ENHANCING STUDENT PERFORMANCE AND ENGAGEMENT IN MATHEMATICS VIA PEERAGOGY

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ABSTRACT: *Peeragogy is a collection of the best practices of effective peer-learning and teaching utilizing technology. This pilot study examined the mathematics performance and engagement of students via Peeragogy at Central Mindanao University Senior High School. It aimed to: (a) find out the level of students' academic performance when exposed to Peeragogy and those exposed to non-Peeragogy in terms of pretest, posttest, and retention test; (b) determine the level of students' engagement in Mathematics when exposed to different pedagogy in terms of, pre-test scores, and posttest scores; (c) compare the academic performance of students in these two groups in terms of their posttest scores and retention test scores; (d) differentiate the level of students' engagement in mathematics when exposed to different interventions. The study made use of the quasi-experimental research design. It was conducted at Central Mindanao University Senior High School with the Grade 11 students as participants. The students' academic performance and engagement in Mathematics were gathered using validated instruments to answer the research problems. Results showed that students have performance ranging from very low performance in the pretest to low or moderate performance in the posttest and retention test. Analysis of Covariance (ANCOVA) revealed that a significant difference existed in students' performance in terms of posttest as well as retention test while no significant difference was found in their engagement in Mathematics. Students in the Peeragogy group performed better in the posttest and retention test, however, both groups were comparably engaged in learning Mathematics.*

Keywords: *academic performance, engagement, mathematics, peeragogy, senior high school*

1. INTRODUCTION

Mathematics is considered a very important subject because it is widely used in all spheres of human life [1]. That is why one more problem about learning Mathematics is that the students find it boring, very difficult, and uninteresting. They claim it has no importance to their lives because of the teachers' lack of teaching strategies that will let them think critically and apply the lesson learned in class in their real life.

Education has been transformed due to globalization. The changes in human life have prompted some educators to argue that the traditional teaching methodology is no longer enough for the learners. The 21st-century skills must be integrated into school to thrive in a rapidly evolving, technology-saturated world. Thus, in the 21st century, there is a need for teachers to learn to utilize technology to maximize instruction and enhance student learning. Hence, the goal of education nowadays is to develop the 21st-century skills such as critical thinking, creativity, collaboration, communication, information literacy, media literacy, technology literacy, flexibility, leadership, initiative, productivity, and social skills. It is not only student learning as the focus of instruction but in this generation, we need that our student will know how to use technology and encourage to use it in the learning process.

We need to engage in Education 4.0 where the use of technology-based tools and resources to drive education in non-traditional ways is encouraged [2]. Thus, learning is enabled anytime, anywhere as the e-learning tools and applications will provide opportunities for remote, self-paced learning. This means that students are no longer in traditional classrooms learning from teachers using textbooks, pens, and papers only. Instead, in Education 4.0, technology or devices are used by students to gain an education. While every subject has its own set of knowledge and information that the students can grasp, the road to attaining this knowledge can vary. This means that the students will be able to choose the tools and techniques through which they want to acquire this knowledge. Techniques like Peeragogy is one of the examples of Education 4.0 classroom.

Peeragogy is a collection of techniques for collaborative learning and collaborative work [3]. It deals with the transmission of knowledge from teacher to students with the help of technology, also the teacher allows the students to use the technology to connect with peers and gain insight from them, the students can evaluate their knowledge using technology, the students can enhance their creativity towards Mathematics, hence they can extend their knowledge and inculcate new idea. Moreover, promoting student engagement [4, 5], collaborative work [6], and participation in Mathematics is considered important for students' learning and subsequent study in Mathematics [7], which is also the core element in Peeragogy that the students will participate or engage in the instruction.

There are already several types of researches conducted to enhance students' performance. Researchers look into other student-related variables like self-efficacy [8, 9], students' beliefs [10], mathematics anxiety [11], and attitudes towards mathematics [12] and how these are improved while utilizing contemporary teaching methods using technology like self-blend approach [13] and flipped classroom [14]. However, these limited studies cannot give conclusive results on whether technology-enhanced teaching techniques will indeed improve students' performance in Mathematics in the region.

