The use of SIWI strategy to improve the performance of Grade 8 students in factoring polynomials by a common monomial

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ABSTRACT

Teachers play an important role in honing students' knowledge and skills. The strategy used in teaching greatly affects the final result of students learning. Hence, the teacher should properly plan and organize the strategy to be used. In this paper, we presented another teaching strategy in mathematics which is more fun and easier for students to understand mathematical concepts like factoring polynomials. We devised the so-called ***Substitute It With Icons*** **or (SIWI)** as teaching strategy in factoring polynomials by common monomial. Results revealed that SIWI is more helpful among low achievers group compared to high achievers who still preferred the old variable number style. It is recommended to try out SIWI with other mathematics topic like Algebra.

Keywords. *Mathematics, Learning, Icons, Criticalism, Philippines.*

INTRODUCTION

Dozens of researches around the globe had been focusing on improving students' performance in solving mathematical problem (Banerjee, 2010) with the notion that the lack of sufficient mathematical skills affects a person's ability to decide critically be it during formal education or in professional career. A plethora of researches have accounted students lack of interest (Koller et al. 2001) and difficulty in Mathematics (Desoete, et al. 2004; Philipp, 2007; Dowker, 2004) due to various factors such as teachers beliefs (Philipp, 2007) and competence (Ball et al. 2001).

In order to provide actual scenarios, a short observation was conducted by the team amongst education classrooms of the University of Mindanao Matina Davao City somewhere in December 2016 revealed that half of the class have difficulty in learning Mathematics, half of the students have low proficiency in measuring angles, 25% of students have failing score in Mathematics tests, 25% of the students have low proficiency in differentiating general form and standard form of the equation of a circle, and factoring polynomials, and students have difficulty in understanding postulates. Moreover, 50% of the students have low proficiency in understanding trigonometric identities, 75% of the students are not comfortable in answering without using calculators, 25% of the students have a low mastery level of the competencies involving angles, and 20% of the students felt sleepy during Mathematics class.

This is an alarming scenario since these students are soon to graduate and become teachers. What they learned, most especially how they learned really matters in their future classrooms. Several studies have pointed out techniques in effective mathematics teaching (Anthony & Walshaw, 2009; Boaler, 2008;

Carpenter et al. 1996; Chick et al 2005) but none seems greatly affects the phenomenal problem in mathematics learning particularly in the Philippines.

In this paper, we do not claim to have the answer to the overwhelming problems in students learning in mathematics but present a simple yet effective method in mathematics teaching particularly in solving polynomials. Students nowadays are very fond of gadgets and using different icons in their smart phones in expressing their feelings or sentiments, not surprisingly majority are visual learners. Hence we have come up with a new strategy called Substitute It With Icons or simply 'SIWI'. As its name implies, the students and teachers will use icons in solving polynomial expression. Variables and numbers can be replaced or substituted with icons or images in order for the students to improve their results in the quizzes or test examinations. Instead of merely using x and y or any other letters in the alphabet to represent variables in Algebra, the researchers suggest that these letters can be substituted with icons or images.

Research questions

Teachers play an important role in honing the students' knowledge and skills. It may also be said that the strategy they use in teaching math greatly affects the final results of the students from their whole year experience of learning. To address this problem, the teacher should properly plan and organize the strategy to be used. The purpose of this study is to determine whether the use of images or icons as substitutes for variables and numbers can help students to factor polynomials easily. Specifically, this study will seek to answer the following questions: In what ways does SiwI strategy improve the skills of factoring polynomials by a common monomial? And, what are the students' views on the use of SiwI strategy?

Research paradigm

This research sits in under criticalism research paradigm. Criticalism in the sense that we (as researchers) empower the teacher (Taylor & Medina, 2013) to reflect on what might work easily in solving polynomials in his class and at the same time tapped students as collaborators in the process.

In this process, we guided the teacher to self reflect on what is wrong why his students do not understand polynomials? Who are his students? What his students need? How to address his students needs? At the same time, we also invited the students to have a dialogued with the teacher on how to best learn polynomials.

Quality standards

In order to maintain the rigor of our study and to check our biases, we submit ourselves to authenticity and trustworthiness standards (Guba & Lincoln, 1989) "*distinctly different but 'parallel to' the validity, reliability and objectivity standards of positivism"* (Taylor & Medina, 2013). Polynomial is being taught at grade 8 for 1 week and the team stayed in the class within this duration. We believed that our observation is credible enough to check our interpretations of what has happened in this particular math class. We also observed dependability criteria by engaging in open-ended and emergent inquiry amongst students and the teacher and the team. Moreover, we made sure that by engaging and working with the subject teacher and dialogue with the students, we developed a *critical self-awareness* and *critical understanding* of the *complexity* of social issues (Taylor & Medina, 2013). In this case, the classroom issue we are trying to address is on how to easily solve polynomials.

