Docens Series in Education
ISSN 2583-1054

Christian Laro Salazar, 2022

Volume 3, pp. 71-92

Received: 03rd February 2022

Revised: 23rd May 2022, 15th June 2022, 12th July 2022

Accepted: 13th July 2022

Date of Publication: 20th July 2022

DOI-https://doi.org/10.20319/ dv3.7192

This paper can be cited as: Salazar, C. L., (2022). Influence of Productive Struggle in Mathematics to the 21st Century Learners. Docens Series in Education, 3, 71-92.

INFLUENCE OF PRODUCTIVE STRUGGLE IN MATHEMATICS TO THE 21st CENTURY LEARNERS

Christian Laro Salazar
Secondary School Teacher III, Department of Education, City Schools Division of Tandag
Tandag National Science High School, City of Tandag, Philippines
christian.salazar@deped.gov.ph

Abstract

This study dealt with finding the influence of productive struggle in Mathematics to 21st-century learners. Furthermore, it aimed to determine the problems encountered by the learners when they are exposed to activities that promote productive struggle. This study utilized the quasi-experimental pre-test post-test design. It has been found out that productive struggle is extremely influential to 21st-century learners for it has helped them to be motivated in managing to improve their skills in mathematics. Furthermore, it was found out in this study that the problem that most of the learners encounter when they are in productive struggle is the fact that they cannot finish the activity within a given amount of time. Findings revealed that there is a significant difference in the achievement test scores of the learners with and without activities that promotes productive struggle. In addition, it has also been found out that there is a significant interaction between the achievement test scores of the learners in the experimental group if they will be classified according to their mental capacity. Therefore, independent learning using activities that promote productive struggle is found to be more effective than the conventional lecture method.

Keywords

Activities, Influence, Productive Struggle, Promotes

1. Introduction

Perseverance is a fundamental component in problem solving on the grounds that the first or second approach or strategy may not bring about in a reasonable solution. When students get engaged in a task, they must be mindful about the strategy they use and evaluate whether it is productive or not. When they find they are at an impasse, they should be willing to surrender one strategy for another. When students' make an effort and struggle but continue to pursue to try to comprehend a problem, they are engaging in productive struggle (Kang, 2007). This study is all about productive struggle wherein it is developing strong propensities for mind, such as perseverance and thinking flexibly, simply seeking the correct solution.

As stated by Kang (2007), productive struggle requires that teachers will provide non-routine problems that cannot be solved with a formula, and this is supported by Boaler (2014), for him it is a method of bringing students outside their comfort. Problems that support productive struggle allow room for exploration and inquiry rather than route exercises that require application of already known procedures. These exercises tend to foster practice of skills and encourage the use of a particular algorithm. Encouraging students to make sense of the problem, understand it, and devise plans for how to solve it mathematically is the key in establishing an environment that supports productive struggle (Kang, 2007). In agreement with Abiola and Dhindsa (2012), effective teachers support this process by "encouraging children to make discoveries in well planned environments that support student autonomy". Brownwell and Sims (1946) argued that students must have opportunities to "muddle through" in the process of resolving problematic situations rather than conditioning students through repetition. More recently, Hiebert & Wearne (2007) stated, all students have to undergone struggle with brain stimulating problems if they want to learn mathematics deeply.

Although the circumstance 'struggle' may be internal, it can also be experiential in most classrooms. In the context of classroom interactions, students may voice disarray over directions, the wording of a problem, the inquiry being posed or how to develop a strategy. Students may voice a remark for instance, "I don't get it". A teacher may identify students' misguided judgements that yield contending claims, uncertainty, and intellectual clash in the students'

thinking. An error while solving a problem may lead to a nonsensical answer that astounds a student. A student may be very engaged in working on a mathematics problem but then arrive at an impasse and get "stuck". These things were observed in the Grade 8 students of Tandag National Science High School in which the researcher believed to be one of the reasons of the low Quarterly Mean Percentage Score (MPS), where in fact they got 63.20 in the third periodical examination which is far from the 75% target of the 2019-2020 Annual School Improvement Plan. Therefore, it is crucial to immediately find a proof and solution to this knowledge gap.

Such being the case, it is crucial to determine the influence of productive struggle to the 21st century learners. It is equally important to investigate the influence of productive struggle in order to figure out what problems are encountered as the students are involve in productive struggle. It is hoped that by omitting or at least reducing those problems, teachers, can create a more relaxing environment, so that more effective Mathematics learning would take place. Moreover, it is hoped that with this paper, concrete evidence on the practicality of the said strategy would be produced. More importantly, appropriate suggestions may be initiated to enhance the mathematical pedagogy. Having deemed of this necessity, the researcher finds the need to pursue this study.

2. Literature Review

Students' intellectual effort is a natural part of the learning process. Students' struggles take place when they try to expand their understanding of mathematics concepts that are challenging but are beyond their capabilities. With this, the struggles that the students have been experiencing have been viewed as a negative one or seen as a problem in the mathematical classrooms (Hiebert and Grouws, 2007). However, some have viewed these struggles as a silver lining and have transformed them into productive ones.