With the foregoing statements, the researchers felt the dire need to initially investigate the potential of Peeragogy to enhance students' academic performance and engagement in Mathematics. By then, a more comprehensive investigation will be conducted.

2. MATERIALS AND METHODS

The study assessed the performance and engagement in mathematics via Peeragogy at Central Mindanao University

Senior High School for SY 2019-2020. The study made use of quasi-experimental research design with two different intact classes. One of the two intact classes was set as the experimental group while the other class was the control group. The two groups of students were instructed with the same lessons. Students in the experimental group were exposed to the Peeragogy classroom instruction style while the control group was exposed to Non-Peeragogy.

There were two (2) instruments used to gather the data, namely, the student engagement questionnaire and the validated teacher-made test. One instrument used in the study was a matrix formed close-ended questionnaire that helped the researchers gathered the students' engagement in Mathematics. The questionnaire used was pilot tested in 2015 [15]. The questionnaire consisted of eight (8) cognitive engagement questions, eight (8) behavioral engagement questions, ten (10) emotional engagement questions and seven (7) social engagement questions with scaling rating that ranges from 5 to 1. Reverse scoring procedure was done for a negative statement. A validated teacher-made test was used to measure the mathematics performance of the students with 25 items covering the topics in continuity at a point and the continuity on an interval. Items were scored 1 for every correct response, and 0 if otherwise.

The participants of the study were the Grade 11 who are enrolled in the Academic Track with Science, Technology, Engineering, and Mathematics (STEM) strand with 50 in Peeragogy group and 47 in the non-Peeragogy group.

Before the start of the experiment, pretest on performance and engagement in Mathematics was administered to the students. The pilot experiment was conducted in one week during the third grading period. After the intervention, the students took again the same tests which served as the posttest. Two weeks after the posttest the researchers administered the retention of the students. The results of these tests were utilized to seek answers to the problems which were put forward in this investigation.

The data collected were tabulated and analyzed using appropriate statistical tools using software. Descriptive statistics like mean, standard deviation, frequency, and percentage were used to answer the questions on the descriptive levels. Analysis of Covariance (ANCOVA) was used to investigate the significant difference in the students' engagement and performance in Mathematics between the two groups.

The following rating scale was used to better understand the data:

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	4.51 – 5.0	Strongly agree	Highly Engaged (HE)
4	3.51 – 4.50	Agree	Engaged (E)
3	2.51 – 3.50	Undecided	Fair Engaged (FE)
2	1.51 – 2.50	Disagree	Less Engaged (LE)
1	1.00 – 1.51	Strongly disagree	Not Engaged (NE)

Score	Percentage score	Descriptive rating	Interpretation
0 – 12	74% and below	Beginning	Very Low
13 – 15	75% - 79%	Developing	Low
16 – 18	80 – 85%	Approaching Proficiency	Moderate/Average
19 – 20	86 – 89%	Proficient	High

3. RESULTS AND DISCUSSIONS

This section presents the analysis and interpretation of data gathered from the students' scores relevant to testing the hypothesis of the study. The order of presentation follows the arrangement of the problems identified and presented for this research.

3.1 Mathematics Performance of the Peeragogy and Non-Peeragogy Group

The Mathematics performance of the students exposed to Peeragogy and those exposed to Non-Peeragogy in terms of the pretest is presented in Table 1. As shown in the table, 2% of the students in the Peeragogy group had moderate performance, 12% had low performance and 86% had a very low performance in the pretest. On the other hand, 15% of the students in the Non-Peeragogy group had low performance and 85% had a very low performance in the pretest. The overall mean score of the Peeragogy group in the pretest is 9.90 which indicates a very low performance while the non-Peeragogy had an overall mean score of 9.21 which also specifies a very low performance.

Table 1. Student Performance in Mathematics between two groups in terms of Pretest.

