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Differentiated Instruction with Interactive Multimedia: Based on Pupils' Readiness Level in Mathematics 6

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Abstract

Most teachers find it challenging to motivate students to improve their basic academic performance in mathematics. The efficiency of differentiated instruction with and without interactive multimedia based on the pupils' preparation level in mathematics was investigated using an experimental technique of study using the pretest-posttest with a control group design. According to the findings, Dr. Mayer's theory of multimedia's use of differentiated instruction with interactive multimedia was effective, and Nuris, et al. agreed with Mayer that using multimedia with graphics and animation could result in meaningful learning outcomes for pupils, but pupils who were exposed to differentiated instruction with cooperative learning or without technological engagement were also effective. With a p-value of 0.88, it can be established that the mean gains of learners subjected to differentiated instruction without (cooperative learning) and with interactive multimedia were not significantly different. As a result, technology as a tool for interactive multimedia has an effect similar to enhancing pupils' basic mathematical skills for cooperative learning; thus, Lev Vygotsky's Social Developmental Theory through differentiation should be used in the early development of pupils' basic mathematical skills based on the pupils' readiness level.

Keywords— Differentiated Instruction, Interactive Multimedia, Pupils' Readiness level in Mathematics 6, experimental design

Introduction

In the 1980s, technology was introduced as a tool for classroom instruction. Educators were unfamiliar with the widespread potential of how computers work in the classroom thirty years ago. We are now living in a technological era in which it is no longer a frightening novelty. Learners in the twenty-first century were involved in the development of new educational technology solutions to suit their expectations (Babia, Etulle & Flores, 2021). The majority of people all around the world are driven and drawn to various programs on their cellphones, iPods, tablets, and other internet-connected gadgets. According to the International Society for Teaching Education, this is one of the reasons why technology should be used in the classroom (ISTE). "The lavish promises of technology," according to Schrum (2005), "are that it will make our pupils smarter — and that it will do so faster and cheaper than ever before." As a result, technology may be the key to inspiring students to learn basic mathematics, and the importance of incorporating it into instruction through software must be considered. If education provides such guidance for the use of technology, it is hoped that it will rectify students' misconceptions about the right value of technology use when their devices are not being used for instructional purposes. It will also reorient them on the need of appropriate time management, as they spend most of their time on social media, online games, and online movies, as is widely noticed. Children appear to exclusively use educational technology when they are at school.

Basic mathematics is essential information for advanced mathematical skills. Since it was suggested that technology be utilized as a tool for instruction, one of the key reasons why the researcher decided to conduct a study was to determine the efficiency of using interactive multimedia through technology to improve learners' basic arithmetic skills. The number of students per classroom in the Philippines, according to the Department of Education (DepEd), is typically not the ideal class size. This is visible in big class sizes, where the diversity of learners in the classroom is obvious. According to Non-Destructive Testing for Education (NDT-Ed), all children are distinct, and it is important to understand that each individual in a group of individuals is unique in his or her way, therefore it is apparent that students are diverse learners in the classroom settings (Cole, 2008). As a result, differentiated instruction is one method for assisting students in developing self-confidence and engaging in meaningful learning. According to Joseph et al. (2013), "learners who were exposed to a differentiated education method did better than learners who were exposed to a traditional instruction strategy," therefore differentiation is critical in the primary years (Cox, 2008). Differentiation using interactive multimedia may be the best way to improve students' fundamental math skills.

However, according to Arangkada Philippines' broadband policy brief, eighty percent of public schools in the Philippines still lack internet connectivity (Grace, 2016). The majority of students attend public primary schools, and it is currently a struggle in education to provide quality instruction without incorporating technology into the classroom. "There is solid evidence that utilizing good teaching practices can make a difference, changing the way that children work together, and classroom management and motivation can improve student outcomes," according to Slavin (2014) and Babia and Candia (2021). As a result, the findings of this study suggest that the country has a better possibility of achieving quality education.

Theoretical-Conceptual Framework

The theoretical background which shows the conceptual framework of the study in a schematic diagram is shown in figure 1.