METHODOLOGY

The methodology used in this study is action research. Ferrance (2000) defined action research as a study that is performed by a person, be it a teacher, or a group of people who looks for a problem, take an action through finding ways to solve it, and if their solution does not work they would look for another way. To

improve future actions is the main purpose for this research (Sagor, 2011), in this case is about teaching polynomials while having fun and with ease. All data gathered from the interviews are analysed into themes (Creswell, 2006; 2008).

Participants

The researchers selected 10 students, purposively, from a class consisting of 40 to 50 grade 8 students. The criteria in selecting these students is that they are having difficulties in factoring polynomials, they are on the average level based on their grades and scores, and those with exemplary performance in the said topic. Based on their initial scores in the class, five of them are the low performing students, three of them are the average performing students and two have exemplary performance in factoring polynomials. Primarily, we wanted to see how exemplary, average, and low performing students react on SIWI in solving polynomials. This is very important for us to analyse which student groups that the SIWI is more useful or not, which might be replicated to other classes all over the world.

Action plan

The team underwent the stages of action research: Observe, Reflect, Plan, Act (Creswell, 2006, 2008; Sagor, 2011). The activities in this study are divided into three stages: the pre-implementation, implementation, and post implementation plan. The procedures were as follows:

Pre-implementation stage

1. Gathering of Data

In the pre-implementation stage, the researchers gathered data through observing and monitoring Grade 8 Mathematics classes in the Basic Education Program of the University of Mindanao. An interview was conducted by purposively selecting 10 respondents. An interview was also conducted to the subject teacher. Data were recorded.

2. Transcribing the Data collected

For a week, the team transcribed the recorded answers of the participants, as well as the teacher's. After transcribing, we thoroughly identified the problems that arose in those interviews. Member checking was also made. It was used in finding the gaps of each problem. A critical analysis was used in identifying the most important, urgent, doable, and relevant problem as to why students do not easily/ and/ or cannot solve polynomials. The gaps identified were ranked according to their urgency.

3. *Devising a strategy and selecting the research participants*

At this stage, the team together with the students and teacher planned and decided the strategies we will try-out in the classroom. All prior informed consents of the students and legal protocols including the permission letter from the principal were strictly followed.

Implementation stage

1. Conduct of pre-test

On their first session, the researchers conducted a pre-test on factoring polynomials by a common monomial as baseline data.

2. Introduction of the strategy to the participants

The researchers together with the subject teacher started the next class with a review to make sure that the students can recall the steps on how to factor polynomials using the traditional number-variable method. After this, the researchers gave an iconic expression. During this stage, students are encouraged to familiarized with the icons and their corresponding representation.

3. Applying the SIWI strategy

On the third session, the discussion was focused on introducing the SiwI strategy. The researchers made a table of icons, their corresponding numbers and variables represented. Students are also encouraged to make their own icons for them to easily familiarize. At the same time, the team (researchers and the teacher) gave board works to make sure that the students followed the steps in factoring polynomials using the new strategy presented. Before the session ended, we gave some exercises for the students to work on their own.

4. Conduct of post-test

During the last session, the researchers conducted a post-test to check whether the students have improved their skills in factoring polynomials using SIWI. The same type of mathematical problems was given (pertaining to the pre-test) with modifications. This forms the basis of our analysis (comparing the results of pre-test) for students' improvement in factoring polynomials.

Analysis

Post-test results were then compared to pre-test results. Descriptive statistics such as mean and gain scores were used (see Table 1). For the interview data, a thematic analysis was used and themes were further used as support to the analysis the descriptive data.

RESULTS AND DISCUSSION

Based on Table 1, the pre-test shows that there were students who scored notably higher than the others. These students were identified as the high performing students, Students A and B, who both scored a total of 10 points. The ones who scored 6-9 points were the average performing students. And finally, those who got scores equal or lower than 5 were low performing students. This result is consistent with our criteria on selecting the participants. For this purpose, we have labeled the students based on their pre-test scores as High achievers, Average achievers, and Low achievers.

Table 1. Pre-test, post-test, and gain score of students

Student	Pre-Test	Post-Test	Gain Score	Mean gain score
A (Ha)	10	10	0	0
B (Ha)	10	10	0	
C (Aa)	9	9	0	+1.5
D (Aa)	8	9	1	
E (Aa)	7	9	2	
F (La)	3	6	3	+5.2
G (La)	1	7	6	
H (La)	1	7	6	
I (La)	0	6	6	
J (La)	0	5	5	
Mean	4.9	7.8	2.9	

Legend: Ha – High achievers; Aa – Average achievers; La – Low achievers.

