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Research Article

CONTEXTUAL LEARNING: THE USE OF AUTHENTIC MATERIALS IN TEACHING INDUCTIVELY DIMENSIONAL MATHEMATICS

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Authentic materials in mathematics teaching expedite the process of learning because students are exposed to real objects making mathematics more relevant to their daily experience. This experimental study specifically observes the randomized pretest-posttest control group design to determine the impact of authentic materials in teaching inductively dimensional mathematics to Grade VI students in Pinut-an Elementary School, San Ricardo, Southern Leyte, Philippines. Findings revealed that the use of authentic materials in teaching inductively dimensional mathematics significantly affects Grade VI students' performance at 5% level of significance. The study concludes that authentic materials contribute more to the significant increase in learning brought by the use of inductive teaching. Thus, mathematics teachers are encouraged to utilize authentic materials in the mathematics classroom, especially in teaching dimensional mathematics to increase contextualization and achievement of learning.

Keywords: Contextual learning, authentic materials, dimensional mathematics, quasi-experimental design

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1. INTRODUCTION

The use of authentic materials in mathematics teaching motivates learning and stimulates students' lively participation in a classroom. With students being exposed to real objects in the community, learning mathematical concept is assumed to be contextualized, making mathematics more relevant to their daily experience (Asmara et al., 2019; Utami, 2019). The K-12 curriculum emphasizes the significant role of community involvement to the holistic development of the learners as genuine opportunities for contextualized learning. Thus, the Department of Education (DepEd) adheres to the standards in improving the enhanced basic education curriculum, in which the program of study shall be contextualized yet global (DepEd, 2013). Contextualization maximizes locally available materials that enable and allow schools to enhance learning grounded on their educational and social context (Ahdhianto, 2020).

An authentic material situates students to a real-world condition and serves as a bridge that connects classroom learning to a real-life scenario (Kelly et al., 2002; Herod, 2003). Using authentic materials, learning is expedited and students recall concepts easily because they are grounded on experience. In fact, authentic materials permit students to experience, learn, construct concepts and relationships in a context that involves real-life mathematical problems and stimulating activities (Pinzón, 2020; Umirova, 2020). The value of this assertion is anchored on the universally accepted tenet that students learn more through learning experiences (Hughes, 2005; Casinillo et al., 2020b). Various researchers claim that authentic materials provide a positive impact on the teaching-learning process. It motivates mathematically unmotivated students (Peacock, 1997), increases learners' motivation and serves as a scaffold to learning (Shrum & Glisan, 2000; Guariento & Morley), self-satisfaction (Thanajaro, 2000), and positive impact to learning (Hyland, 2003). Hyland (2003) reveals that authentic materials in teaching developed students' comprehension skills and added that without authentic materials, it will be difficult to expect how the learners achieve in real-life situations. Thus, authentic materials more likely engage in activities outside the classroom and create better classroom interaction (Purcell-Gates et al., 2001; Umirova, 2020). These literatures reflect the significant impact on the use of authentic materials in the teaching-learning process. However, the use of authentic materials was often observed in the teaching of language communication (Peacock, 1997) and seldom in the field of mathematics (Kramarski et al., 2002; Dennis & O'Hair, 2010). Thus, addressing the question of the effectiveness of authentic materials in a mathematics classroom is no longer optional but a timely priority especially on the demand of the K-12 curriculum, that is, to put students' learning always in context (SEI-DOST & MATHTED, 2011).

Dennis and O'Hair (2010) stressed that studies on the use of authentic materials in mathematics instruction are still a wide-open field. Though its essence has been substantiated, yet there are still areas to be explored. It is on this premise that the researcher decided to conduct a study on the effect of the use of authentic materials in teaching inductively dimensional mathematics. Hence, this study aimed to measure the effect of the use of authentic materials in teaching inductively dimensional mathematics. Specifically, this study would answer the following objectives: (i) to know the pretest-posttest performance in dimensional mathematics of the experimental and control group; (ii) to determine the significant difference of the pretest performance in dimensional mathematics between the two groups; (iii) to determine the significant improvement in the post-test performance in dimensional mathematics of the two groups; and (iv) to determine the significant difference of the post-test performance in dimensional mathematics between the two groups. The findings of this study may provide further knowledge on improving mathematics performance by contextualizing its abstract concept through the usage of authentic materials. Looking at the welfare of the school, the findings may serve as inputs for faculty development plan or program in relation to instructional materials for teaching. It may also provide information for a systematic scheme of instructional material that contextualizes and localizes the concept of the lesson.