A productive struggle, as defined, is an instructional method used by teachers to help students solve math problems using their own thinking and reasoning skills (Murdoch et al., 2020). As mentioned by Daily (2021), productive struggles help students understand key concepts, determine where and how errors occur, and how they can fix them using their own thinking and reasoning skills. In the absence of productive struggle instruction, students may be reluctant to work towards developing a deeper understanding of math concepts. With this, math may continue

to be a challenge for students who do not perceive themselves as being competent in math if they do not gain a deeper understanding of mathematical concepts.

On the other hand, in the presence of productive struggle instruction, students could achieve great results. According to Permatasari (2016), teaching mathematics that utilizes the productive struggles of the students will result in great benefits. When students are given opportunities to understand right from the start and work to acquire an understanding, they are more likely to receive rewards that keep them from becoming more involved. In short, utilizing students' struggles can be a great avenue to help them harness their understanding of the concepts of math and achieve great results.

In addition to that, Warshauer (2014) suggests that student struggle can support student learning with understanding and support "doing mathematics." He created a classification structure for describing student struggles and teacher responses, with descriptions of the types of struggles and responses that arose. Additionally, the study identified and analyzed how teaching supports struggles productively.

In the year 2010, Kapur mentioned that there are three conditions that encourage a useful or productive struggle. The learning process should include (1) choosing problems to work on that are challenging without getting frustrated, (2) giving learners the chance to explain and elaborate on what they're doing, and (3) allowing learners to weigh in on the solutions that are good and bad.

Meanwhile, Granberg conducted a study regarding the struggles encountered by students when they encounter errors and difficulties during problem-solving in the year 2016. In this study, it was found that students erroneously construed new knowledge when they were given incorrect prior knowledge. Each participant was engaged in superficial, unproductive struggles between episodes of Schoenfeld's book. After engaging in several of Schoenfeld's episodes, they managed to reconstruct useful prior knowledge and construct correct new knowledge. Despite the overwhelming odds, the majority of students managed to turn their struggles into productive ones.

Aside from that, socio-mathematical norms can also be a driving force in the productive struggle. According to Middleton (2015), in the process of engaging in the social activity of doing mathematics, students tend to compare themselves to what they perceive to be the norms of competence in their classes and construct sets of "stories" in their minds that define their own proclivities and handicaps. Students also tend to think that perseverance is something that some are skilled at rather than something that everyone can learn. As a means of perseverance, one must

understand that a struggle that may inevitably be a part of solving a problem is an opportunity to learn (Star, 2015). For them to understand that struggle is just part of the process, teachers can be a great help to that.

According to Warshauer (2011), as cited by Pasquale (2015), there are four strategies that teachers can employ to be able to promote students' productive struggle. These are: (1) when a student struggles, teachers could ask questions which help him or her focus on the source of the problem and identify other ways to approach it; (2) students are encouraged to reflect on their work, and teachers support students who are having difficulty with their effort rather than only getting the right answers; (3) when students face adversity and failure, teachers give time and try not to intervene too soon or help too much; and (4) mathematics teachers recognize the value of struggle in learning and doing mathematics. These strategies will provide the teachers with the means to enable the productive efforts of students' struggles.

Aside from the students' struggles, the teachers' attitudes towards students' struggles were also given emphasis, and a study conducted by Russo (2021) is one of the examples. His study investigates the attitude of the teachers towards students' struggles in learning mathematics in a remote learning setting. In the context of a professional learning initiative focused on teaching mathematics through sequences of challenging tasks, 82 Australian early years primary teachers completed a questionnaire comparing the two settings, namely the remote and classroom learning settings. The results have shown that teachers in classroom-based settings were more positive about the importance of student struggle than those in remote learning environments. In a remote learning setting, teachers had four important reasons to believe that supporting productive struggle would be problematic: an absence of a teacher-facilitated, synchronous, learning environment; parents' negative attitudes towards difficulty when learning mathematics; a lack of social connections and peer collaboration; and difficulty accessing learning materials.

Another study regarding teachers' productive struggles was conducted by Trinter & Hughes (2021). This study examined the experiences of teachers who served on design teams that developed interdisciplinary curriculum units while supported by a researcher-practitioner partnership and working in a school structure that valued teachers' involvement in curriculum design. Throughout the process, teachers experienced productive struggle and were less likely to offload or adapt their curriculum than to improvise it. Also, this study found that creating

experiences tailored to the particular needs of their middle school students can be better accomplished if the teachers themselves design the experiences.

Aside from the teachers and students, parents were also involved in the process. They are involved because they helped their children do their homework and helped improve their mathematical ability. In a study conducted by Vasquez et al. (2020), it was found that parents must deliberately facilitate student-centered experiences to ensure productive struggle occurs. Specific homework-related behaviors should be emphasized in programs targeting parents, rather than generalizations about how to increase involvement. As well as providing parents with guidance, schools and educators should also explain how gender stereotypes and parents' own math anxiety can harm students and ways to limit homework interaction while students struggle with difficult problems.