It is clear that there is no significant gain or loss on the high performing students. This means that these students whether they use icons or solve polynomials with the old symbols of *X* and *Y*, they tend to produce same correct answers. Minimal gain score (1.5) is also observed in the middle achievers which also mean that SIWI can be useful to this student group. Both high and middle achievers might have good prior knowledge in solving polynomials (Anderson, 1981; Svinicki, 1993). It seems easy for them to

answer the old fashion of X & Y than icons. Teacher factor also affects students understanding in mathematics (Svinicki, 1993).

> "*The SIWI is good, it is fun, but I find easier solving polynomials the old way. My former teacher taught us very well; hence I find it easy to solve polynomials.* " – Student A (Ha)

What is remarkable is the improvement seen among low achieving students with the gain score of +5.2. This is very promising especially helping low performing students to understand polynomials. This might be due to the fact that most low performing students are visual learners, which often not given proper treatment inside the classroom. Often teachers teach the way they learned (Sitt-Gohdes, 2001) and this created bias as to the way he treated students in the classroom. Most often, students who have good verbal abilities benefited wonderfully but left behind those students who love to see figures, icons, and other presentations on the subject matter. During our interview with the teacher, he reveals that…

> "*I learned polynomials before using lecture-board-talk method. Often, our professors would just give us exercises and it is up for us to solve the problems. I guess because of this, it is innate in me teaching this way*". – Teacher

This might be the explanation as to why these students failed during the pre-test. They cannot understand the significance of what really X and Y means. Using icons, they have the sense of understanding that relates to themselves and the things around them.

The researchers conducted formative assessments during the sessions that they had with the students. Here are some of the students' outputs during their seat work without the use of SiwI strategy. Figure 1 will showed the common errors the low achieving students committed during the pre-test.

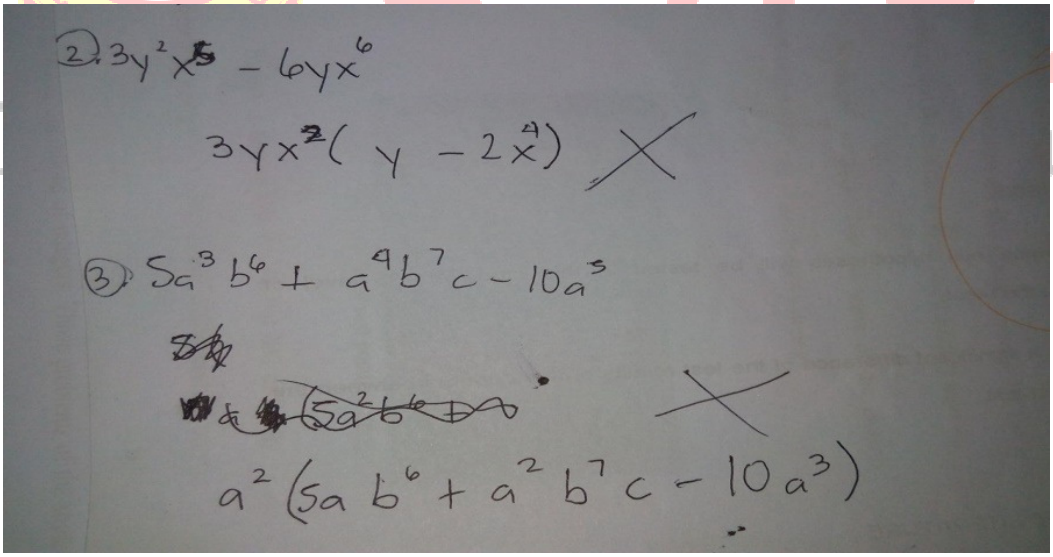

Figure 1. Common errors committed by low performing students when factoring polynomials by a common monomial

A common error from the students was their manipulation of the exponents when factoring a single polynomial. As shown in Fig. 1 students commited error when he factored 'x' in the expression. In factoring $3y^2x^5 - 6yx^6$, the answer should be $3yx^5(y - 2x)$, not $3yx^2(y - 2x^4)$, such an alarming

sight. This also indicates that the students have not familiarised the laws of exponents. The same goes in item no. 3.

