Effects of Differentiated Instruction on Mathematics Achievement and Critical Thinking Skills of Students

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Abstract

This quasi-experimental study ascertained the effects of differentiated instruction on the mathematics achievement and critical thinking skills of the 54 Grade 10 high school students of a state university in Roxas City. The investigation specifically covers the topics on permutation, combinations, union and intersection of events, dependent and independent events, mutually exclusive events and probability of events. Different strategies of teaching to suit the needs of the learners were used during the total 28-hour period experiment. The study utilized a validated researcher-made test in mathematics and critical thinking skills test, a learning style and multiple intelligence inventories. Results disclose that the students in the differentiated instruction had interactive, analytic, and introspective learning styles and were visual and kinesthetic learners. The pre-test mathematics achievement of the two instructional groups – the differentiated and the non-differentiated- are comparably "low", whereas their critical thinking skills are "unreflective". However, post-test results show that the differentiated instruction group has "high" mathematics achievement and "developing" critical thinking skills; while the non-differentiated group has an "average" post-test mathematics achievement and "developed" critical thinking skills. Significant differences were noted in the pre-test and post-test mean gains of the two groups in mathematics achievement and critical thinking skills, in favor of the differentiated group. With this, the researcher posits that there is a need for practitioners to understand the components of differentiation to design lessons that address the needs of learners.

Keywords: critical thinking skills differentiated instruction, mathematics achievements

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Mathematics is viewed as the foundation of scientific technological knowledge that is vital in the economic development of a nation. According to Drew (1996), mathematics is the most important factor that relates to an individual's success. She describes mathematics as a subject that is required for entry into many professions and for existing as well as emerging occupations in the global economy. Saffer (1999) also states that mathematics is useful not only just in day-to-day chores such as managing money, but also in countless jobs that call for mathematics skills. This explains why mathematics is hailed at a higher rate compared to other fields of knowledge, and it has been called the "queen of all sciences and a servant to all disciplines (Arjayc, Kawani, & Adenyanju, 2013).

Unfortunately, learners' achievement in mathematics over the years has not been encouraging at the all levels of education not only in the Philippines but also in other countries around the world. Educators, trainers, and researchers have long been interested in exploring teaching strategies that effectively contribute to quality mathematics performance of learners. More than ever, teaching effectiveness is predicated on teachers' ability to meet the needs of a wide range of students.

With the implementation of the K-12 mathematics curriculum by the Department of Education, educators have made up one ultimate learning objective for all students: to help them think critically; thus, the researcher used differentiated instruction to improve students' mathematics achievement and to enhance their critical thinking skills.

Differentiated instruction is a means of teaching all children to help them reach a common goal, regardless of the path they take to get there (Tomlinson, 2009). Butt and Kausar (2010) opine that "differentiated instruction is an approach to planning so that one lesson may be taught to the entire class while meeting the individual needs of each child". Moreover, Levy (2008) explains that the focus of differentiated instruction is to ensure that all learners reach the same goals, however, with the tools of differentiated instruction, the process of arriving there is unique for each student. Ankrum and Bean (2008) state that "true differentiation means that the lesson focus is different for each group". Evans and Waring (2011) argue that "differentiated instruction is not teaching students one by one; rather, it requires the educator to understand the strengths and needs of all students in his/her classroom".

In differentiated instruction, teaching is anchored on the curriculum and on the students learning needs. The learning goals are adjusted to the students' learning preferences. A teacher who emphasizes creative and critical thinking and the application of learning uses several instructional formats (for example, whole class, small groups, partners, individuals) and a variety of instructional strategies (for example, lectures, manipulative, role plays, simulations, readings). Furthermore, a teacher's reteaching activities demand higher-level thinking while reinforcing basic skills and content. A teacher applies relevant assessment to check students' learning throughout an instructional sequence and allows for learner differences by providing a variety of ways to show learning. On the other hand, in non – differentiated instruction, covering the curriculum is the first priority, and it directs the teaching. The learning goals remain the same for all students and the teacher emphasizes mastery of content and skills. Primarily, the teacher uses whole-class instruction and tends to employ similar instructional strategies day to day. Moreover, a teacher's reteaching activities typically involve lower-level thinking-knowledge and comprehension to reinforce basic skills and content. Usually the teacher assesses students' learning at the end of an instructional sequence. In this instruction, the teacher typically uses the same assessment tool, product, or project for all students as well (Tomlinson, 2002).