Students do need time to solve these mathematical problems. In addition to the time needed for solving mathematical problems, they should also be given ample time to develop genuine curiosity (Goldenberg, 2015). With that being said, Zeybek (2016) then concluded that teachers should really be careful in choosing tasks that do not only require students to struggle but also to develop curiosity. Tasks chosen should not lead students down a narrow path to one correct solution, but rather provide a range of options and provide them with the support they need without reducing their cognitive demands.

Teachers must also cultivate a classroom culture in which struggle is seen as a normal part of learning (Star, 2015). In this way, students will be able to see their potential and will be motivated to persevere until they succeed. In the end, creating situations involving uncertainty in the classroom is a powerful way to enhance learning in mathematics, so schools should make use of this potential in their lessons (Zaslavsky, 2005).

3. Research Questions

This study aimed to find out the Influence of Productive Struggle in Mathematics of to the 21st Century Learners.

In particular, it seeks to find answers to the following questions:

1. What is the mean score of the learners with or without using activities that promotes productive struggle?

2. What is the level of influence of using activities that promotes productive struggle in Mathematics 8?

3. What problems were encountered in the use of activities that promotes productive struggle in Mathematics 8?

4. Is a difference on the achievement test scores of the students with and without the activities that promotes productive struggle?

5. Is there a significant interaction on the achievement test scores of the students and their mental capacity?

6. What intervention program can be proposed as an output of the study?

3.1. Hypotheses

The study is guided with the following hypotheses:

Ho_1: There is no difference on the achievement test scores of the students with and without the activities that promotes productive struggle.

Ho_2: There is no significant interaction on the achievement test scores of the students and their mental capacity.

4. Method and Design

In this study, the researcher utilized the quasi-experimental pre- test post-test design to determine the Influence of Productive Struggle to the 21st Century Learners. In this design, two groups of students were involved: the experimental group and the control group. Two intact classes were utilized in the study. A pre-test post-test design is an experiment where *measurements are taken both before and after a treatment.* The design was utilized in this study so that the researcher will be able to see the effects of the treatment on the experimental group.

4.1. Research Locale and Research Subjects

The study took place at Tandag National Science High School. It is a high school system of secondary public sciences in the City of Tandag in Surigao del Sur, Caraga, (Region XIII), which caters Grade 7- 12 students. The subjects of this study were the Grade 8 students who are enrolled at Tandag National Science High School for the school year 2019- 2020. There are two sections (Grade 8 – Elion and Grade 8 – Euclid) and there are approximately twenty- three (23) students in each class. One section was randomly assigned as the experimental group and the other section was the control group. Out of this number, only forty- four (44) was considered as the

subjects of the study because the maximum number of students in one of the sections is twenty-two (22). The twenty- two (22) subjects in each group were chosen according to their general average in Mathematics subject from first quarter to the third quarter of the same school year to ensure that the two groups are comparable.

5. Results

This chapter presents the data gathered from the sets of instruments administered to the Grade 8- students of Tandag National Science High School. The data gathered are herein presented, analyzed and interpreted following the sequence of the statement of the problem.

5.1. Mean Scores of Pre-Test and Post- Test of the Two (2) Groups

The table below showed the mean scores of the pre-test and post-test of the two controlled and experimental groups. Each group has been subdivided into two different groups which was based on their mental capacity (High Grades and Low Grades).

Table 1: *Mean Scores of Pre-Test and Post- Test of the Two (2) Groups*

Subjects of the Study	**Mean Score**	
	Pre- Test	**Post- Test**
Controlled Group		
High Grades	21.00	37.82
Low Grades	16.09	22.64
Experimental Group		
High Grades	20.64	41.73
Low Grades	16.64	37.82

(**Source:** *Self*)

Based on the table presented, we can see that the difference of the pre-test mean scores of the Controlled Group *(High Grades)* of 21.00 and Experimental Group *(High Grades)* 20.64 has only a difference of 0.36, while the Controlled Group *(Low Grades)* with a mean score of 16.09 and Experimental Group (*Low Grades)* with a mean score of 16.64 has a difference of 0.55. This denotes that during the conduct of the study the subjects are of equal knowledge when it comes to the topics in the 4th Quarter. The pre-test is conducted before the actual discussion of the topic to measure the level of learning that the subjects have in their past experience.

Furthermore, the table also showed the post-test mean score, it is evident that the Experimental Group has a higher mean score for High Grades (41.73) and Low Grades (37.82) compared to the mean score of the Controlled Group for High Grades (37.82) and Low Grades (22. 64). This implies that the use of activities that promotes productive struggle is more effective than that of traditional way of teaching Mathematics.

The results correspond with Andaya (2014), whereby the achievements in Mathematics are highly correlated to individual and educational factors, and moderately correlated with the management and assessment factors in the classroom. Individual factors and educational factors affect fundamental mathematical achievements greatly. The predictor number one is the educational factor which affects students' achievement in the field of Mathematics and the educational factor.

Moreover, the finding is also comparable to the study conducted by Capate and Lapinid (2015) that students have problems with the application of formats, properties, theorems and/or laws. Therefore, it is recommended that instruction be improved, automation practice be carried out, mastery and retention classes be initiated, explicit instruction be instructed and mathematics with pair assistance be taught.