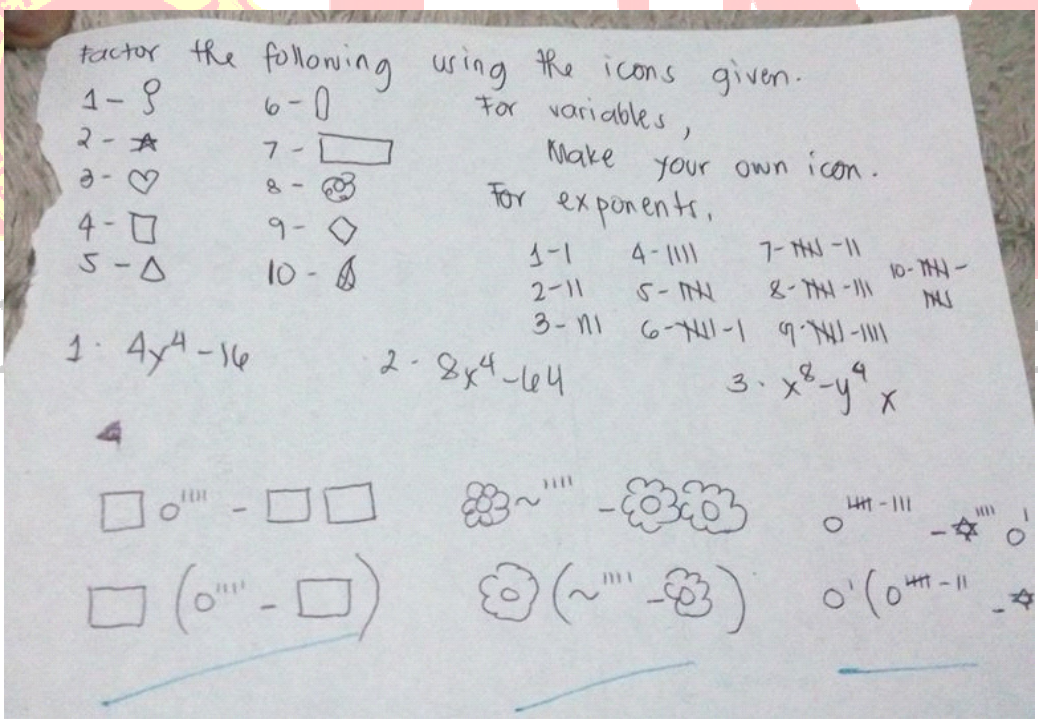

Figure 2. Factoring polynomials by common monomial using SIWI

Figure 2 shows how the students used SIWI in factoring polynomials by a common monomial. Through the use of iconic representation, the students' difficulty in factoring polynomials was settled. It was easier for them to solve the given expression since the icons that they used was given by the researchers, so it took them less time to think about what icons to draw. It was evident on their answers that their difficulty in factoring polynomials especially when they have to find for the common monomial in the given

expression was eliminated. Because the icons were almost the same, the students' complication in factoring polynomials was eradicated.

Higher-level math and science courses rely heavily on visualization and spatial reasoning skills to solve problems, thus the use of visual representation is an important skill that students should possess (Goldin & Kaput, 1996). Additionally, these representations could help students to think of the best way to answer a certain mathematical problem.

The use of visual representations enable students to make connections between their own experience and mathematical concepts (Barmy, Bolden, raine & Thompson, 2012; Post & Cramer, 1989) that through representations, students gain insight into abstract mathematical ideas.

