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Mathematics Problem-Solving Skills and Engagement through Interactive Learning

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Abstract: : The current curriculum promotes a student-centered classroom and emphasizes the importance of problem-solving in mathematics. Designing activities that support students in class and encourage their engagement have posed a challenge to the teachers. This study explores the use of interactive learning with digital tools on the problem-solving skills and engagement of Grade 7 students. Digital interactive learning (DIL) and non-digital interactive learning (non-DIL) class have results concentrated on very low problem-solving skills on pre-test and are engaged in behavioral, emotional, and cognitive engagement. Both groups have also revealed an increase on their post-test and retention test on problem-solving test with some students having high level skills. Post-test on engagement showed to be still engaged in behavioral, emotional, and cognitive engagement. Both post-test and retention test revealed a significant difference between groups with F-value of 7.496 and p-value of .008 on post-test and F-value of 10.749 and p-value of .002 on retention test in their problem-solving skills. It is recommended to consider interactive learning in mathematics class to help the students in their problem-solving skills and engagement.

Keywords: *mathematics problem-solving skills, engagement, interactive learning.*

1. INTRODUCTION

The most important aim of mathematics education is to address real-world problems and apply it in our daily lives. With the purpose of attaining this, problem-solving skills must be developed. However, it is undeniable that most High School students are struggling to perform in these areas. The Department of Education (DepEd) seeks improvements through developing the current Mathematics curriculum that encompasses more than just abstract representations and tedious computations [1]. The National Council of Teachers of Mathematics have been emphasizing that problem solving plays a vital part in learning mathematics that would allow students to develop ways of thinking and even be confident in atypical circumstances outside their classroom. One of the focuses of the Philippines' Mathematics education curriculum is to develop the problem-solving skills of the students which is incorporated into the curriculum together with the learners' skills, processes, values, and attitudes. This builds the foundation for the crucial concepts and life skills that the students must develop in their basic education [2].

The Trends in Mathematics and Science Study (TIMSS) presented International Results in Mathematics and Science wherein the mathematics assessment includes three (3) content areas - number, which included prealgebra; measurement and geometry; and data. Only 19% of Filipino were able to reach "low benchmark" implying that they have "some basic mathematical knowledge" while the remaining 81% did not even reach this level [3]. The assessment was established by the partaking countries to reflect their curricular goals. The Philippines got an average scale score of 297 which is significantly lower than the center point (500) of the TIMSS scale. This result is also significantly lower than other countries in comparison as Philippines rank lowest in the said assessment. Also, the average scale score of Philippines continually declines since 2003 with an average of 358 to its lowest point on the current result in 2019 with an average of 297 [4]. Similar results were also found out by the Organization for Economic Cooperation and Development (OECD) for the Programme for International Assessment (PISA) which is a comprehensive and reliable indicator of students' capabilities. In Mathematics, the Philippines scored 355 for mathematics assessment signifying that it is below level 1 proficiency [5]. It is also observed with the National Achievement Test (NAT) results of students indicating a low average score including in the problem-solving area with only 39.73 mean percentage score [6].

On the other hand, it is still a challenge for teachers to make students be engaged in learning mathematics. Teachers must recognize the need to use a variety of teaching approaches and ideas to enhance students' knowledge and make it more meaningful and engaging. The teaching methods used in the classroom provide a huge impact on the students' level of understanding [7]. The traditional teaching methods used in most private and public schools often result in students losing interest in the subject matter which is evident in the rising number of passive students in the class [8]. Students often find mathematics subject difficult and unexciting leading to teachers having difficulties in engaging them in learning the subject. Their engagement is not only observed in their behavior but also cognitively, and emotionally [9].