Meyer (2010) also strongly supported the result, emphasizing that students do not simply become independent learners on their own. It is necessary to teach you how to learn by teachers' guidance. In order to do this, teachers should not concentrate more on traditional teaching method – the method of lecture. Mathematics teaching must be more process-oriented so that students do not become passive in the process of learning. Thus, making them lifelong learners: efficient self-employed learning depends on productive interactions between teacher and students.

On the basis of the result of the study, the used of activities that promotes productive struggle engaged the students in active learning, develop self-esteem and promotes academic achievement. Concepts learned independently are easy to be remembered.

The result further implied that students with high and low mathematical ability will achieve better through independent learning in teaching mathematics compared to the high and low levels of mathematical ability in which the teacher alone teaches through a lecture method of teaching.

5.2. Level of Influence of Productive Struggle

Table 2 showcased the results on the level of influence of productive struggle to the 21st century learners.

The table 2 showed that the use of activities that promotes productive struggle in teaching

Indicators	Weighted Arithmetic Mean	Adjectival Description	Rank
1. Productive Struggle builds on the knowledge I already have.	4.32	Extremely Influential	6
2. Productive Struggle exposes and discusses common misconceptions.	4.00	Very Influential	10
3. Productive Struggle uses my higher-order thinking skills.	4.50	Extremely Influential	4
4. Productive Struggle encourages my reasoning and critical thinking rather than 'answer getting'.	4.32	Extremely Influential	6
5. Productive Struggle uses rich and collaborative tasks.	4.14	Very Influential	9
6. Productive Struggle helps me create connections between topics.	4.32	Extremely Influential	6
7. Productive Struggle made me realize that I am capable of doing well in Mathematics with effort and perseverance.	4.18	Very Influential	8
8. Productive Struggle is a valuable opportunity in the classroom to deepen my understanding of Mathematics.	4.68	Extremely Influential	2
9. Productive Struggle creates a classroom climate where it is okay to make mistakes, respected, inspected and corrected.	4.59	Extremely Influential	3
10. Productive Struggle helps me to be motivated managing and trying to improve my skills in mathematics problem solving.	4.73	Extremely Influential	1
Total Weighted Mean	**4.38**	**Extremely Influential**	

Table 2: *Level of Influence of Productive Struggle*

(**Source:** *Self*)

mathematics is ***Extremely Influential*** with a weighted mean of 4.38. Moreover, the indicator 10 which states that Productive Struggle helps the subjects to be motivated managing and trying to

improve their skills in mathematics problem solving ranked 1st and got a mean score of 4.73 ***(Extremely Influential).*** Posamentier (2017) confirmed that one of the most effective ways of motivating students is to ask them to justify one of many relevant mathematical edifices.

Students should know the mathematical curiosity and be comfortable before calling on them to defend it. He added that Mathematics teacher should understand the fundamental motives of their students. The teacher can then take these motivations to maximize commitment and to make the teaching process more efficient. The development of artificial mathematics problems and situations can lead by the use of student motives and affinities.

On the other hand, indicator which states that Productive Struggle exposes and discusses common misconceptions ranked last with a mean score of 4.00 ***(Very Influential)***. The results of

Warshauer (2014) showed that fighting the misconceptions of the students seemed to be examples when deeply filled misconceptions were used to solve problems and not the misunderstandings or possible mistakes of their students due to carelessness.

This was when students shared their work and communicated during small group discussions or classroom discussions to other students or to teachers.

Teachers should often communicate that struggle, stimulates brain growth and helps to develop a growing attitude, in addition to providing challenging tasks (Boaler, 2014). It is recommended by the NCTM that teachers should offer opportunities for productive struggle, which is important and essential to learning understanding Mathematics (NCTM, 2014).

In order to allow for learning and understanding through productive struggle to occur, teachers must pose appropriate challenges which allow students to engage with the task, having a point of entry and some notion of where to begin.

In its research, Gray (2019) pointed out that an effective task enables students to determine whether answers are incorrect without knowing how they are responding and reflect or adapt methods accordingly. Learners should have a way of recognizing and assessing their progress on their own, so creativity is given priority. The problem is ideally structure so that partial answers are a vehicle monitoring progress. This is important to encourage productive struggle, as it promotes creativity in the thinking and reflection of students.

Finally, Kapur (2010) stressed that students must be offered opportunities to grapple with, struggle with and make sense of the content they study in order to foster meaningful and profound learning in Mathematics. Teaching that embraces and uses productive combat can have lasting benefits that enable learners to use their learning in and outside the school environment for new problems.

5.3. Problems Encountered in the Use of Productive Struggle

The table below showed the problems that were encountered by the subjects when they are immersed in activities that promotes productive struggle.