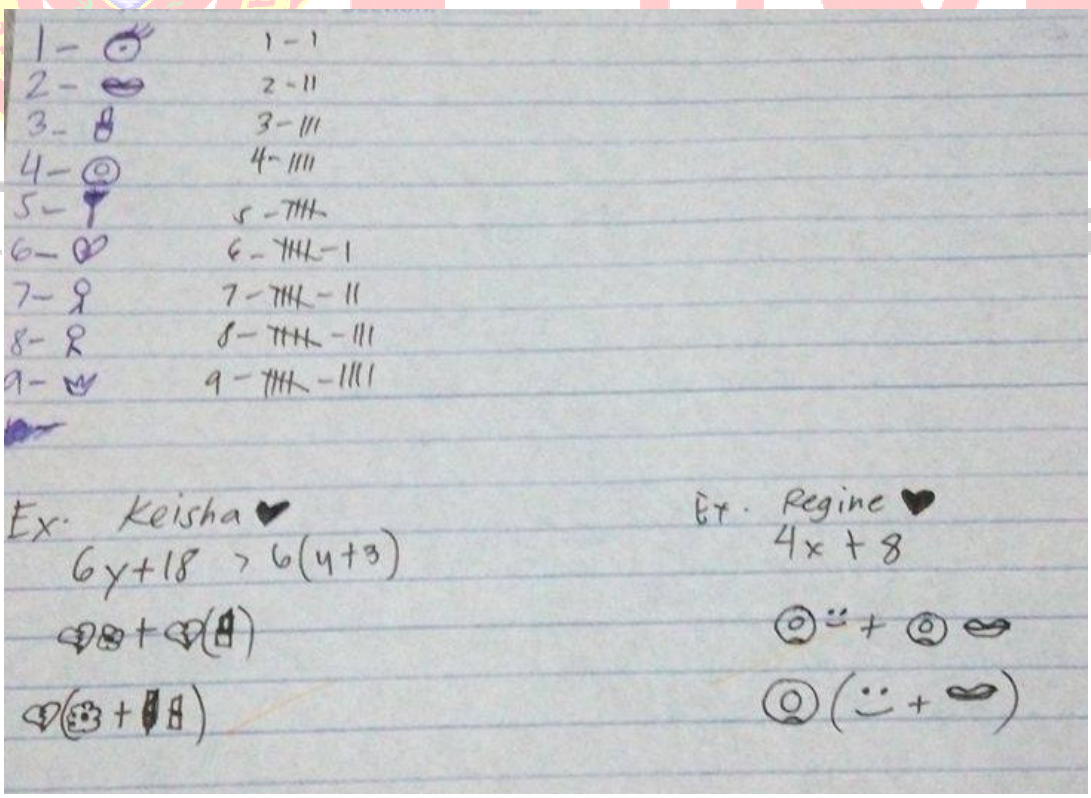

Figure 3. Factoring polynomials by the icons made by the students

Figure 3 shows that the students factor polynomials by a common monomial using the icons that they personally made. Here, the students were able to draw the icons that they want, according to their own preference. In the figure, the icons that the students drew were similar to the things that they use in their everyday activity. Hence, the students were able to build connections between their own experiences and factoring polynomials by a common monomial. Furthermore, the students' creativity was manifested.

Results in the interview

The notable perfect scores of the high achieving students are due to their good background in the Laws of Exponents and good mentoring. When asked on how they feel about the SIWI strategy, all of them answered that they like the strategy. However, they were most comfortable using the traditional number-variable method suggesting that this group of students is most likely logical-mathematical learners which might supports the Multiple Intelligence Theory of Gardner in its logical mathematical aspect.

> *"I prefer the number- variable method because I'm used to it. In terms of speed, it would be better to use the traditional way. But in terms of* ***understanding****, I prefer the icons."-* Ha student

Since learners in this type of intelligence love to find connections in abstract things, algebra is one of the best examples of this. Students tend to find relationships between two or more variables and must think with higher order thinking skills in order to answer the questions (Goldin & Kaput, 1996; Nathan & Koedinger, 2000).

3 out of 3 average performing students agreed that the use of the strategy helped them understand the topic. During their interview, they shared to the team that they enjoyed doing math using the SIWI strategy. All of them showed positive emotions and considered the activity as enjoyable. This is something to ponder in mathematics teaching that it is important also to consider how students feel during their class. We theorized that emotions play a role in students understanding of mathematics and can be connected to their positive performance. This is supported by Schukajlow (2015) that a positive emotion in classroom can inspire students to engage themselves to the lesson.

The low performing students, who had the most notable improvement as shown in the mean gain scores, mentioned that they understood the topic because they enjoy doing it. This further means that when students enjoyed what they are doing in the classroom, they tend to be more engage, and when they are engage, they learned. Perhaps we can consider this as transformative mathematics learning. One of them shared that she liked solving using icons since if she used numbers it would get too boring to solve. And since, at some point, they were using their own sets of icons, then they could develop and enhance their understanding on their own, making reasoning and critical thinking a must but still enjoyable.

> "*I believed this is a promising teaching strategy especially for slow learners (low achieving). Although it is very time consuming, but students learning (understanding) is more important*". – Teacher

Visual representation is needed since it does not only appeal to the eyes of the students but it also models problem solving and learning as a whole (Zhang et al, 2012). However, to have an effective classroom where the use of representations merit the students, the teacher should maximize enjoyment and positive self-concept - which the researchers may have inadequately imparted to that one particular student who gets confused in using the strategy. One of the highlights in the interview was when one a student realized that the strategy could also be used to other topics in mathematics, particularly in Algebra. This is promising.

CONCLUSION

SiwI strategy improved students' performance in factoring polynomials by a common monomial. The use of this strategy in solving polynomial is very promising, easier to be understood by the students, and enjoyable. This method is more effective to visual learners.

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