The conceptual framework was based on Lev Vygotsky's mother theory in Social Development. According to the Social Developmental Theory, social interaction is an important aspect of learning, and learning occurs twice: at the social level and then individually. To aid the teaching-learning process, the more knowledgeable other (MKO) might be used as a tutor. The MKOs' job is to interact with the students to unlock the potential of their ZPD in learning basic math skills. To address children's various needs, differentiated instruction is guided by Vygotsky's Social Developmental theory, according to Tomlinson. Johnson and Johnson's cooperative learning theory is a successful teaching strategy in which students worked closely with their tutor for social interaction to gather learning from their peers, and then differentiated activities were assigned based on the students' ability to learn the skills. Learners understand concepts through the use of words and images, according to Dr. Mayer's multimedia learning theory: "People always relate new learnings to their prior knowledge, rearrange it, try to make sense of it, and focus on knowledge construction, which requires an active-learning approach." Based on the learners' readiness level, cooperative and multimedia learning theories were combined with Social Developmental theory to distinguish instruction with and without interactive multimedia.

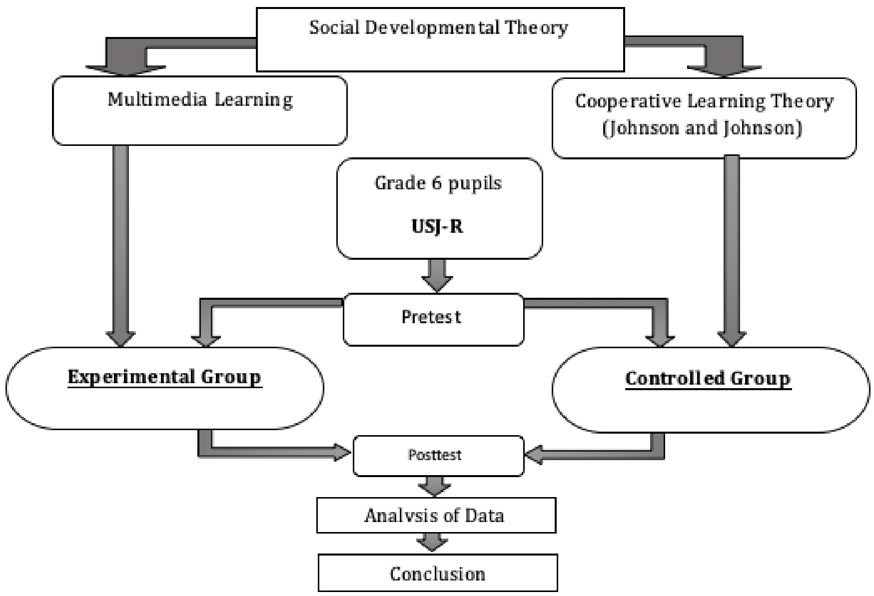

Figure 1. The Schematic Diagram of implementing the Theoretical-conceptual Framework

The study involved randomized Grade 6 students from the USJ-R Grade School Department. Based on their past grades in mathematics 6, the students were classified as high-achiever, moderate-achiever, or an underachiever. The kids were graded according to their past mathematical grades before being assigned to the control and experimental groups, resulting in homogeneous groupings. The computation did not contain projects or performance assignments because the researcher was just interested in basic mathematical skills. This study identified 18 percent high performers, 30 percent intermediate achievers, and 18 percent underachievers using systematic random sampling.

Control and experimental groups were established for each group. During the pretesting, both groups were given a validated teacher-made test. Then genuine experimentation could begin. The control group received differentiated education without interactive multimedia but cooperative grouping, whereas the experimental group received differentiated instruction with interactive multimedia generated by the Diwa e-learning platform (Genyo). Post-testing was given after the students were exposed to the teaching-learning process for the basic competencies in Mathematics. The data collected from the teacher-made test included pre- and post-test scores, which were evaluated and interpreted using statistical analyses. The study could then conclude if differentiated instruction with interactive multimedia in the teaching-learning process is more effective than differentiated instruction without interactive multimedia in teaching basic skills in Mathematics. In this study, the experimental research approach was used. The experimental group completed the task using individualized instruction with interactive multimedia based on the students' specific arithmetic proficiency levels. The control group, on the other hand, received differentiated teaching without interactive multimedia but did use a cooperative learning strategy. The degree of difficulty in basic mathematics skills was used to address or challenge the students' academic demands. Both groups were given different formative assessments for monitoring objectives.