2. METHODOLOGY

Research Design

This study employed a quasi-experimental design with matched subjects based on the study of Yunzal and Casinillo (2020). This was made primarily for the purpose of comparing groups and/or measuring change resulting from experimental treatments (White & Sabarwal, 2014). In describing the data gathered, some descriptive measures were used, and for determining the effectiveness of the treatment, a t-test was employed. Table 1 shows the experimental layout of the study.

Table 1. The Quasi-Experimental Design

Group	Random Assignment	Time →		
Treatment Group	M_r	Pretest	X	Posttest
Control Group	M_r	Pretest	C	Posttest

Note: (a) M_r means that the participants of experimental and control groups are randomly assigned; (b) X symbolizes the experimental treatment; (c) C symbolizes that the participants of the control group do not obtain the experimental treatment.

The Ethical procedure and Research Participants

Before the study commenced, the researcher secured a permit to conduct the study from the District Supervisor of San Ricardo District, the head-teacher of the Pinut-an Elementary School, and the president of the homeroom officers of Grade VI class. The schedule for the conduct of the study was stipulated in the letter to inform all the concerned authority regarding when and where the study is conducted. Then, the parents' consent was also requested through a formal letter saying that no sensitive information was gathered during the conduct of the study. Indeed, the participation was voluntary and assured that data gathered from students shall be solely used for this research only. The respondents of this study were bona fide Grade VI students of Pinut-an Elementary School, San Ricardo District, San Ricardo, Southern Leyte, Philippines. The respondents of the study were randomly assigned to either control or experimental group. Sample selection for each group was based on a baseline characteristic, that is, Grade V general weighted average. The baseline characteristic was considered to get homogeneous students within two groups. Hence, this experiment only uses a small sample size in order for the researcher to easily monitor the students and get accurate data. Using t-test, it is revealed that two groups are equivalent (t=0.782, p-value=0.601) in terms of Grade V general weighted average. Table 2 shows the comparison between control and experimental groups in terms of Grade V general weighted average.

Table 2. Comparison of Grade V general weighted average

Group	N	Minimum	Maximum	Mean	Std. deviation	t-computed	p-value
Experimental	13	76.00	92.00	80.92	5.78	0.782^{ns}	0.601
Control	13	76.00	91.00	80.50	5.50		

Note: ns - not significant.

The Research Instrument and Research Procedure

This study utilized a Trends in International Mathematics and Science Study (TIMSS)-based self-developed module as its main instrument (Martin et al., 2004). This self-developed module underwent an evaluation by three experts in the field of mathematics education holding relevant master's degrees. Experts have evaluated the content, relevance, effectiveness, efficiency, and approach in learning mathematics. Moreover, the module contained (i) the topics discussed following the inductive method of teaching with specified authentic materials used in each of the topics, (ii) the standardized Pretest-Posttest questions, (iii) the table of specifications reflecting the equal distribution of the questions, and (iv) the key answer of the questions. The researcher developed a TIMMS-based module that contained the topics included in the discussion for dimensional mathematics and has the following competencies (Table 3).

Table 3. Matrix on the Lesson included the time allotted and the competencies

Lesson No.	Tittle	Competencies	Time allotted
Lesson 1	Measuring Length	Measure and approximate using non-standard and standard units through authentic materials on measuring length.	45 min.
Lesson 2	Metric system of linear measure	Convert one unit of the metric system to a larger and smaller unit. Approximate measurement of length, with, height and distance	45 min.
Lesson 3	Perimeter	Derive a formula and solve word problems involving perimeter measure	45 min.
Lesson 4	Area of the Rectangle	Derive the formula and solve word problems involving area of a rectangle	45 min.
Lesson 5	Area of the triangle	Derive the formula for finding the area of a triangle and solve word problems involving area of a triangle	45 min.
Lesson 6	Area of the square	Derive the formula and solve word problems involving area of a square	45 min.
Lesson 7	Standard units in measuring volume	Identify and convert the correct unit of measure for volumes	45 min.
Lesson 8	Volume of Rectangular prisms	Derive the formula and solve word problem involving measuring of volume of a rectangular prism.	45 min.
Lesson 9	Volume of Cylinder	Derive formula and solve word problem involving measuring of volume of a cylinder.	45 min.