The rapid development of education through technology provides an opportunity for the use of digital tools to make the learning environment more interesting and interactive for the students [10]. Digital tools provide learning experiences through text, photos, audio, and even videos. We cannot neglect the use of digital tools in the classroom as it is an essential tool for learning mathematics due to its potential in teaching and learning [11]. Since the current

curriculum also promotes students' engagement in the classroom, it shifts from a traditional approach of a teacher-centered classroom to a student-centered one. It focuses on increasing students' participation and improving their fortes. Teachers' roles also became the facilitator in class as they guide the students in the learning process [12]. Interactive learning promotes interaction between teachers and their peers. The students are given the opportunity to seek knowledge through engagement in inquiry, interactive lectures, response systems, etc. Teachers may facilitate the classroom by monitoring the students as they go around the classroom and encouraging students to express their insights. Questioning can also elicit responses and discussions from the students. Other activities such as brainstorming, Think, Pair, and Share, and questioning strategies, are some of the most effective ways to promote engagement and make students retain more information using an interactive approach [13].

Quezon Bukidnon Comprehensive High School also encountered problems on students' performance in their mathematics class especially during the resumption of face-to-face classes. The teachers are also having difficulties in designing learning activities that would encourage their engagement in class and improve their problem-solving skills. Students have difficulties in solving problems on their own and applying their knowledge in real-life situations. The use of digital tools has created opportunities to support teachers and students in class. The international results and local issues have been acknowledged by the researcher and that there is a need to address the difficulties on problem-solving skills of the students as it affects their performance in Mathematics. This study examined the students' problem-solving skills and engagement in class as interactive learning approach is implemented.

2. METHOD

This study used a quasi-experimental design with 2 intact sections. This was conducted at Quezon Bukidnon Comprehensive National High School (QBCNHS) with Grade 7 students as respondents. The experimental group have 42 students while the controlled group have 37 students. A permit from the Instutional Ethics Review Committee (IERC) was secured before conducting this study and proper communication letter was sent to the Department of Education (DepEd) Bukidnon and QBCNHS. A researcher-made problem-solving questionnaire was employed which was checked and validated by local experts. Using the standard set of DepEd Order no. 8 series of 2015, the results were interpreted using the scale below after the scores were then transmuted. To provide a better understanding of the scales, a descriptor was used:

Range	**Descriptive Rating**	**Descriptive Interpretation**
90 – 100	Exemplary	Very High Problem-Solving Skills (VH)
85 – 89	Above Average	High Problem-Solving Skills (H)
80 – 84	Average	Moderate Problem-Solving Skills (M)
75 – 79	Below Average	Low Problem-Solving Skills (L)
74 below	Deficient	Very Low Problem-Solving Skills (VL)

A survey questionnaire on engagement was adopted from Flores, et. al and was pilot-tested with Cronbach alpha of 0.831. The levels of problem-solving skills and engagement of students was determined using descriptive statistics such as mean, frequency, and percentage. Then, the Analysis of Covariance (ANCOVA) was used to investigate the significant difference between the students' academic performance and engagement in mathematics between the two groups. A scale was used to interpret the data that was collected providing a better understanding of the scores for the engagement of the students. The scale is as follows:

Rating	**Scale**	**Descriptive Rating**	**Qualitative Interpretation**
4	3.50 – 4.00	Strongly Agree	Highly Engaged (HE)
3	2.50 – 3.49	Agree	Engaged (E)
2	1.50 – 2.49	Disagree	Not Engaged (NE)
1	1.00 – 1.49	Strongly Disagree	Highly Not Engaged (HNE)

3. RESULTS AND DISCUSSION

3.1. Level of students' problem-solving skills in pretest, posttest, and retention test.

Range	**Descriptive Rating**	**Pre-test**				**Post-test**				**Retention test**				**Qualitative Interpretation**
		DIL		Non-DIL		DIL		Non-DIL		DIL		Non-DIL		
		F	%	F	%	F	%	F	%	F	%	F	%	
90 – 100	Exemplary	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	VH
85 – 89	Above Average	0	0%	0	0%	4	10%	0	0%	10	24%	3	8%	H
80 – 84	Average	0	0%	0	0%	3	7%	1	3%	2	5%	1	3%	M
75 – 79	Below Average	1	2%	1	3%	5	12%	5	13%	11	26%	7	19%	L
74 below	Deficient	41	98%	36	97%	30	71%	31	84%	19	45%	26	70%	VL

