RESEARCH ARTICLE

EFFECTS OF DIFFERENTIATED INSTRUCTION ON COLLEGE STUDENTS' ACHIEVEMENT IN AND ATTITUDE TOWARDS TRIGONOMETRY

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ABSTRACT

The study explored the effects of differentiated instruction (DI) on students' achievement in and attitude towards Trigonometry using a quasi-experimental design. Based on the students' identified learning needs, instruction made use of flexible grouping, varied formats (e.g. cooperative learning, group projects, whole-class discussion, peer teaching, experiential learning approach), and various strategies such as compacting, tiering, cubing, choice boards, anchor activities, RAFT, think-tac-toe, think dots, and layered curriculum. Results showed that the students taught using DI had a significantly higher achievement in Trigonometry than those who were taught using the lecture-discussion method. The use of DI did not change the students' attitude towards the subject in the 2-month period of the study. However, the students' learning journals showed that DI provided the students with more positive learning experiences.

Keywords: D*ifferentiated instruction, Student achievement, Attitude, Teaching strategies*

INTRODUCTION

In the lecture-discussion approach to teaching which is prevalent in the Philippine educational setting, there is an assumption that all students have the same capacity and rate of learning. Students are not given the opportunity to develop, improve, and learn according to their own capacity of understanding and rate of completing and learning a task or knowledge (Tomlinson, 1999; Norlund, 2003; Domingo, 2008).

A one-size-fits-all classroom setting demonstrates major problems for the slow, average, and advanced learners. The slow or struggling learners are faced with high expectations of the school system but are left alone in their own devices to figure out how to cope with these expectations (Tomlinson, 1999; Reyes, 2006). The fast learners, on the other hand, have to wait patiently for the others to catch up and as a result, they are limited from learning more complex and challenging concepts and skills (Allan & Tomlinson, 2000). Gardner's (2011) theory of multiple intelligences states that people have different intelligences and they learn in many different ways. No two individuals have exactly the same profile of intelligences. Gardner's work challenged schools to look at what students could do well, instead of what they could not do. With the continued slide of students' performance in mathematics in the Philippines, there is a clear need to explore other perspectives to teaching and learning that will address students' differences and multiple intelligences.

A differentiated instruction (DI) contrasts with the one-size-fits-all traditional lecture-discussion method as it requires teachers to proactively plan and design a variety of instructional methods and materials to best facilitate systematic and effective learning experiences appropriate to the diverse learners in a classroom (Tomlinson, 1999). In this context, students who learn in different ways, have different interests, and learn in different phases and rates, are recognized and guided systematically to maximize learning. Since each student is a unique individual, it is the teacher's responsibility to understand and respond to the needs, interests and capacities of each student to ensure his or her educational growth and development (Anderson, 2007).

The theoretical and philosophical influences embedded in DI support its three key elements: readiness, interest, and learning profile (Allan & Tomlinson, 2000). Vygotsky (1986) showed that individuals learn best in accordance with their **readiness**. The readiness of the individual should match what a student learns, how he learns it, and how he demonstrates what he learned using DI. The difficulty of skills taught should be slightly in advance of the child's current level of mastery. This view is grounded in Vygotsky's work and the zone of proximal development (ZPD), the range at which learning takes place. This theoretical influence provides a concrete foundation for the teaching approach of differentiated instruction. Psychologists tell us that a student only learns when a task is a little too hard for the learner. When a student can do work with little effort, s/he is not learning, but rather rehearsing. When a student finds a task beyond reach, frustration, not learning, is the result. Only when a task is a bit beyond the student's comfort level, and s/he finds a support system to bridge the gap, does learning occur. Considering the diversity of needs of students in today's classrooms, it is unlikely that a teacher will consistently be able to develop one-size-fits-all learning experiences within the zones of proximal development of all students in a particular class.

Student **interest,** the second key element of DI, is supported by the philosophical idea that interest-based options seize on intrinsic motivation. According to Jerome Bruner, when interest is tapped, learning is more likely to be rewarding and effective and the student becomes a more autonomous learner (Erickson, 2007). Educators can encourage and support learner's natural curiosity and motivation to learn by attending to individual differences in learner's perception of optimal novelty and difficulty, relevance and personal choice, and control.

Gardner's theory of multiple intelligences supports the third key element of DI, that accounts for students' different **learning profiles** or learning styles. People have different intelligences and learn in many different ways (Gardner, 1997). In fact, no two individuals have exactly the same profile of intelligences. The theory suggests that schools should offer individual-centered education, having curriculum tailored to a child's intelligence preference (Allan & Tomlinson, 2000).