Design and Methods

This study was designed to cover a one unit topic. The topic and competence were chosen based on the Academic Year 2016-2017's Third Grading Period. The data collection period lasted till the end of the unit topic. The experimental group consisted of kids with varying academic levels in fundamental mathematics skills, with 18 high achievers, 30 moderate achievers, and 18 underachievers, whereas the control group consisted of the same number of pupils and was classified in the same way as the experimental group. In every Math class, the experimental group received differentiated instruction with interactive multimedia. To address the learners' ZPD, the teacher and the computers served as MKOs or tutors. Through the GENYO e-learning software designed by DIWA as lesson packages, each child in the experimental group used interactive multimedia through technology, which includes I PowerPoint presentations, I movies, (ii) games, and (iv) online quizzes. The level of difficulty in the topic was changed to reflect the students' academic achievement and to encourage them to improve their indicated mathematical skills. The teacher reviewed the outcomes of the online quizzes at the end of each activity for monitoring purposes.

The control group was designed to form two small groups in every Math class. The (i) cooperative grouping (peer-tutoring) was employed to use the advanced learners (high-achiever) and the teacher as the MKOs or the tutors to address the pupils' ZPD and the (ii) differentiated grouping (STAD) was employed to address pupils' readiness level on the basic skills in mathematics by adjusting the level of difficulties of the said subject based on pupils' readiness level. The subjects were matched accordingly based on their previous academic performances. Both the experimental and control groups' learning experiences ended after the unit topic from the Third Grading period was completed. The post-test was given after all of the learning events or intervention to see if there were significant changes in the means of the two groups from the pretests to the posttests, and if there was a significant difference between the primary gains of the experimental and control groups.

Results and Discussion

- **Performance Level of the Grade 6 Pupils on the Basic Skills in Mathematics**

Table 1 shows the performance levels of the control and experimental groups on the Basic Skills in Mathematics pretest and posttest. The pre- and post-experimentation pretests and post-tests were used to determine the performance level of the Grade 6 students.

Table 1. Pretest and Posttest Performance Levels of the Grade 6 Pupils on the Basic Skills in Mathematics

Group	n	Pretest		Posttest	
		Mean	SD	Mean	SD
Control (Exposed to Differentiated Instruction *without* Interactive Multimedia)	66	12.41 BA	5.28	18.94 A	6.68
Experimental (Exposed to Differentiated Instruction *with* Interactive Multimedia)	66	11.86 BA	4.86	18.76 A	6.86

The standard Criterion of 60% is set by USJ-R Grade School Department
The hypothetical means is in the range of 18.50-19.40
BA Below Average A Average AA Above Average

It can be gleaned from the data that control group had a pretest mean score of 12.41 with a standard deviation of 5.28, while the experimental group had a pretest mean score of 11.86 with a standard deviation of 6.68. Both groups scored below average in Math on the pretest, failing to achieve the USJ-R Grade School Department's standard of 60%. Both groups performed below average in the pretest due to the lack of intervention or discussion and their inadequate prior understanding of the topic.

On the other hand, both groups' posttest scores were higher than their pretest scores. In their posttests, the control group received an average score of 18.94 with a standard deviation of 6.68, while the experimental group received an average score of 18.76 with a standard deviation of 6.86. Both groups obtained 60 percent of their post-test performance levels in mathematics based on the hypothetical mean of 18.50-19.40. This shows that both groups reached the average level of performance set by the school. The post-test findings in both groups showed that differentiated instruction with and without interactive multimedia (DI with cooperative learning) was equally effective in teaching basic math skills.

Since both groups improved their math skills following the intervention, Bender's advice that primary school readiness skills be stressed to improve number sense and early mathematical skills is correct. Differentiation is critical in the primary years, according to Cox (2008), since "pupils' early learning experiences have a reflecting imprint on their opinions of the school, their comprehension of the learning process, and their views of themselves as learners." This backed with Joseph et al(2012) .'s findings that "Learners who were exposed to a differentiated instruction strategy fared better."