Included in the module development was the standardization of the Pretest-Posttest questions. The questions were validated using face and content validity by experts who evaluated the module. The experts have also checked the congruence of test items in regards to the table of specification and both agreed on its content validity. Reliability was measured using homogeneity (Internal Consistency) measure. Reliability testing was conducted to students of the same characteristics to that of the participants of the study but was not included in the control and experimental groups, that is, from different school. Hence, it is found out that Chronbach's alpha is equal to 0.81, which suggests that the instrument is reliable. Prior to the implementation of the intervention, a pretest evaluation was administered for both control and experimental groups. The allotted time for each class session was only one hour per day for each group. The experiment started from the month of October and culminated in the month of December, which is scheduled every Friday. This corresponds to the official number of hours during regular school days intended for the subject. The experimental class session was conducted from 10:00 to 11:00 and the control class session was scheduled on 1:30 to 2:30 in the afternoon. In this study, all conditions (teacher, subject characteristics, time, environment, topic, teaching method) were held approximately the same for both the experimental and control groups, with the exception that the experimental group was exposed to a treatment, the use of authentic materials, whereas the control group was not. Upon completion of the module, the evaluation (posttest) was immediately administered. Figure 1 shows an example of authentic material to measure the volume of a rectangular prism.

Figure 1. Example of Authentic Material.

The Data Analysis

For logical analysis and interpretation of the data gathered, the following statistical treatment were used: (1) mean described the pretest-posttest performance in dimensional mathematics of the experimental and control groups; (2) standard deviation described how scattered was the data around the mean; (3) t-test for independent sample helped determine the significant difference of the pretest performance and the posttest performance between experimental and control groups; and (4) t-test for related sample used to determine significant improvement of the posttest performance in each group in relation to the pretest performance. The statistical difference were measured using alpha = 0.05 level of significance. The Statistical Packages for Social Sciences (SPSS) version 20.0 was used in the analysis

3. RESULTS AND DISCUSSION

Pretest-Posttest Performance in Dimensional Mathematics of Grade VI students

Pre-experimental analysis reveals that experimental (M=19.77; sd=6.09) and control (M=18.08; sd=3.45) groups are performing equally at Developing Level (Table 4). Though the experimental group has a higher mean (M=24.38; sd=8.16) compared to that of the control group (M=21.92; sd=6.56), they are still equally performing and categorized in the approaching proficiency level. The increase in performance of both groups reflects the effectiveness of the use of authentic materials in teaching dimensional mathematics through inductive teaching. Consideration on the pretest performance of the control and experimental group provides the assurance that both groups are initially equivalent as to cognitive ability based on K-12 levels of proficiency. Specifically, both groups, who are performing at developing level, imply that the student-participants possess the minimum knowledge and skills and core understanding of certain topics and subject contents.

The pretest performance result of the two groups is evident that many students tend to have low performance in mathematics. According to Gonzales et al. (2004), Filipino students were weakest in Mathematics and Science compared to their Asian counterparts. In fact, Trends in International Mathematics and Science Study (TIMSS) in 2008 result showed that the Philippines ranked the lowest, even with only the science high schools joining the Advanced

Mathematics category (Ogena et al., 2010). Several researchers claim that Filipinos have low performance when it comes to mathematics and the largest number of failures in school subjects was mathematics (Gonzales et al., 2004; Casinillo, 2019; Casinillo et al., 2020a). The same goes with Casinillo and Aure (2018) who found out that most of the students have difficulty in learning mathematics, regardless of the reason for students' mathematical difficulties i.e. intrinsic or extrinsic factors. Moreover, Andaya (2014) mentioned that the low performance of students in mathematics was due to lack of foundation and knowledge in content of mathematics, student's attitudes towards mathematics and teachers commitment and emphasized instructional is a factor that greatly affects performance.

Leongson and Limjap (2003) revealed that Filipino students excelled in knowledge acquisition but fare considerably low in lessons requiring higher-order thinking skills, particularly mathematics subjects.

However, a glance at the posttest performance shows that the control and experimental groups performed better than their pretest performance. Table 4 shows that both groups are performing at approaching proficiency level in their posttest. Performing at Approaching Proficiency level means that student has established the essential information of certain topics and subject contents through authentic performance tasks. The control and experimental group show an increase of performance from developing level to approaching proficiency level. The increase of performance in the posttest result reflects that inductive teaching and/or inductive teaching with authentic materials are effective methods in teaching dimensional mathematics. This is consistent with the findings of Rott (2021) who revealed that students exposed to inductive teaching (discovery learning) performed better than those who were not. In fact, in the study Marrs and Novak (2004), it is found that the practice of inductive teaching to students led to improved academic achievement, progress retention, and student study habits. Moreover, Prince (2004) concluded that inductive teaching improved students' developmental skills, retaining information, applying learned material, and students tend to remember a lesson when learning occurs inductively.