Range	PEERAGOGY			Non-Peeragogy		
	f	%	Interpretation	f	%	Interpretation
90% - 100%			Very High			Very High
86% - 89%			High			High
80% - 85%	1	2%	Moderate			Moderate
75% - 79%	6	12%	Low	7	15%	Low
65% - 74%	43	86%	Very Low	40	85%	Very Low
	Mean = 9.90 (Very Low)			Mean = 9.21 (Very Low)		

The result of this study shows that both groups had a very low level of performance in the pretest. This implies that students in both groups have little or no prior knowledge of the concepts of continuity before the conduct of the experiment.

Some researchers found out that students have very low performance before the conduct of the study [16, 4, 5, 6]. It implicates further that students never exposed themselves to topics in Mathematics independently.

Table 2 shows the Mathematics performance of the students exposed to Peeragogy and Non-Peeragogy in terms of the posttest. It can be seen in Table 2 that 6% of the students in Peeragogy group had very high performance, 36% had high performance, 30% had moderate performance, 20% had low performance and 8% had a very low performance in the posttest.

Table 2. Student's academic performance in Mathematics when exposed Peeragogy and Non-Peeragogy in terms of Posttest.

Range	PEERAGOGY			Non-Peeragogy		
	F	%	Interpretation	f	%	Interpretation
90% - 100%	3	6%	Very High	1	2%	Very High
86% - 89%	18	36%	High	6	13 %	High
80% - 85%	15	30%	Moderate	11	23 %	Moderate
75% - 79%	10	20%	Low	15	32 %	Low
65% - 74%	4	8%	Very Low	14	30 %	Very Low
		Mean = 17.26 (Moderate)			Mean = 14.13 (low)	

On the contrary, 2% of the students in the non-Peeragogy group had very high performance, 13% had high performance, 23% had moderate performance, 32% of the students had low performance and 30% had very low performance in the posttest

The overall mean of Peeragogy group in the posttest is 17.26 which indicates a moderate performance while the non-Peeragogy group had an overall mean score of 14.13 which specifies a low performance.

Results imply that students in both groups learned continuity topics as evidenced by the increased mean scores in their posttest. While some students showed improved performance after the intervention [8], others did not show such substantial increased [9, 14].

The mathematics performance of the students exposed to Peeragogy and non-Peeragogy in terms of retention test is presented in Table 3. It can be gleaned that 14% of the students in Peeragogy group had high performance, 42% had moderate performance, 34% had low performance and 10% had a very low performance in the retention test. On the other hand, 11% of the students in the non-Peeragogy group had high performance, 17% had moderate performance, 32% had low performance and 40% had a very low performance in the retention test. The overall mean score of the Peeragogy group in the retention test is 15.60 which indicates a moderate performance while the non-Peeragogy group had an overall mean score of 13.5 which shows a low performance.

The mean scores of the students in the retention tests indicate that students did not retain all the lessons they learned. With the decreasing mean from the posttest, it signals low retention skills among students [13], which is anticipated to increase with the use of technology [4].

Table 3. Student Performance in Mathematics between two groups in terms of Retention test.

Range	PEERAGOGY			Non-Peeragogy		
	F	%	Interpretation	f	%	Interpretation
90% - 100%	0	0	Very High	0	0	Very High
86% - 89%	7	14%	High	5	11%	High
80% - 85%	21	42%	Moderate	8	17%	Moderate
75% - 79%	17	34%	Low	15	32%	Low
65% - 74%	5	10%	Very Low	19	40%	Very Low
		Mean = 15.60 (Moderate)			Mean = 13.5 (low)	

3.2 Students' Engagement in Mathematics before and after the intervention

Table 4 shows the Students' Engagement in Mathematics between the Peeragogy and Non-Peeragogy before and after the intervention period. In the pretest, students in Peeragogy group rated "agree" on the 17 items, "undecided" on 15 items and "disagree" on 1 item. However, students in the non-Peeragogy group rated "agree" on 26 items and "undecided" on 7 items among the 33 items. These results reveal that students in the Peeragogy group tried to understand their mistakes when they get something wrong (4.32; highest mean), they liked working with classmates (4.28), and they wanted to understand what is learned in mathematics class (4.28), as the first three (3) important things they did to be engaged in Mathematics. On the other hand, students in the other group wanted to understand what is learned in mathematics class (4.47, highest), they kept trying even if something is hard (4.40) and they tried to understand their mistakes when they get wrong (4.30), got the first three highest means. Even if students in both groups differ in their ways of perceiving the things they did in mathematics class, nevertheless, both groups showed they were engaged in their classes.