	Mean	15.02	11.89	21.76	17.16	24.62	19.27	

Range	Descriptive Rating	Qualitative Interpretation
90 – 100	Exemplary	Very High Problem-Solving Skills (VH)
85 – 89	Above Average	High Problem-Solving Skills (H)
80 – 84	Average	Moderate Problem-Solving Skills (M)
75 – 79	Below Average	Low Problem-Solving Skills (L)
74 below	Deficient	Very Low Problem-Solving Skills (VL)

The problem-solving skills of the DIL and non-DIL group students are concentrated on the very low level before the intervention was employed. It is clearly shown that students from the DIL group have increased on the results from the pre-test with 98% of students having very low problem-solving skills, to post-test with only 71% of very low problem-solving skills, and even 10% having high problem-solving skills. This continued to improve on the retention test with only 45% having very low problem-solving skills, and 24% of the students with high problem-solving skills. Meanwhile, the non-DIL group have also shown improvements on their results. From pre-test with 97% of the students having very low problem-solving skills, to the post-test with only 84% of the students having very low problem-solving skills, and 3% with moderate problem-solving skills. And continued to progress with only 70% having very low problem-solving skills, and 8% with high problem-solving skills in the retention test.

It showed that both students from DIL and non-DIL group have increased scores on their problem-solving test based on the mean score presented. Furthermore, the DIL group have higher mean score on their post-test which is 21.76 than of the students from non-DIL group which is 17.16. The retention test result also showed a higher mean score for DIL group which is 24.62 than the non-DIL group which is 19.27. But it can be observed that students from both groups have improved in their problem-solving skills based on their mean scores.

Several studies [3] [5] [14] have also shown similar results on low pre-test scores of students before intervention was employed. These studies also revealed an increase of students' problem-solving skills on their post-test and retention test after an intervention was utilized in class. In contrast, a study by Ermac and Tan (2023) have shown a decline on students' retention test in problem-solving when using a method that lets the students work through collaborative activities. Ref [15] have shown that multimedia can assist students in developing their problem-solving skills through various activities encouraging their interaction in class. These activities allow the students to share and discuss their ideas with their teachers and classmates. The use of various instructional materials also helps the students attain their learning outcomes [16]. Moreover, with the help of digital technology, it is now possible to utilize different applications and digital instructional materials that might significantly affect their learning process.

3.2. Behavioral Engagement

Statements	**Before the Intervention**				**After the Intervention**			
	DIL		**Non-DIL**		**DIL**		**Non-DIL**	
	Mean	**QD**	**Mean**	**QD**	**Mean**	**QD**	**Mean**	**QD**
I listen to my teacher in my math class.	3.36	E	3.19	E	3.33	E	3.57	HE
I follow my teacher's directions in math class.	3.26	E	3.32	E	3.05	E	3.32	E
I ask my friends or teachers for a help when I cannot solve math problems.	3.21	E	3.22	E	3.12	E	3.41	E
When I make mistakes in math, I work until I correct them.	3.05	E	3.05	E	2.95	E	3.03	E
I participate in the discussion in math class.	2.93	E	2.84	E	3.10	E	3.16	E
I work hard in math class.	2.81	E	2.62	E	3.02	E	2.76	E
At home I review math problems that I did not understand in school.	2.76	E	2.65	E	3.00	E	2.54	E
I sometimes act out as if I am studying in math class. *	2.62	E	2.41	NE	2.29	NE	2.35	NE
When I see difficult math problems, I stop working on them. *	2.52	E	2.32	NE	2.19	NE	2.35	NE
Sometimes I skip difficult math questions	2.48	NE	2.46	NE	2.57	E	2.59	E
I get easily distracted in math class. *	2.05	NE	2.49	NE	2.38	NE	2.49	NE
Overall Mean	**2.82**	**E**	**2.78**	**E**	**2.82**	**E**	**2.87**	**E**

Rating	Scale	Descriptive Rating	Qualitative Interpretation
4	3.50 – 4.00	Strongly Agree	Highly Engaged (HE)
3	2.50 – 3.49	Agree	Engaged (E)
2	1.50 – 2.49	Disagree	Not Engaged (NE)
1	1.00 – 1.49	Strongly Disagree	Highly Not Engaged (HNE)

Both students in DIL and non-DIL are engaged in terms of behavioral engagement in their mathematics class before the intervention with mean score of 2.82 and 2.78, respectively. Out of the 11 statements for behavioral engagement, 9 have been perceived as engaged by the

students before the intervention by the DIL group and 2 have been not engaged. While only 7 out of 11 statements is identified as engaged by the non-DIL group and 4 were not engaged. None of the groups have highly engaged or highly not engaged in terms of behavioral engagement before the intervention.