Table 3*: Problems encountered in the use of Productive Struggle*

Indicators	Weighted Arithmetic Mean	Adjectival Description	Rank
1. I got confused with the questions/problems, given by the teacher.	3.45	More Serious Problem	7
2. I have problem to understand the language in the question.	3.18	Serious Problem	9
3. I always make mistakes in managing the facts in the questions/problems.	3.55	More Serious Problem	5
4. I have difficulty in transforming the information concerned into meaningful mathematical sentences in order to answer the problem.	3.64	More Serious Problem	2
5. I do not verify terms of concepts, strategies, calculations, and answers.	3.09	Serious Problem	10
6. I cannot concentrate during the process of problem solving.	3.36	Serious Problem	8
7. I cannot finish the activity within the given amount of time.	3.68	More Serious Problem	1
8. I have difficulty in differentiating, relating and organizing information.	3.55	More Serious Problem	4
9. I always tend to give up easily and guess the answer without thinking process.	3.50	More Serious Problem	6
10. I do not like to read long and unclear questions.	3.59	More Serious Problem	3
Total Weighted Mean	**3.46**	**More Serious Problem**	

(**Source:** *Self*)

It can be gleaned from the table that problems encountered in the use of productive struggle got a weighted mean of 3.46 ***(More Serious Problem)***. The problem that majority of the subjects encountered was being unable to finish the activity in a given amount of time. They often struggle with the idea that they are given a problem or activity to be solved without a preview of the lesson, thus they resorted to trial-and-error method of getting an answers and oftentimes undergone series of steps in arriving to an answer in which they are not sure about.

Parallel to Gray (2019), the findings of this study indicated that time is a common prevention factor for productive struggle. It takes students longer than direct instruction or other teaching methods to struggle with the learning material through problem solving. Teachers may

not feel that there is sufficient time for students to expose themselves to such tasks and still stay on weekly, monthly, or daily plans. Although teachers prioritize being on a strict timetable to cover the entire curriculum, students are denied access to productive struggle opportunities.

"When you are out doing a job, in any business," said Ray Peacock, a research director at Philips Laboratories, United Kingdom. The works aren't maximum 45 minutes, they usually involve three-week dollops or one-day dollops or something, so you don't want the man you don't give up. Mathematics outside the classroom in the 'real' world isn't on that strict, it's not on the timeline but is still dealt with as such. As the time limits for classes and the pressures to stay on schedule, it is harder to plan and implement meaningful lessons that lead to productive struggle through problem solving. In order to move forward, teachers should consider using challenges, thinking and provoking issues that are similar to the presentation of mathematics outside the school instead of focusing on the time these tasks can take. A noble educational objective is to prepare students to solve problems independently, both in and outside the school environment.

Psychological time can, in accordance with a model of Caroll (Ionescu, 2015), act on intrinsic motivation, encouragement or inhibition in the constructive and destructive way, thus it becomes needed to construct time perspectives by setting goals or levels of aspiration. The way that people perceive and invest time reflects the results. Time is a major resource in learning.

As Castagno- Dysart and Matera (2019) noted it is necessary component of today's classrooms to engage students in perseverance and productivity. Teachers who apply productive struggle education policies know, however, that allowing their students 'to do the work' will encourage students to think, take risks and persist. Students who learn productive work believe in their ability to try and complete tasks that they may not be able to solve. Teacher can use strategies such as questioning, encouragement, time allocation, and admission to encourage students to pursue complex tasks. Giving students a rich range of opportunity to develop meanings out of experiences, in the context of unfamiliar mathematics, which challenge the way students think and act, increases the ability to make conceptual leap from concrete to abstract thinking.

5.4. Significant Difference on the Achievement Test Scores of the Students with or Without the Activities that Promotes Productive Struggle

The table below showed the significant difference in the achievement test scores of the students when they are taught with the use of activities that promotes productive struggle and without the use of activities that promotes productive struggle.

Table 4: *Difference on the achievement test scores of the students With or without the activities that promotes productive struggle*

Sources of Variations	T-Value	P-Value	Decision	Conclusion
Pre-Test (Controlled vs Experimental)	0.08	0.939	Failed to Reject H_O	There is no significant difference
Post-Test (Controlled vs Experimental)	6.29	0.000	Reject H_O	There is significant difference

(**Source:** *Self*)

Based on the table above, at 0.05 significance level, it showed that Pre-Test has a p-value of **0.939** which is greater than 0.05, thus we **failed to reject the null hypothesis.** Therefore, it can be concluded that there is no significant difference with the pre-test scores of the subjects in the controlled and experimental group. It can then be deduced that the scores are closely related to each other and thus giving an insight that during the conduct of the pre-test the subjects have equal knowledge on the lessons for the Fourth quarter.

On the other hand, the table above also showed that at 0.05 significance level, Post-Test has a p-value of **0.000** which is less than 0.05, thus we have to **reject the null hypothesis.** Therefore, it can be concluded that there is significant difference with the post-test scores of the subjects in the controlled and experimental group. This only means that the scores in the experimental group are higher compared to the scores in controlled group. It only shows that activities which promotes productive struggle is effective in increasing the scores of the students for they have almost the same level in understanding the concepts well, and that resulted to their high scores in tests.

National Council of Teachers of Mathematics (2014) emphasizes that a major part of Mathematics is a commitment to problem solving and working on mathematical tasks that can offer intellectual challenges to improve mathematical understanding and development for students. If Mathematics is a problem-solving process, it is important to stress challenges and productive difficulties faced during problem-solving as part of the learning process. Learning Mathematics using student struggles can be good ways to improve their Mathematics understanding so that it is effective.