- **Mean Gain of the Grade 6 Pupils' Performance in Mathematics 6**

Table 2 shows the computed *p*-value results for correlated samples to determine whether the Grade 6 pupils gain significant improvement in their performances from the pretests to the posttests on the basic skills in Mathematics.

Table 2. Mean Gains in Pupils Performance in Mathematics 6

Group	n	Mean		$\bar{d}$	SD	Sig. (2-Tailed) p – value
		Pretest	Posttest			
Control	66	12.41	18.94	6.53	4.61	0.00*
Experimental	66	11.86	18.76	6.90	4.77	0.00*

* Significant

The data reveals that pupils who received differentiated instruction without interactive multimedia had a mean gain score of 6.53 with a standard deviation of 4.16, whereas pupils who received differentiated instruction with interactive multimedia had a mean gain score of 6.90 with a standard deviation of 4.77. Pupils exposed to differentiated instruction without and with interactive multimedia showed significant mean improvements. (p-values = 0.00) The results demonstrated that both interventions, differentiated instruction without (DI with cooperative learning) and interactive multimedia using technology, were effective in improving the performance of Grade 6 students in basic mathematics skills.

These large increases in both groups may be attributed to Vygotsky's Social Developmental Theory; hence, the MKOs addressed the prospective academic aspect of the kids' ability to learn based on their ZPDs or learning capacities. Despite no technological assistance, the students demonstrated significant learning in mathematics while using the cooperative learning technique or without interactive multimedia. Interaction between students and peers who had a better comprehension of the concept/topic helped them obtain a better understanding of the concept/topic. This finding demonstrated that Johnson and Johnson's Cooperative Learning helped students acquire confidence and achieve great outcomes. Similarly, working in small groups had a positive impact on students' mathematics performance (Hossain et al., 2012).

On the other hand, using interactive multimedia through technology to teach mathematics may have offered students with audio-visual resources and gaming applications to help them learn the skills and grasp the concept. Dr. Mayer (2014) is true when he states that multimedia training uses words and images to assist students understand concepts. This conclusion corroborated the findings of Nuris et al. (2012), who found that using interactive multimedia in the classroom helped students improve their basic mathematics skills.

- **Mean Gains of the High-achiever, Moderate-achiever and Underachiever Pupils' Performance on the Basic Skills in Mathematics 6**

Table 3 shows the computed *p*-value results for correlated samples. This is determined whether the High-achiever, Moderate-achiever and Underachiever pupils gain significant improvements in their performances from the pretests to the posttests on the basic skills in Mathematics 6.

Table 3. Mean Gains in High-achiever, Moderate-achiever and Underachiever's Performances in Mathematics 6

Group	n	Mean Pretest	Mean Posttest	*d*	*SD*	Sig. (2-Tailed) *p* – value
High-Achiever (HA)						
Control	18	17.89^BA	26.28 ^AA	8.39	4.87	0.00*
Experimental	18	16.06^BA	24.94^AA	8.88	4.60	0.00*
Moderate-Achiever (MA)						
Control	30	11.17^BA	18.70^A	7.53	4.58	0.00*
Experimental	30	11.50^BA	18.93^A	7.43	4.76	0.00*
Underachiever (UA)						
Control	18	9.00^BA	12.00^BA	3.00	2.67	0.00*
Experimental	18	8.28^BA	12.28^BA	4.00	3.62	0.00*

***** Significant

DI = Differentiated Instruction

IM = Interactive Multimedia

The data shows that high-achiever pupils exposed to DI without IM gained an average of 8.39 points with a standard deviation of 4.87, while high-achiever pupils exposed to DI with IM gained an average of 8.88 points with a standard deviation of 4.60. The mean gain score for moderate-achiever children exposed to DI without IM was 7.53 with a standard deviation of 4.58, while the mean gain score for moderate-achiever pupils exposed to DI with IM was 7.43 with a standard variation of 4.76. The mean gain score of underachiever students exposed to DI without IM was 3.00 with a standard deviation of 2.67, while the mean gain score of underachiever students exposed to DI with IM was 4.00 with a standard deviation of 3.62.