Critical thinking skills refers to the ability that students have developed after the intervention was done and measured using the 5-open-ended researcher-made test and was rated employing a researcher made rubrics.

Purpose of the Study

This study ascertained the effects of differentiated instruction on students' mathematics achievement and critical thinking skills.

Specifically, the research questions that guided this paper are as follows:

1. What are the learning styles, emotional intelligence, and multiple intelligences of the students in the differentiated instruction?

2. What is the pretest and posttest mathematics achievement level and critical thinking skills of students exposed to (a) differentiated instruction and (b) non-differentiated instruction?

3. What is the mean gain in mathematics achievement and critical thinking skills of students in the (a) differentiated instruction and (b) non-differentiated instruction?

4. Is there a significant difference in the pretest mean results in mathematics achievement and critical thinking skills of students in the differentiated and the non-differentiated instruction?

5. Is there a significant difference in the post-test mean outcomes in mathematics achievement and critical thinking skills of students in the differentiated and the non-differentiated instruction?

6. Is there a significant difference in the mean gains in mathematics achievement and critical thinking skills of students in the differentiated and the non-differentiated instruction?

7. Is there a significant difference in the pre-test and post-test mean results in mathematics achievement and critical thinking skills of students in the differentiated and the non-differentiated instruction?

Materials and Methods

The quasi-experimental, specifically the matching-only pre-test –post-test research design, was employed in this study. The investigation involved 54 purposively chosen Grade 10 high school students, 27 of whom were assigned to the experimental group (differentiated instruction) and the other 27 to the control group (non-differentiated instruction). The students were comprehensively match-paired on the basis of their learning styles and multiple intelligences. Match pairing was done to determine if there was a difference on the effect of the differentiated instruction and the non-differentiated instruction between the control and experimental group.

The research instruments that were utilized to gather data were a survey questionnaire adapted from Walter McKenzie (1999) for the participants' learning styles and multiple intelligences, a 5 open-ended question on critical thinking skills and a researcher-made validated 40-item multiple-choice test comprising questions on permutation, combinations, union, and intersection of events and probability of events.

The research procedure is shown in Figure 1.