Mathematics, on the other hand, is not only capable of performing, but can think logically, solve problems, and take decisions. Mathematics is a dynamic discipline, according to Warshauer (2014), involving problems, the search for solutions, ideas, conjectures, and reasoning in contrast to a static discipline, consisting of a structured system of facts, procedures and concepts which can only be memorized and re-learned.

However, because of how mathematics is publicly seen and dealt with, Mathematics can be discouraged because of the misrepresentation in school (Gray, 2019). Based on this perspective, even though mathematics educators and students want to improve understanding, they will not encourage failure by solving problems. It is thus important to accept for teachers to accept struggle and pass on this message as an important part of Mathematics learning. To activate and implement productive struggles, change practice in a culture would be necessary.

Lastly, Pasquale (2015) highlighted that teachers and students must cooperate to support the struggle in the classroom of Mathematics. Teachers need to carefully select the tasks that students need to struggle and provide the support they need without providing too much help. Wrong answers must not be considered to be failure but rather opportunities to explore, to grow and to learn to support students and to encourage them to continue. The error of the student is one of the cognitive approaches to understanding Mathematics as source of information in their understanding. Students need time to solve difficulties, as well as genuine curiosity and long-term endurance. In the Mathematics classroom they also influence their way of perceiving and approaching struggle. They can provide adequate guidance and support so that Mathematics can continue to understand and to reflect deeper mathematical concepts.

5.5. Significant Interaction of the Achievement Test Scores of the Students and Their Mental Capacity

The table underscored the findings on the significant interaction of the achievement test scores of the students when they are grouped according to their mental capacity. It can be gleaned on the table below, at 0.05 significance level, it showed that Controlled Group, both High Grades and Low Grades has p-values of 0.299 and 0.201 respectively, which is greater than 0.05, thus we *failed to reject the null hypothesis.*

Table 5: *Significant interaction of the achievement test scores of the students and their mental capacity*

Sources of Variations	T-Value	P-Value	Decision	Conclusion
Controlled Group (Pre vs Post)				
High Grades	0.345	0.299	Failed to Reject Ho	There is no significant interaction
Low Grades	0.418	0.201	Failed to Reject Ho	There is no significant interaction
Experimental Group (Pre vs Post)				
High Grades	0.616	0.000	Reject Ho	There is significant interaction
Low Grades	0.821	0.002	Reject Ho	There is significant interaction

(**Source:** *Self*)

Therefore, it can be concluded that there is no significant interaction within the controlled group if they will be sorted as to their mental capacity. It can then be inferred that regardless of the mental capacity of the students, all the subjects have almost the same level of difficulty in answering the problem and they have almost the same level of knowledge as to the lessons in the fourth quarter when they are exposed to the conventional method of teaching.

After the experimental group has been subjected to the different methods, post-test has been given to both groups to measure how much they have learned during the conduct of the study. It is evident in the table above that Experimental Group for both High Grades and Low Grades has p-values of 0.000 and 0.002, respectively which is less than 0.05, thus we must **reject the null hypothesis.** Therefore, it can be concluded that there is significant interaction with the achievement test scores of the subjects in the experimental group if they will be sorted as to their mental capacity. The result only suggested that those subjects which are exposed to activities that promotes productive struggle performs better than those who are exposed to conventional method of teaching even if they are grouped according to their mental capacity.

The mathematical scores will not increase according to Freemyer (2019) because of top-down initiatives aimed at imposing pressure on local Mathematics teachers. Mathematical scores will only be competitive with teacher's collaborative effort, including those of the leaders who roll their sleeves to provide guidance, support, encouragement, and resources. To further students in this subject, higher education through a more conceptual approach is necessary. This requires greater engagement of students in productive struggle, genuine problematic solution, investigation,

and student discourse. It essential to be convinced that everyone learns and loves the beauty of Mathematics.

The framework of Carol Dweck (2017) provides the foundation for showing how we can use a growth attitude to reach all students. Thus, we need to have a major shift. Teachers must be content-loving, must approach their jobs by research-led practices that stimulate students, must be willing to provide further assistance and must be willing to help and encourage all students to adapt their teaching, for it will indeed make a positive difference for younger people in their lives.

Effective Mathematics learning uses the struggle of students as valuable opportunity to deepen its understanding of Mathematics, said Principles of Actions (2014). Students become aware that they can do well with effort and perseverance in Mathematics in thinking, making sense and solving problems. In addition, Hiebert and Grouws (2007) added that the productive struggle is difficult. The effort by a student to gain meaning in Mathematics and to identify something which is not immediately apparent can promote students' thinking and play an important role in deepening their understanding, if carefully supported for resolving the and given time.

6. Discussion

On the basis of the foregoing study, the following salient findings were drawn. The results showed that the pre-test mean score in the controlled group for High Grades and Low Grades is 21.00 and 16.09 respectively, on the other hand the mean score of the experimental group is 20.64 (High Grade) and 16.64 (Low Grade). Moreover, the post-test mean score for controlled group is 37.82 (High Grades) and 22.64 (Low Grades) while the experimental group's mean score for High Grades and Low Grades is 41.73 and 38.82, respectively. It can be observed that means scores for both the controlled group and experimental group have increased.

