality Task which are not entirely different from the given

Out of 70 students from each group, there were 51 Filipino and 65 Japanese students who were able to give correct solutions. Others either left the item blank or gave a wrong solution. The percent of students from each group who gave entirely different solutions, disregarding the computational errors, was computed and the results are shown in Table 3.

Table 3. Distribution of Students who gave entirely different Solutions in the Originality Task

	Entirely different solution	Not entirely different solution
Filipino (N = 51)	31%	69%
Japanese (N = 65)	71%	29%

The distribution of the kind of solution given in both groups is almost the exact opposite of each other. A more significant number of the Filipino group was not able to generate an entirely different solution (69%); i.e., the solutions given were variations due to properties of multiplication. Almost the same percent of Japanese students (71%) were able to come up with an original solution. This suggests that the Japanese students are more capable of original thinking than their Filipino counterparts. Success in this task demonstrates a break from an algorithmic fixation. The results suggest that more Japanese students overcome such fixation.

The researchers observed training in originality in the mathematics classes in Japan. The students were encouraged to come up with their own solutions to a problem that they encountered for the first time. The teacher did not demonstrate how to solve the problem and then asked the students to answer a similar problem. Instead, the Japanese students were trained to come up with solutions on their own and not follow a template of solution that the teacher provided. Moreover, all the Japanese students were given equal and ample time to struggle with the questions which gave them more opportunity to think critically and creatively. All students in the Japanese class had the chance to form and share their thoughts before the mathematical concept was revealed. Meanwhile, mathematics classes in the Philippines are generally characterized by a teacher asking the students what they know about a topic and then proceeds to explaining definition and rules (Department of Education et al., 2000 as cited in Ulep, 2002). Similar pattern is observed by the researchers of the present study. Moreover, it was observed that in the Philippine classroom, only the students who were quick in giving answers were able to completely generate their own ideas; others just followed the flow of the discussion and accepted the concepts as their classmates answer the questions posed by the teacher. Some students might have attempted to answer the questions on their own, but their thinking was halted by the reveal of the answer by a quicker classmate.

Expression of original ideas is also subtly promoted in the Japanese textbooks where solutions to problems are presented as students' ideas. The solutions are presented in a speech balloon said by a cartoon character who represents a student. The solutions are labeled with the student's name on it, e.g., "Yuki's idea." In the modules from the Philippines, the solutions are plainly discussed.

Conclusion and Recommendation

The present study revealed that Japanese students are better mathematical creative thinkers in terms of fluency, flexibility, and originality compared to the Filipino students based on their performance on the creativity tasks given to them. Classroom observations and textbooks and modules provide evidence that the Japanese students are given more opportunities to practice creativity in mathematics than their Filipino counterparts. With regard to fluency, the Japanese students' edge in computational fluency was attributed to the *juku* (cram schools) where they answer numerous mathematical exercises as practice. Considering flexibility and originality, it is evident that the Filipino group was not used to looking at problems from unique and different perspectives. Creation of ideas is explicitly advocated in the Japanese textbooks and is expected of all students in mathematics classes. Meanwhile, such promotion of flexible and original thinking is not observed in Philippine textbooks and not all students are given opportunities to completely generate ideas during mathematics classes.

Understanding these differences in the mathematical creativity of Filipino and Japanese students as well as how such creativity is developed in the respective countries provides an insight on the achievement gap between the two countries and how to minimize it. With this, it is recommended that Filipino students be given more opportunities to think creatively during mathematics classes by designing lessons such that all students are given time to dig deep into mathematical concepts and form their mathematical ideas. Authors of learning materials should also write textbooks and modules that put emphasis on creative thinking, e.g., mathematical concepts and solutions to word problems should be scaffolded, not immediately reported, and multiple solutions should be presented. The analyses in the present study are delimited to academic considerations, e.g. classes, textbooks, and modules. But previous studies suggest that generally, a person's creativity is largely dependent on his/her cultural context. However, this link between culture and creativity had not yet been confirmed to specific domains such as mathematics. With this, future researchers may look into cultural factors in exploring the differences in mathematical creativity of students from different countries.

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