Also reflected in table 4 are the three (3) items with lower means in the Peeragogy and non-Peeragogy groups. Students in the Peeragogy group perceived that they were not often frustrated in math class (2.48), they just did enough to get by (2.62), and they felt good when they were in mathematics class (2.9). These are the three indicators with lowest means. While in the non-Peeragogy group, they were often frustrated in mathematics class (rev) (2.72), they just did enough to get by (rev) (2.79) and when work is hard, they only study the easy parts (2.83) had the lowest means.

These findings show that students from different groups have varied perceptions on how they were engaged in their mathematics class. Consequently, they had different perceived feelings of being in the class. However, both showed positive engagement in the mathematics instruction.

Students are positively engaged in Mathematics when they try their best to learn especially when they found out that they need to correct their misconceptions in the subject [4]. They are more engaged in the subject when they have classmates or peers to work with them in whom they liked [4, 5]. Subsequently, they are trying to involve themselves when things get hard in the mathematics class [5]. However, it is also possible that students may be disengaged in Mathematics [17].

Table 4. Student's Engagement in Mathematics between Peeragogy and Non-Peeragogy before and after the intervention.

Engagement in Mathematics	PEERAGOGY Before		PEERAGOGY After		Non-PEERAGOGY Before		Non-PEERAGOGY After	
	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation
I go through the work for math class and make sure that it's right.	3.56	E	3.79	E	3.88	E	3.94	E
I think about different ways to solve a problem.	3.52	E	3.68	E	3.58	E	3.74	E
I try to connect what I am learning to things I have learned before.	3.86	E	4.11	E	3.84	E	4.06	E
I try to understand my mistakes when I get something wrong.	4.32	E	4.30	E	4.14	E	4.40	E
I would rather be told the answer than have to do the work (rev).	3.02	FE	3.00	FE	3.2	FE	3.23	FE
I don't think that hard when I am doing work for class (rev).	3.24	FE	2.87	FE	3.36	FE	3.04	FE
When work is hard, I only study the easy parts (rev).	3.18	FE	2.83	FE	3.52	E	3.26	FE
I do just enough to get by (rev).	2.62	FE	2.79	FE	3.18	FE	2.91	FE
I stay focused.	3.64	E	4.02	E	3.68	E	4.04	E
I put effort into learning math.	3.86	E	4.15	E	4	E	4.21	E
I keep trying even if something is hard.	4.1	E	4.40	E	3.94	E	4.19	E
I complete my	3.26	FE	3.96	E	3.34	FE	3.91	E

homework on time.								
I talk about math outside of class.	3.04	FE	3.49	FE	3.1	FE	3.53	E
I don't participate in class (rev).	3.44	FE	3.87	E	3.38	FE	3.83	E
I do other things when I am supposed to be paying attention (rev).	3.52	E	3.32	FE	3.46	FE	3.57	E
If I don't understand, I give up right away (rev)	3.48	FE	3.83	E	3.6	E	3.91	E
I look forward to math class.	3.16	FE	3.81	E	3.32	FE	3.72	E
I enjoy learning new things about math.	3.32	FE	4.02	E	3.44	FE	4.02	E
I want to understand what is learned in math class.	4.18	E	4.47	E	4.18	E	4.40	E
I feel good when I am in math class.	2.9	FE	3.51	E	3	FE	3.55	E
I often feel frustrated in math class (rev).	2.48	LE	2.72	FE	2.98	FE	2.70	FE
I think that math class is boring (rev).	3.42	FE	3.81	E	3.62	E	3.96	E
I don't want to be in math class (rev).	3.4	FE	4.09	E	3.76	E	4.11	E
I don't care about learning math (rev).	4.04	E	4.06	E	3.76	E	4.45	E
I often feel down when I am in math class (rev).	3.1	FE	3.70	E	3.38	FE	3.91	E
I get worried when I learn new things about math (rev).	3.82	E	3.53	E	3.62	E	3.72	E
I build on others' ideas	3.44	FE	3.83	E	3.7	E	3.89	E
I try to understand other people's ideas in math class.	3.94	E	4.09	E	3.94	E	4.30	E
I try to work with others who can help me in math.	4.16	E	4.23	E	4.16	E	4.40	E
I try to help others who are struggling in math.	3.64	E	4.09	E	3.6	E	3.94	E
I don't care about other people's ideas (rev).	4.1	E	3.60	E	4.06	E	4.26	E
When working with others, I don't share ideas (rev).	3.96	E	3.72	E	4.02	E	4.30	E
I don't like working with classmates (rev).	4.28	E	4.02	E	4.12	E	4.40	E
Overall Mean Interpretation	3.55	E	3.75	E	3.63	E	3.87	E