A specific look at the experimental group provides an idea that the increase of posttest performance is due to the authentic materials as a supplemental tool of inductive teaching. With the experimental group (M=24.38; sd=8.16) performed better compared to that of the control group (M=21.92; sd=6.56), the result implies that the use of authentic materials through inductive teaching contributes more to the increase of posttest results. According to

Berardo (2006), it is noticed that authentic materials contribute to increasing learners' interest and positive results of students' performance. Educators asserted that authentic materials in teaching will provide meaning and relevance to the concepts and its effectiveness in improving students' achievement (Hipp & Huffman, 2003; Jacobson et al., 2003; Newmann et al., 2001; Starratt, 2005). Thus, the use of authentic materials through inductive teaching can be of great help in the teaching-learning process as it improves students' motivation, provides learners' needs and contextualizes learning in line to K-12 program as a way to enhance students' motivation and increase students' performance. The best authentic materials can be instructional materials that can contextualize concepts and are appropriate to the lesson (Velazquez, 2007).

Furthermore, by Shapiro-Wilk test, it is revealed that the data set for pretest and posttest for both control and experimental group are normally distributed since the p-values are greater than 10% level (Table 4).

Table 4. Pretest-Posttest Performance in Dimensional Mathematics

Group	Test	N	Mean Score (M)	Std dev (sd)	Normality (Shapiro-Wilk test)	p-value	Description*
Control Group	Pretest	13	18.08	3.45	Z=-2.59	0.943	Developing
	Posttest	13	21.92	6.56	Z=-2.01	0.977	Approaching Proficiency
Experimental Group	Pretest	13	19.77	6.09	Z=-1.16	0.876	Developing
	Posttest	13	24.38	8.16	Z=-2.91	0.978	Approaching Proficiency

*Description is based on k-12 transmutation table (1–10 = Beginning, 11-20 = Developing, 21-30 = Approaching Proficiency, 31-40 = Proficient, 41-50 = Advance)

Pretest Performance in Dimensional Mathematics

Comparison of the pretest performance between control and experimental group affirms the assumption of this experiment that two groups are indeed equivalent in cognition level as measured through their Grade V General Weighted Average. The pretest performance of experimental (M=19.77; sd=6.09) and control (M=18.08; sd=3.45) groups reveals that despite mean difference, the two groups are equally performing at the developing levels based on the K-12 levels of proficiency. In more specific information, this study hypothesized that there is no significant difference in the pretest performance of control and experimental groups. The result failed to reject this hypothesis and stressed that there is no significant difference (t=-0,872, df=24, p-value=0.392) between the pretest performance result of the experimental group and control group (Table 5). This confirms the assumption of this experiment that the two groups are equally performing in the pretest performance based on their cognition level - an assumption that will help the researcher to attribute the change of performance (delta performance) to the intervention applied.

Pretest performance of the two groups performs only at developing level which is not quite performing well. Students usually get low grades in their performance in mathematics, particularly in geometry that includes dimensional mathematics due to the lack of conceptual understanding and knowledge of the fundamental manipulation or mathematical skills; and most of all, the lack of interest in mathematics that may create difficulty and negativism towards the subject (Bayaga et al., 2019). Apparently, the Trends in Mathematics and Science Study (TIMSS) revealed that the Philippines had unsatisfactory results in Mathematics (Ogena et al., 2010). It is therefore imperative that teachers must foster a more stimulating learning process and find ways and means to find better teaching strategies and appropriate learning materials in mathematics for the lesson to be more interesting and meaningful, giving the students a better understanding of mathematical concepts (Casinillo, 2019; Casinillo & Guarte, 2018).