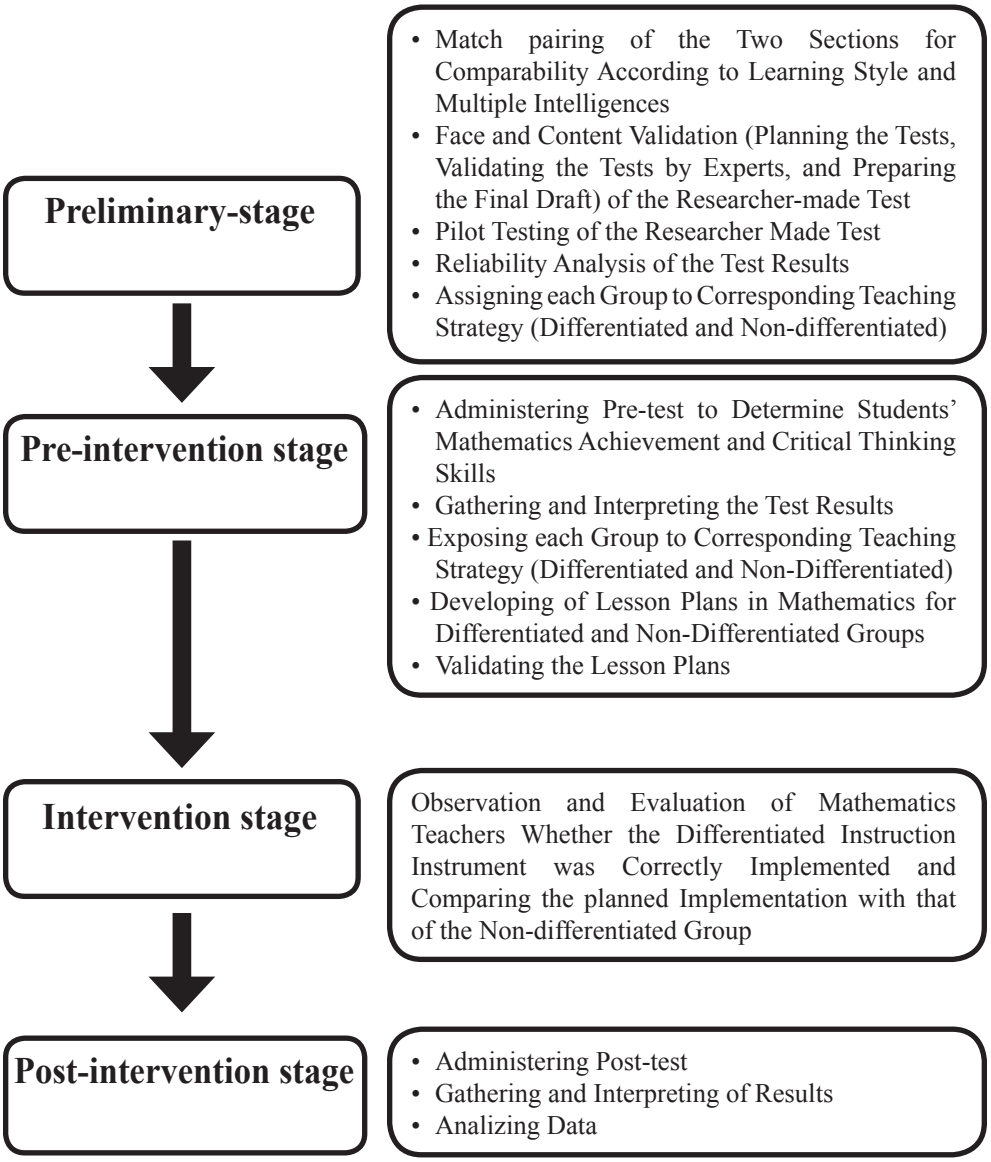

Figure 1: The research procedure.

Results and Conclusions

Participants in the differentiated instruction were found to be interactive, analytic, and introspective; most of them were visual, existential and kinesthetic as to their multiple intelligences. This indicates that a single classroom could

become a home to students with varying characteristics, learning styles, and multiples intelligences. Thus, attending to students' differences, teacher/ student collaboration regarding learning expectations, and uniting assessment and instruction (Logan, 2011) will help ensure that all students are reaching the same academic goal, but with the tools of differentiated instruction, the process of arriving there is unique for each student (Levy, 2008).

The pre-test mean scores of the two instructional groups in mathematics achievement were low and their critical thinking skills mean scores were "unreflective". However, the post-test mathematics mean score of the participants in the differentiated instruction was high, while that of the non-differentiated instruction groups was "average". The differentiated instruction group had a "developing" critical thinking level while the non-differentiated instruction group was found in the emerging level.

There was a big leap in the mean gain in mathematics achievement (low to high) of the differentiated instruction participants compared to a slight improvement in mathematics achievement (low to average) of the non-differentiated instruction group. Likewise, the mean gain score of the differentiated instruction class in critical thinking was shown to be highly better (developing) than the non-differentiated instruction class' critical thinking level (emerging thinkers). These findings agree with results from the studies of Voke (2002), Mills (2007), Beecher and Sweeny (2008), Grimes and Stevens (2009), Tomlinson (2009), Levy (2008), Lauria (2010), Goodnough (2009), Chamberlin and Powers (2010) and Tulbore (2011) that through differentiated instruction, students become successful, have better achievement and make students reach the same academic goal, and the process of arriving there is distinctive .Furthermore, Mulder (2015) found that although differentiation is widely acknowledged to be an important instructional approach for all students, as it is expected to improve the learning of each student, there is little known about the precise relationship between differentiation and learning of students. Hayes and Deyle (2001) claim that it is difficult to determine the possible effects of differentiated instruction on the achievement of students because the effects of differentiation may differ in each school. On a more positive note, Dee (2010) and Roy, et al. (2013), argue that differentiated instruction can be labeled as a promising approach in improving education. They see differentiated instruction as the key to academic success for all students in regular classroom- thus, supporting the findings of this study.