It has been found out in the conduct of the study that the level of influence of productive struggle to the subjects is extremely influential with a weighted mean of 4.38. Furthermore, the study revealed that productive struggle helps the subjects to be motivated in managing and trying to improve their skills in mathematics problem solving.

It was revealed in the study that the problems encountered in the conduct of the study is considered more serious problem with a weighted mean of 3.46. The problem that most of the subjects encountered is that they cannot finish the activity within the given amount of time.

It was found out that there is no significant difference between the pre- test scores of the controlled and experimental group which can be inferred that subjects have almost equal knowledge of the lessons in the fourth quarter. On the other hand, when it comes to the post-test scores of the subjects there is a significant difference between the controlled and experimental group. It can be deduced that after the subjects have been exposed into two different methods, the experimental group have significant increase in their scores.

The study affirmed that when it comes to controlled group there is no significant interaction between the achievement test scores of the subjects and their mental capacity. On the contrary, after the experimental group have been immersed into different methods, and post-test have been given it was found out that there is significant interaction between the achievement test scores of the subjects and their mental capacity, which only means that those in experimental group both high and low grades have performed best as compared to the subjects with high and low grades of the controlled group.

7. Conclusion

Based on the findings of the study, the following conclusions were drawn. In view of the mean scores of the subjects in pre-test it can be concluded that during the conduct of the study, the subjects have equal knowledge and understanding when it comes to the lessons in the fourth quarter. On the other hand, there is a huge difference between the mean scores of the experimental and controlled group. It can then be deduced that activities that promotes productive struggle is more effective as compared to the conventional way of teaching.

The researcher concluded that students are more likely to be internally motivated to engage in productive struggle to achieve a goal. Furthermore, productive struggle makes the subjects eager for new challenges, and enthusiastic rather than fearful about learning from mistakes. It can be concluded that when students are engaged in a productive struggle, they have to be given enough time to answer the problem or to finish the given activity.

Since there is significant difference between the achievement post- test scores of experimental and controlled groups. It can then be concluded that activities that promotes productive struggle has engaged the subjects in active learning, it has developed self-esteem and promotes academic achievement. Concepts learned independently are easy to be remembered.

It can be concluded that when activities that promotes productive struggle will be incorporated in teaching Mathematics, the students with High and Low mathematical ability levels will be improved more in their Mathematics achievement compared to the High and Low mathematical ability levels who are taught solely by the teacher through lecture method.

The focal intention of this study is to find out the Influence of Productive Struggle in Mathematics to the 21st Century Learners. The study is implemented in fourth grading period in the school year 2019-2020 at Tandag National Science High School.

Only Grade 8 students were involved in the conduct of the study. The research participants are further narrowed to the two selected sections with twenty- two (22) students each. One section served as the experimental group and the other as the control group. The experimental group was subjected to teaching with the use of productive struggle activities, while the control group used the conventional teaching strategy. To ensure consistency, only one teacher handled both groups.

The experiment was entirely conducted in the fourth quarter with a total of 20 sessions. The lessons that were included in the conduct of the study are in line with the Curriculum Guide provided with the Department of Education; the following are the only competencies which were covered in the conduct of the study: (1) Illustrates an experiment, outcome, sample space and event. (M8GE-IVf-1), (2) Counts the number of occurrences of an outcome in an experiment: (a) table; (b) tree diagram; (c) systematic listing; and (d) fundamental counting principle. (M8GE-IVf-g-1), (3) Finds the probability of a simple event. (M8GE-IVh-1), (4) Illustrates an experimental probability and a theoretical probability. (M8GE-IVi-1), (5) Solves problems involving probabilities of simple events. (M8GE-IVi-j-1).

Since the study conducted was done only in one quarter the researcher highly recommends that in the future conduct of research the use of productive struggle in teaching Mathematics is to be employed quarterly. After implementation, evaluation shall follow. It is to ensure that the students achieve high academic performance through tracing the development in their scores every grading period.

Educators are recommended to have a seminar on localizing and contextualizing of instructional materials. This will improve the content of the activities. Using examples that are found in the community will help the students understand the topics. Thus, it is highly recommended to conduct research on the effectivity of localized and contextualized materials that promotes productive struggle in the classroom.

REFERENCES

Abiola, O.O. and Dhindsa (2012). Improving classroom practices using our knowledge of how the brain works. International Journal of Environmental and Science Education, 7(1):71–81, 1 2012.

Andaya, O.V (2014). Factors That Affect Mathematics Achievements of Students of Philippine Normal University - Isabela Campus.). Retrieved on May 6, 2020. Retrieved from https://www.questia.com/library/journal/1P3-3495263551/factors-that-affect-mathematics-achievements-of-students.

Boaler, J. (2014). The mathematics of hope: Moving from performance to learning in mathematics classrooms.