Table 5. Pretest Performance in Dimensional Mathematics

Test	Group	N	Mean	St dev	Mean Difference	t-test	df	p-value
PRETEST	Control Group	13	18.08	3.451	-1.69	-0.872^{ns}	24	0.392
	Experimental Group	13	19.77	6.085				

Note: ns – not significant

Significant Improvement in the Pretest-Posttest Performance in Dimensional Mathematics

Posttest performance of the experimental and control groups is the measure to determine whether there is an increase of performance of the two groups from the pretest result, with the use of authentic materials for the experimental group and without the use of authentic materials for the control group through inductive teaching. The posttest performance result shows that experimental (M=24.38; sd=8.16) and control (M=21.92; sd=6.56) groups performed higher compared to their pretest performance. The results of the experiment revealed that the two groups significantly increased their performance from developing level to approaching proficiency level based on the K-12 levels of proficiency. This finding rejects the hypothesis stating that there is no significant difference in the pretest and posttest performance of the control and experimental groups at 5 percent level of significance (Table 6). The significant improvement in the posttest performance of the experimental (*t=-4.62, df=12, p-value=.001*) and control (*t=-3.85, df=12, p-value=.033*) groups show the effectiveness of inductive teaching and/or the use of authentic materials in dimensional mathematics through inductive teaching. Hence, it can be considered that the use of inductive teaching as one of the control variables in this experiment contributed to the increase of performance in the posttest result. Inductive teaching is a better way to motivate the learners and permits them to enter and penetrate more deeply into the world of mathematics than most other teaching approaches fail to do so (Istiqomah & Al-Badrani, 2020; Prince & Fedler, 2006). On the other hand, authentic materials also provide an increase of performance in the experimental group as it increases the pretest result (M=19.77; sd=6.09) to the posttest result (M=24.38; sd=8.16). This implies that the effectiveness of inductive teaching as mentioned by various researchers can be intensified through the use of authentic materials.

Teaching strategies such as inquiry-based learning and case-based learning, which are interrelated to inductive teaching, were led to authentic interaction in classroom through the use of authentic materials; these authentic materials served as instructional aid of students in providing a meaningful understanding to the concept inside the classroom (Namaziandost et al., 2021; Prince & Fedler, 2006; Siegel, 2019).

Table 6. Pretest-Posttest Performance Improvement in Dimensional Mathematics

Group	Test	N	Mean Score	St dev	Mean Difference	t-test	df	p-value
Control Group	Pretest	13	18.08	3.45	-3.85	-2.47*	12	0.033
	Posttest	13	21.92	6.56				
Experimental Group	Pretest	13	19.77	6.09	-4.62	-4.66**	12	0.001
	Posttest	13	24.38	8.16				

Note: * - p-value<0.05, ** - p-value<0.01.

Posttest Performance in Dimensional Mathematics

The difference in the posttest performance between the experimental and control group determine further the effectiveness of using authentic materials in dimensional mathematics through inductive teaching. This finding fails to reject the null hypothesis of this study, stating that there is no significant difference in the posttest performance of the experimental and control group (t=-0.848, df=24, p-value=0.405) (Table 7). This implies that using authentic materials through inductive teaching does not cause the difference in the posttest significant. However, the posttest performance results show that the experimental (M=24.38; sd=8.16) group has a higher mean than that of the control (M=21.92; sd=6.56) group. Though the difference is not significant, the result implies that the use of authentic materials increases the performance in the experimental group through inductive teaching than of the control group. However, while the mean performance of the experimental group is higher than that of the control group, it does not guarantee that the experimental group performed better than of control group. An intense look at the data shows that the use of authentic materials through inductive teaching produces a higher mean than without authentic materials. This illustrates the significant contribution of authentic materials in the learning process as reflected by several studies which reveal the positive effect of authentic materials, as it motivates students and connects classroom learning to real-life scenarios of the students (Kelly et al., 2002; Jacobson et al., 2003; Berardo, 2006; Namaziandost et al., 2021). In addition, Umirova (2020) sees the advantage of authentic material in the contextualization of concepts as the learning process that connects student’s prior knowledge and experience to the lesson.

Table 7. Difference of the Posttest Performance in Dimensional Mathematics between Control and Experimental Groups

Test	Group	N	Mean	St dev	Mean Difference	t-test	df	p-value
POSTTEST	Control Group	13	21.92	6.563	-2.46	-0.848^{ns}	24	0.405
	Experimental Group	13	24.38	8.160				

Note: ns – not significant

4. CONCLUSION

It is concluded that contextual learning through inductive teaching significantly affects students' performance in dimensional mathematics. It increases performance as students will be challenged with a specific real-world problem through a gradual creation and transformation of experiences. However, the use of authentic materials contributes to this significant increase in academic performance because it allows learners to define their own meaning through authentic tasks responding to the challenges in a more personal and highly motivated manner. Hence, mathematics teachers can enhance their instructional competence by being resourceful in using authentic material as a teaching aid to reinforce and expedite students' learning of mathematical concepts. For future research, further studies on the use of authentic materials as aids in inductive mathematics teaching should be conducted with large participants of students to gather richer information.

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