Table 1

Pre-test and Post-test Performance of the Differentiated and the Non-differentiated Groups

	Differentiated Instruction			Non-differentiated Instruction		
	SD	M	Interpretation	SD	M	Interpretation
Pre-test						
Mathematics Achievement Test	3.85	14.52	Low	3.43	13.11	Low
Critical Thinking Skills	1.49	1.19	Unreflective	1.50	1.11	Unreflective
Post-test						
Mathematics Achievement Test	3.59	27.19	High	2.87	20.78	Average
Critical Thinking Skills	3.19	10.74	Developing	3.90	7.56	Emerging

Note: Mathematics Achievement: 32.01 – 40.00=Very High; 24.01 – 32.00=High; 16.01 – 24.00=Average; 0.00 – 8.00=Very Low
Creative Thinking Skills: 33.78 – 45.00= Very Creative; 22.52 – 33.77=Creative, 11.26 – 22.51=Ordinary/ Routine, 00.00 – 11.25=Imitative
Critical Thinking Skills: 16.01 – 20.00=Exemplary Thinker; 12.01 – 16.00= Proficient Thinker; 8.01 – 12.00=Developing Thinker; 4.01 – 8.00=Emerging Thinker; 00.00 – 4.00=Unreflective Thinker.

Further findings of this study show that there is no significant difference in the pre-test scores in mathematics achievement, and critical thinking skills of the two groups. However, significant differences are found in the post-test scores of the two instructional classes in mathematics achievement and critical thinking skills in favor of the differentiated group. As McAdamis (2001) notes, differentiated instruction increases the students' motivation and interests in the lesson, which shows similarities to the findings of this study. Differentiated instruction increases the students' interest toward the lessons (Tieso, 2005, 2001; Fahey, 2001; McAdamis, 2001).

Table 2

Difference in the Pre-test and Post-test Scores of Students in Mathematics Achievement, Creative Thinking Skills, and Critical Thinking Skills of the Non-Differentiated Instruction

Differentiated Instruction	Mean	z	Sig
Mathematics Achievement			
Pre-test	13.11	4.546*	0.000
Post-test	20.78		
Critical Thinking Skills			
Pre-test	1.11s	4.559*	0.000
Post-test	7.56		

Note: *$p < 0.001$.

Conclusions and Recommendations

Differentiation as a framework may be used to build a lesson using the best teaching practices. Since, differentiation involves student pre-assessment data, no two classrooms are exactly the same, although the framework could be.

Educators who want success for all students need to change their current practices. Understanding the importance of pre-assessment, either as a simple observation or a pre-test is the first step to accomplishing this change. By administering a learning style inventory at the beginning of each school year, teachers can become cognizant of their students' strengths and weaknesses and make modifications to lessons to ensure that learning takes place for all students.

With the advent of differentiated instruction as an approach to teaching, in-service trainings and workshops should be designed by state colleges and universities to update teachers in different fields of endeavor and to use this effective instructional strategy, thus making learning engaging.

Policy makers of the university and other institutions may implement realistic policy in terms of the use of differentiated instruction; this will help students find mathematics instruction not boring but more enjoyable, engaging, and active, and will lead them to think critically and creatively. Also, teachers may provide varied activities supportive of students' learning to encourage them to be creatively and critically engaged in different learning activities in mathematics. On the other hand, students should be given freedom of choice in their assignments of activities, be this in terms of journal making, role playing, graphic organizing, musical composition, and poetry writing to make mathematics lessons engaging.