The main gain from pretest to post-test scores for high-achiever pupils subjected to DI without and with IM was 47 percent and 55 percent, respectively. The average gain of high-achieving pupils exposed to DI with IM was 8% higher than the mean gain of high-achieving pupils exposed to DI without IM. The mean gain from pretest to post-test scores for moderate-achiever pupils exposed to DI without and with IM was 67 percent and 65 percent, respectively. The average gain of moderate-achiever kids exposed to DI with IM was 2% lower than the average gain of moderate-achiever pupils exposed to DI without IM. From the pretest to the post - test, the mean gains of underachiever pupils exposed to DI without and with IM were 33 percent and 48 percent, respectively. Pupils exposed to DI with IM scored 15% higher than those exposed to DI without IM. The underachiever pupils subjected to DI with IM had a higher mean gain than the other groups of performers in all three groups. In the underachiever students, a 15 percent higher mean gain indicates that kids exposed to DI with IM learnt slightly better than pupils exposed to DI without IM.

It may be deduced that there were significant mean gains between the pretests and posttests of Grade 6 kids exposed to DI without and with IM at all levels of performance (High-achiever, Moderate-achiever, and Underachievers) (All p-values equal to 0.00). Teachers should use differentiated instruction to meet the requirements of students and challenge them, as each type of student's preparedness capacity varies (Grass, 2013). The HA pupils raised their post-test to above-average level from the pretest of below-average level, while the MA pupils raised their post-test to average level from the pretest of below-average level. However, the underachiever pupils did not meet the USJ-R Grade School Department's standard criterion, implying that intensive monitoring of these pupils' learning progression, as well as special attention through learning acts, should be observed. However, the results of this study show that underachiever students who were given differentiated instruction without (cooperative learning) and with interactive multimedia had significantly higher mean gains from pretest to post-test, even though they remained below-average after the two teaching-learning methods were used.

- **Comparison of the Mean Gains Performance on the Basic Skills in Mathematics 6 between the control and the experimental groups.**

With a p-value of 0.88, it can be established that the mean gains of learners subjected to differentiated instruction without (cooperative learning) and with interactive multimedia were not significantly different. This could be because differentiated instruction was used effectively in both groups. There is no evidence that differentiated instruction with interactive multimedia delivered through technology is more successful than differentiated instruction without interactive multimedia or DI delivered through the cooperative learning technique. However, there is a very small difference in mean gains between kids exposed to differentiated instruction with interactive multimedia through technology and pupils subjected to differentiated instruction without interactive multimedia or DI with cooperative learning in the latter.

Since both methods were effective in improving pupils' basic mathematical performance and the mean gains of both groups did not differ significantly, it is reasonable to infer that, despite the difficulty of integrating technology nowadays, pupils can still significantly improve their basic mathematical skills even without using interactive multimedia through technology. According to Slavin (2014), effective teaching strategies can enhance math outcomes for all students, and this study focuses on the critical function of MKOs in addressing the students' ZPD. There was no significant difference in mean gains between the control and experimental groups, indicating that the cooperative learning approach used by pupils exposed to differentiated instruction without interactive multimedia had an equivalent learning outcome on basic mathematical skills to pupils exposed to differentiated instruction with interactive multimedia through technology. This could indicate that technology cannot replace teachers in helping students improve their basic mathematics skills. There are still many ways to meet the new trend in teaching without using technology, but the researcher believes that 21st-century learners must be exposed to technology in order to cope with the worldwide demand for the many skills ahead.

Conclusion

The students' readiness level is one of the elements for differentiation that would address the students' requirements (for some moderate and underachievers) and push them in learning the fundamental abilities in mathematics (for some moderate and high achievers). According to the study's findings, Dr. Mayer's theory of multimedia in learning mathematics was beneficial in using differentiated instruction with interactive multimedia using technology. Nuris, et al. agreed with Mayer that using multimedia with graphics and animation could lead to meaningful learning outcomes for students, but they found that the pupils had the same learning outcomes as those exposed to differentiated instruction with cooperative learning by Johnson & Johnson and the teacher's ability to facilitate the teaching-learning process in the classroom. As a result, at this time, technology as a tool for interactive multimedia cannot replace teachers in strengthening children' basic mathematical skills; thus, Lev Vygotsky's theory of social development through differentiation should be used in the early development of pupils' mathematical skills.

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