After the intervention, both groups are still engaged in terms of behavioral engagement with DIL group having a mean score of 2.82 and non-DIL group a mean score 2.87. There are 8 out of 11 behavioral engagement statements indicates that students are engaged in class while there are 3 that are less engaged. On the other hand, non-DIL group have 1 which is highly engaged, 7 out of 11 behavioral engagement statements that are shown as engaged, and the 3 remaining are not engaged.

Ref [17] also supports this finding as teachers can create an environment conducive for learning through promoting interactive discussions, giving students feedback, and encouraging their participation in class fostering a positive environment in class and improving their behavioral engagement as well. Moreover, the teachers can guide the students when working on their tasks on how they are going to solve problems and achieve their learning outcomes. Their behavioral engagement can be observed on their positive conduct on their given tasks and other activities, improvements on their performance, and their involvement in class and school activities. However, it can also be observed on their inattentive behavior and other negative behavior in class [18]. With the negative conduct of the students presented in the results, the teacher can also discuss with the students what they are expected show in class and their behavior to better meet the expectations in the future. A sustained interaction with the students throughout the lesson can also help increase their behavioral engagement and interest in their class. Students' participation can also be observed even at home through an educational platform providing them more opportunities in learning mathematics. But they can also exhibit negative behaviors especially in adjusting to the delivery of lessons and being accustomed to it. With the students being used to using digital tools, they can have more opportunity to take note of their questions and clarifications about the lessons since it is uploaded on the educational platform before the discussions. They also exert more effort in their tasks and improved their learning outcomes [19].

3.3. Emotional Engagement

Statement	**Before the Intervention**				**After the Intervention**			
	DIL		**Non-DIL**		**DIL**		**Non-DIL**	
	Mean	**QD**	**Mean**	**QD**	**Mean**	**QD**	**Mean**	**QD**
Learning math is fun.	3.21	E	2.78	E	3.00	E	2.89	E
I am interested in learning new things in math.	3.02	E	2.86	E	3.05	E	3.19	E
I feel excited when I study in math class.	2.79	E	2.76	E	2.83	E	2.65	E
Time passes very quickly when I study math.	2.69	E	2.54	E	2.81	E	2.54	E
I want to spend more time solving math problems.	2.67	E	2.62	E	2.93	E	2.73	E
I like to study other subject s rather than math.*	2.60	E	2.70	E	2.81	E	2.81	E
I am excited about solving difficult math problems.	2.57	E	2.35	NE	2.67	E	2.43	NE
I forget where I am when I study math	2.55	E	2.59	E	2.24	NE	2.41	NE
I do not like attending math classes.*	2.31	NE	1.97	NE	2.24	NE	2.22	NE
I feel bored when I study in math.*	2.24	NE	2.51	E	2.02	NE	2.41	NE
Overall Mean	**2.66**	**E**	**2.57**	**E**	**2.66**	**E**	**2.63**	**E**

Rating	Scale	Descriptive Rating	Qualitative Interpretation
4	3.50 – 4.00	Strongly Agree	Highly Engaged (HE)
3	2.50 – 3.49	Agree	Engaged (E)
2	1.50 – 2.49	Disagree	Not Engaged (NE)
1	1.00 – 1.49	Strongly Disagree	Highly Not Engaged (HNE)

Both DIL and non-DIL group are engaged in terms of emotional engagement before the intervention with a mean of 2.66 and 2.57, respectively. DIL group is engaged on 8 out of 10 statements on emotional engagement and there are 2 statements which are not engaged. On the other hand, the non-DIL group is engaged on 8 out of 10 statements on emotional engagement and the rest of the statements have been shown to be not engaged by the students. Both groups have not shown any highly engaged or highly not engaged statement in terms of emotional engagement.