Brownell, W. A., & Sims, V. M. (1946). The nature of understanding. The forty-fifth yearbook of the National Society for the Study of Education. Part I: The Measurement of Understanding, 27-43. https://doi.org/10.1177/016146814604700903

Capate, R.N.A. and Lapinid, M.R.C. (2015). Assessing the Mathematics Performance of Grade 8 Students as Basis. Retrieved on May 6, 2020. Retrieved from www.dlsu.edu.ph/conferences/dlsu_research_congress/.../020LLI_Capate_RN.pdf

Castagno-Dysart, D., & Matera, B. (2019). Learner persistence – the productive struggle. Retrieved July 12, 2020, from https://www.teachermagazine.com.au/articles/learner-persistence-the-productive-struggle

Daily, S. (2021). "Productive Struggle" as an Effective Strategy in Elementary Math Classrooms. International Journal of the Whole Child, 6(2), 85.

Freemyer, J. (2019). The Big Ask. In the Next Step: Today's Methods for Today's Math (pp. 38 - 39). Lanham: Rowman & Littlefield.

Goldenberg, P. E., Mark, J., Kang, J., Fries, M., Carter, C. J., & Cordner, T. (2015). Making sense of algebra: Developing students' habits of mind. Portsmouth, NH: Heinemann

Granberg, C. (2016). Discovering and addressing errors during mathematics problem-solving—A productive struggle? The Journal of Mathematical Behavior, 42, 33–48. https://doi.org/10.1016/j.jmathb.2016.02.002

Gray, E. (2019). Productive Struggle: How Struggle in Mathematics Can Impact Teaching and Learning. (Electronic Thesis or Dissertation). Retrieved from https://etd.ohiolink.edu/

Hiebert, J. and Grouws, D. A (2007). "The effects of classroom mathematics teaching on students' learning," in J. Frank & K. Lester (Eds.), Second handbook of research on mathematics teaching and learning, Charlotte: Information Age, 2007, pp. 371-404.

Ionescu, M. (2015). Didactica modernă [Modern didactics]. Cluj-Napoca: PUC.

Kang, H. (2007) .8 teaching habits that block productive struggle in math students. MIND Research Institute.

Kapur M. (2010). Examining productive failure, productive success, unproductive failure, and unproductive success in learning. Educational Psychologist. 2016;51(2):289-299 https://doi.org/10.1080/00461520.2016.1155457

Meyer W R, (2010). Independent learning: a literature review and a new project. Evaluation and Research Department. Paper presented at the British Educational Research Association Annual Conference, University of Warwick. Retrieved on May 6, 2020. Retrieved from www.leeds.ac.uk/educol/documents/193305.pdf

Middleton, J. A., Tallman, M. A., Hatfield, N., & Davis, O. (2015). Taking the severe out of perseverance: Strategies for building mathematical determination (White paper). Chicago, IL: Spencer Foundation.

Murdoch, D., English, A. R., Hintz, A., & Tyson, K. (2020). "Feeling heard": Inclusive education, transformative learning, and productive struggle. Educational Theory, 70(5) 653-679. https://doi.org/10.1111/edth.12449

National Council of Teachers of Mathematics (NCTM). (2014). Principles to actions: Ensuring mathematical success for All. Reston, VA: NCTM.

Pasquale, M. (2015). ERIC - ED571660 - Productive Struggle in Mathematics. Interactive STEM Research + Practice Brief, Education Development Center, Inc., 2016. Education Development Center, Inc. https://eric.ed.gov/?id=ED571660

Permatasari, D. (2016). The Role of Productive Struggle to Enhance Learning Mathematics with Understanding. Mathematics Teaching in the Middle School, 95–100. https://doi.org/10.5951/mathteacmiddscho.22.1.0051

Posamentier, A. (2017). 9 Strategies for Motivating Students in Mathematics. Retrieved May 7, 2020, from https://www.edutopia.org/blog/9-strategies-motivating-students-mathematics-alfred-posamentier

Russo, J. (2021). Primary Teacher Attitudes towards Productive Struggle in Mathematics in Remote Learning versus Classroom-Based Settings. MDPI. https://doi.org/10.3390/educsci11020035

Star, J. R. (2015, April). When not to persevere – Nuances related to perseverance in mathematical problem solving (White paper). Chicago, IL: Spencer Foundation.

Trinter, C. P., & Hughes, H. E. (2021). Teachers as Curriculum Designers: Inviting Teachers into the Productive Struggle. RMLE Online, 44(3), 1–16. https://doi.org/10.1080/19404476.2021.1878417

Vazquez, S. R., Ermeling, B. A., & Ramirez, G. (2020). Parental Beliefs on the Efficacy of Productive Struggle and Their Relation to Homework-Helping Behavior. Journal for Research in Mathematics Education, 51(2), 179–203. https://doi.org/10.5951/jresematheduc-2020-0019

Warshauer, H. K. (2014). Productive struggle in middle school mathematics classrooms. Journal of Mathematics Teacher Education, 18(4), 375–400. https://doi.org/10.1007/s10857-014-9286-3

Zaslavsky, O. (2005). Seizing the opportunity to create uncertainty in learning mathematics. Educational Studies in Mathematics, 60(3),297-321. https://doi.org/10.1007/s10649-005-0606-5

Zeybek, Z. (2016). Productive Struggle in a Geometry Class. International Journal of Research in Education and Science, 2(2), 396. https://doi.org/10.21890/ijres.86961