(rev) means scoring is reversed

Legend:

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	4.51-5.00	Strongly Agree	Highly Engaged (HE)
4	3.51-4.50	Agree	Engaged (E)
3	2.51-3.50	Undecided	Fairly Engaged (FE)
2	1.51-2.50	Disagree	Less Engaged (LE)
1	1.00-1.50	Strongly Disagree	Not Engaged (NE)

After the intervention, students perceived their engagement in Mathematics differently. In the Peeragogy group, students agreed on 21 items, while undecided on the 12 items. Conversely, students in the non-Peeragogy group agreed on 28 items and undecided on 5 items only.

Students in the Peeragogy group claimed that they wanted to understand what is learned in mathematics class (4.18), tried to work with others who can help them (4.16), and tried to understand their mistakes when they get something wrong (4.14) received the highest means. These findings imply that students realized that working with others who can help them is essential in mathematics class. Exposure to Peeragogy has the potential to allow students to shift their perspective on collaboration and peer learning.

On the other hand, the three (3) items with higher means in the non-Peeragogy group include they cared about learning mathematics (4.45), tried to understand their mistakes when they get something wrong (4.40), and liked to work with classmates (4.40). Realizing that working with others is very necessary was also acknowledged by the group who were not exposed to peer learning. The absence of group activities may make students realized its importance.

The overall mean score of students' engagement in Mathematics after intervention indicated that both groups had been engaged in their mathematics classes unlike another research findings [17]. The results further implicate that students become positively engaged in Mathematics with the help of another person [18], they can gain knowledge with their peers when they socialized with them [5]. Also, students are more engaged in Mathematics when they feel that it is challenging for them, by this they put more effort to study well [4]. More especially students don't get easily give-up when they got the wrong answer but rather, they make an action to correct themselves [4, 5].

3.3 Analysis of Covariance (ANCOVA) of Posttest Results between Treatments

Table 5 shows the Analysis of Covariance (ANCOVA) of Posttest results between treatments. As shown in the table, the pretest was used as a covariate to statistically equate dissimilar prognostic variables which may influence the analysis. The F-value between groups is 19.676 with the probability value of 0.000($p< 0.05$) indicating a highly significant difference, thus the null hypothesis that there is no significant difference in students' performance in terms of posttest is rejected. This means that Peeragogy group with mean 17.26 performed better than the non-Peeragogy with mean 14.13. This result indicates further that Peeragogy showed great potential to enhance students' performance in Mathematics.

Table 5. Comparison of students' performance on the posttest.

GROUP	N	MEAN	SD
PEERAGOGY	50	17.2600	2.81983
Non-PEERAGOGY	47	14.1277	3.80284
TOTAL	97	15.7423	3.66935

Source	SS	df	MS	F-value	Sig.
Group	218.208	1	218.208	19.676	0.000**
Pre-test	12.378	1	12.378	1.116	0.293
Error	1042.476	94	11.090		
Total	25331.000	97			

**P< Highly Significant at 0.01 level

Similar studies using technology to possibly enhance students' performance and achievement were also successful [4, 14]. This pilot study utilizing Peeragogy also made some impending possibilities to increase student learning outcomes. While other local studies failed to show the possibility of incorporating contemporary techniques in assessment [9], few researchers find it noteworthy to investigate such innovative methods in teaching [5, 10] and evaluation of learning [15].