After the intervention, Both groups have higher mean compared to their pre-test which are fairly engaged with a mean score of 2.66 for the DIL group and 2.63 for the non-DIL group in their mathematics class. The DIL group have 7 out of 10 emotional engagement statements shown as engaged, and 3 statements which are less engaged. While the non-DIL group have 6 out of 10 statements which are engaged and 4 which are not engaged. None of the groups have shown highly engaged or highly not engaged in terms of emotional engagement.

Students' emotions such as interest, joy, and frustration, as well as their lack of boredom and anxiety [20] can affect their learning process. Their emotion drives the increase in their learning and memory [21]. Students view for new challenges and learning tasks given to them

plays a crucial role in achieving their learning outcomes. It is important to note that they should feel positively and belonged in their classroom as this would support their motivation on improving their outcomes. Students' emotion is very important as it increases their memory and learning in class. Activities that are collaborative also helps the students to recall related events or memories linking to the current discussions. Their positive emotions such as interest and enjoyment in class can help them achieve their learning outcomes and complete their tasks. Meanwhile, negative emotions may undesirably affect their outcomes as well [22].

3.4. Cognitive Engagement

Cognitive Engagement	Before the Intervention				After the Intervention			
	DIL		Non-DIL		DIL		Non-DIL	
	Mean	QD	Mean	QD	Mean	QD	Mean	QD
I want to spend more time solving math problems.	3.48	E	3.57	HE	3.31	E	3.49	E
When I study math, I ask myself questions to make sure I understand it correctly.	3.21	E	3.11	E	3.26	E	3.11	E
I memorize important facts to understand math better.	3.17	E	2.68	E	3.12	E	3.08	E
I try to develop my own strategy when I solve math problems.	3.00	E	2.81	E	3.02	E	3.27	E
I set goal for myself when I study math.	2.98	E	2.86	E	2.93	E	3.03	E
I try to think different ways to solve math problems.	2.93	E	2.62	E	2.90	E	2.84	E
I am focused when I study math.	2.90	E	2.57	E	2.83	E	3.08	E
I try to connect math to real life situations.	2.88	E	2.70	E	2.83	E	2.92	E
At home I think about what I learned in math class.	2.83	E	2.57	E	2.76	E	3.03	E
Sometimes I follow my best guess when I do not the answer. *	2.64	E	2.62	E	2.71	E	2.65	E
I often think about something else when I study math. *	2.55	E	2.38	NE	2.64	E	3.00	E
When I cannot solve a math problem, I try to change my strategy.	2.36	NE	2.59	E	2.57	E	2.54	E
Overall Engagement	**2.86**	**E**	**2.68**	**E**	**2.87**	**E**	**2.96**	**E**

Rating	Scale	Descriptive Rating	Qualitative Interpretation
4	3.50 – 4.00	Strongly Agree	Highly Engaged (HE)
3	2.50 – 3.49	Agree	Engaged (E)
2	1.50 – 2.49	Disagree	Not Engaged (NE)
1	1.00 – 1.49	Strongly Disagree	Highly Not Engaged (HNE)

Students' cognitive engagement before the intervention which showed that both groups are engaged in class with a mean of 2.86 on the DIL group and 2.68 on non-DIL group. Out of 12 statements on cognitive engagement, DIL group have 11 that have a mean score as engaged, and 1 which is less engaged. While non-DIL group have 1 which is highly engaged, 10 which is engaged, and 1 that is not engaged statements.

Both groups are engaged in mathematics class in terms of cognitive engagement with mean scores of 2.87 for DIL group and 2.96 for non-DIL group. 12 out of 12 statements are shown as engaged in both groups. None of the groups are highly engaged nor highly not engaged in terms of cognitive engagement after the intervention was employed.

It is crucial to encourage the students to analyze problems before they respond as it promotes deeper analytical thinking. Applying different strategies would help the students explore more ways to solve the problems. Materials given to the students also play an important role as these cognitive strategies affects their learning [23]. Ref [24] opened some ideas on students' mathematics learning that the students also appreciate connecting what they have learned to real-life situations and question themselves to understand the concepts better. It is also acknowledged that memorization is still found to be useful by the students especially when suing formula in solving problems. Furthermore, allowing students to communicate with their peers through arguments and explanations developed their reasoning and have a positive effect on their cognitive engagement.