Lastly, future researchers can investigate on which instructional strategy apart from differentiated instruction may work best for different cultures, disabilities, and economic status. Also, teachers may use the learning guide and sample exemplary instructional materials designed by the researcher and introduce a specific differentiated instructional strategy for every learning group.

References

Ankrum, W.W. & Bean, R.M. (2008). Differentiated reading instruction: What and how. *Reading Horizons*, *48*(2), 133-146. Retrieved from ERIC database. (EJ833886).

Arjayc, K.O, Kawani, A.O, & Adenyanju, H.I (2013). Effects of students' attitude and self-concept on achievement in Senior High School Secondary School Mathematics in Ogin State, Nigeria. *Journal of Research in National Renelyzest*, *9*(2), 202-211.

Beecher, M. & Sweeny, S. M. (2008), Closing the achievement gap with curriculum enrichment and differentiation: One school's story. *Journal of Advanced Academics*, *19*(3), 502-530

Butt, M. & Kausar, S.(2010). A comparative study using differentiated instruction of public school teacher. *Malaysian Journal of Distance Education*, *12*(1), 105-124. Retrieved from Education Research Complete Database. (Accession No. 78221508).

Chamberlin, M., & Powers, R. (2010). The promise of differentiated instruction for enhancing the mathematical understandings of college students. *Teaching Mathematics and Its Applications, 29*(3), 113-139.

Drew, D. E. (1996) *Aptitude revisited*. Baltimore: Md. John Hopkins University Press.

Evans, C. & Waring, M. (2011). How can an understanding of cognitive style enable trainee teachers to have a better understanding of differentiation in a classroom? *Educational Research for Policy and Practice*, *10*(3), 149-169.

Goodnough, K. (2010). Investigating pre-service science teachers' developing professional knowledge through the lens of differentiated instruction. *Research in Science Education, 40*(2), 239-265.

Grimes, K. J., & Stevens, D. D. (2009). Glass, bug, mud: A self-assessment system enables teachers to differentiate elementary mathematics instruction, which boosts both student learning and students' sense of themselves as mathematicians. *Phi Delta Kappan*, *90*(9), 677-680. doi: 10.1177/003172170909000914

Levy, H.M. (2008). Meeting the needs of all students through differentiated instruction: Helping every child reach and exceed standards. *Clearing House*, *81*(4), 161-164. Retrieved from Education Source database. Accession No. EJ789449).

Logan, B. (2011). Examining differentiated instruction: Teachers respond. *Research in Higher Education Journal*, *1*(3), 1-14. Retrieved from Education Research Complete database. (Accession No. 70547708).

Saffer, N. (1999). Core Subjects and your career. *Occupational Outlook Quarterly*, 26-40. Retrieved 25 June 2013 from http://216.12.136.114/downloads/Core_Subjects_and_Your_Career.pdf.

Sternberg, R. J. (2006). Recognizing neglected strengths. *Educational Leadership*, *64*(1), 30-5.

Tomlinson, C. A. (2009). Intersections between differentiation and literacy instruction: Shared principles worth sharing. *The NERA Journal*, *45*(1), 28-33. Retrieved from Education Research Complete database. (Accession No. 44765141)

Tomlinson, C.A. (2001). *How to differentiate instruction in mixed-ability classrooms* (2nd ed.). Virginia: Association for Supervision and Curriculum Development

Tomlinson, C.A. (2002). Different learners, different lessons. *Instructor*, *112* (2), 21-26.

Tomlinson, C.A. & Brighton, C. et.al. (2003). Differentiating instruction in response to student readiness, interest, and learning profile in academically diverse classrooms: A review of literature. *Journal for the Education of the Gifted*, *27* (2/3), 199-145.

Tulbure, C. (2011). Differentiated instruction for pre-service teachers: An experimental investigation. *Procedia-Social and Behavioral Sciences*, *30*, 448-452. doi: 10.1016/j.sbspro.2011.10.088