3.4 Analysis of Covariance (ANCOVA) of Retention Test Result between Treatments

Table 6 (on page 157) shows the analysis of covariance (ANCOVA) of retention test results between treatments. As presented in the table, the F-value is equal to 7.759 with a p-

value of 0.006 ($p < 0.05$) between groups which indicates a high significance difference, thus the null hypothesis that there is no significant difference in students' performance in terms of retention is rejected. This means that Peeragogy group with mean 15.60 retained their learning better than the non-Peeragogy group with mean 13.62. This specifies that this teaching technique has the potential to improve the retention skills of the student in learning Mathematics.

This finding differs from other local studies when researchers found that innovative learning did not show a significant difference in the retention test scores of the students such as gradual release instructional model [8], and flipped classroom [14]. Conversely, the finding confirms that indeed inclusion of technology in the mathematics class may improve retention of students' learning [5, 13].

Table 6. Comparison of students' performance on the retention test.

GROUP		N	MEAN		SD
PEERAGOGY		50	15.60		2.96923
Non-PEERAGOGY		47	13.62		3.46130
TOTAL		97	14.64		3.35157
Source	SS	df	MS	F-value	Sig.
Group	78.404	1	78.404	7.759	0.006**
Pre-test	33.306	1	33.306	3.296	0.73
Error	949.800	94	10.104		
Total	21866.000	97			

** P< Highly Significant at 0.01 level

3.5 Analysis of Covariance (ANCOVA) of Students' Engagement in Mathematics between Two Groups

Table 7 presents the comparison of engagement of students who were exposed to two varied interventions. The mean posttest score of the Peeragogy group in terms of engagement is 3.75 with a standard deviation of 0.415 while the non-Peeragogy group has a mean score of 3.87 with a standard deviation of 0.446. As seen in the table, the F-value is 8.702 and the p-value is 0.440 implying that there is no significant difference in the engagement of two groups exposed to Peeragogy and non-Peeragogy. Thus, the null hypothesis, stating that there is no significant difference between the engagement of the students in Mathematics when exposed to Peeragogy and Non-Peeragogy is not rejected. This result further implicates that students in both groups had a similar level of engagement in Mathematics.

Table 7. Comparison of students' Engagement between groups

GROUP		N	MEAN		SD
PEERAGOGY		50	3.75		0.415
Non-PEERAGOGY		47	3.87		0.446
TOTAL		97	3.75		0.456
Source	SS	df	MS	F-value	Sig.
Group	1.520	1	1.520	8.702	0.440
Pre-test	1.190	1	1.190	6.809	0.011
Error	16.423	94	0.175		
Total	1407.732	97			

*P< Significant at 0.05 level

Students' engagement in Mathematics after intervention indicated that both groups were comparably engaged in their mathematics classes. It shows that regardless of teaching techniques, students engaged themselves in Mathematics with the help of another person [18], and most of all Filipino students are more engaged in Mathematics when they feel that it is challenging for them, by this they put more effort to study well [4], unlike African who disengaged themselves in learning the subject [17].

CONCLUSIONS AND RECOMMENDATIONS

Based on the above findings, the conclusions were drawn as follows:

Students have a very low to moderate level of performance in Mathematics for the Peeragogy group while very low to low performance for the non-Peeragogy group in the pretest and posttest, respectively. Students in both groups have decreasing mean indicating retention of only a few topics in continuity.

Students in Peeragogy group perform better in Mathematics and they tend to retain more learnings on continuity than those exposed to non-Peeragogy. Students in both groups are positively engaged in their mathematics classes.

Based on the aforementioned conclusion, mathematics teachers are encouraged to update themselves on the 21st century teaching techniques especially on utilizing technology to maximize instruction and improve students' engagement. A similar study may be conducted in a longer period to determine further the potential of Peeragogy to improve the engagement of students in mathematics classes. Other essential variables like 21st-century skills may be included as one of the dependent variables.

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