3.5. Analysis of Covariance of Students' Problem-Solving Skills

On the posttest, with an F-value of 7.496 and a p-value of .008 ($p<0.05$), suggests that the groups differ in their impact on the posttest scores. That is, the mean posttest score of DIL group which is 21.76 is significantly higher compare to those non-DIL group with a mean score of 17.16.

On the retention test, with an F-value of 10.749 and a p-value of .002 ($p<0.05$), suggests that the groups differ in their impact on the retention test scores. That is, the mean of retention test score of DIL group which is 24.62 is significantly higher compare to those non-DIL group with a mean score of 19.27.

This also implies that digital interactive learning has a significant impact on students' problem-solving skills in mathematics in terms of posttest and retention test. Indicating that digital interactive learning has significantly improved the students' problem-solving skills compared to those that are exposed to non-digital interactive approach. Using the digital tools in class boosts their mathematics problem-solving skills compared to those in the non-DIL class.

With the current advancement of technology, utilization of different materials, applications, and websites are very helpful in aiding students. With the available resources, students can access their lessons any time to study. Teachers can also provide materials incorporating audio, pictures, and even videos. Utilizing digital tools have significantly improved students' learning and provided availability of resources to students anywhere due to wide access of digital information. Effective communication in class became an avenue to improve their learning through the aid of digital devices which in this study used Kahoot! as a digital tool for learning. This also paved way for students to access information and review their lessons, decreasing the limitations of learning just in the four walls of the classroom. Digital tools also affect the students' performance in class through promoting interaction and engaging students in real-world problems in a computer-based instruction in mathematics as it supports relevant mathematical situations based on the lessons. It provides learners with both visual and auditory channel for their learning. This also encourage the schools to improve computer equipment to provide better effects in mathematics classroom [25].

3.6. Analysis of Covariance of Students' Learning Engagement

Students' behaviorial engagement has an F-value of 0.229 and a p-value of 0.634 ($p>0.05$), this suggests that the groups does not differ in their impact on the post-test scores. The mean of post-test score of DIL group which is 2.82 is not significantly higher compare to those non-DIL group with a mean score of 2.87. For their emotional engagement, with an F-value of 1.548 and a p-value of 0.217 ($p>0.05$), suggests that the groups does not differ in their impact on the post-test scores. The mean of post-test score of DIL group which is 2.66 is not significantly higher compare to those non-DIL group with a mean score of 2.63. For students' cognitive engagement, with an F-value of 2.563 and a p-value of 0.114 ($p>0.05$), suggests that the groups does not differ in their impact on the post-test scores. That is, the mean of post-test score of DIL group which is 2.87 is not significantly higher compare to those non-DIL group with a mean score of 2.96.

Although using digital tools increase their engagement, there are also alternative ways to make students work in their tasks promoting their participation in class. It must also be acknowledged that both groups are exposed to interactive learning environment and are provided with the same activities but with the use of different materials. This allows both groups to experience and learn the same lessons throughout the duration of this study. The teacher was also able to give the same amount of support and encouragement to the non-digital interactive class.

4. CONCLUSION

With the findings of this study, the following conclusions were drawn: (1) Before exposure to interactive learning approach, both DIL and non-DIL groups have similar problem-solving skills with students mostly on the very low level. After the students were exposed to interactive learning, both groups exhibit improvement with students even having reach a high-level problem-solving skill. (2) The students have shown fair engagement in mathematics class in terms of behavioral, emotional, and cognitive engagement before and after the intervention. (3) Students exposed to DIL have significant improvement of problem-solving skills than those in non-DIL class. (4) Students exposed to DIL have not shown any significant difference in behavioral, emotional, and cognitive engagement after the intervention. There are approaches and educational resources that may help the students improve their problem-solving skills and engagement in mathematics. May the findings of this study be used for future explorations on interactive learning approach and framework for crafting strategies that develops holistic mathematics learning of students.

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