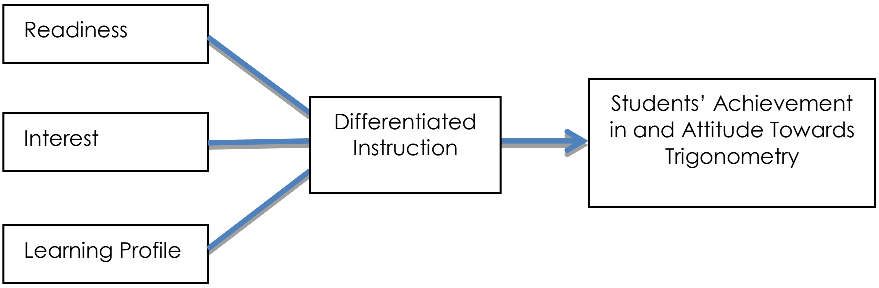

Figure 1. Research framework

In the face of successful studies on the use of DI in many countries such as the United States (Tomlinson, 1995, 1999) and Canada (McQuarrie & McRae, 2010), it would be interesting to examine the effects of DI on the Filipino tertiary students' achievement in and attitudes toward Trigonometry.

METHODOLOGY

This study aimed to make a comparative analysis between the effects of differentiated and traditional lecture-discussion teaching methods on the achievement in and attitude of students towards Trigonometry. The key elements of the independent variable (DI) were students' readiness level, learning interest and learning profile. The dependent variables were the students' achievement in and attitude towards Trigonometry, measured by their posttest scores in Plane Trigonometry achievement test and the attitudinal questionnaire, respectively.

A quasi-experimental method of research, particularly the non-equivalent control group design was used with two intact sections of college freshmen from Bulacan State University as participants. To ensure equivalence between the two intact groups, students were pretested prior to experimentation, and the results of their pretest were used as a covariate in the study.

A table of specifications served as guide in determining the distribution and cognitive level of questions in the achievement test. It related outcomes to content and indicated the relative weight to be given to each of the various areas (Gronlund, 1997). Mathematics experts in Bulacan State University checked the content validity of the test. A trial run of the achievement test was done with a group of college students to determine the language suitability of the items, the clarity of the test directions, and the sufficiency of time for the test. An item analysis followed based on the students' responses. The revised version was given to another group of students and the results were used for the item and options analyses. On the other hand, the attitudinal questionnaire was adapted from Arañador (1990) with the author's permission.

The researcher taught both the experimental and control groups. In the experimental group, the researcher carefully studied the individual differences of the students as reflected in their interest and learning style inventories and their achievement test. The results served as the basis in adjusting the instruction to the identified learning needs of the students in the experimental group. Varied instructional materials and formats were provided to the students in each lesson based on their learning needs. Flexible grouping was used in the instruction to best facilitate differentiation based on readiness level, interest or learning styles of the students and to avoid students being tagged as slow or struggling learners. The results of assessment of the prior knowledge of the students indicated that they were largely different from one another in their entry points relative to particular topics. Thus, they were grouped according to their background knowledge. Students with less than adequate knowledge sat in front of the class. They were taught using the model method and were given closer guidance. Students with adequate understanding of the topic but needed more practice for mastery were grouped together to work on a worksheet prepared by the teacher. Students with evident mastery of the topic were given more complicated and challenging tasks. Some of the students were also allowed to work alone if this was found to be their best modality of learning.

This study made use of the following strategies for differentiated instruction: compacting, tiering, cubing, choice boards, anchor activities, RAFT, think-tac-toe, think dots, cooperative learning, layered curriculum, and some other beneficial and effective teaching strategies that were deemed responsive to students' differences in terms of their readiness level, interest, and learning preferences.

The inventory showed that the students were more interested to do real-life applications of Trigonometry and they differed on their ways of learning. While some students preferred to read about the topic, or listen to others discussing it, others claimed to acquire knowledge by manipulating objects associated with the content. Thus, the lessons were presented in a variety of ways using different instructional materials.

The students were also given anchor activities to make learning continuous. Some students even suggested activities that they found interesting. They were also given the freedom to choose to work alone or in groups.

Assessment and learning evaluation were integrated in the instruction through reflection exit cards. Figure 2 shows an example of an activity that was differentiated based on students' interest with its own reflection exit card:

Trigonometry R.A.F.T.: CHOOSE YOUR OWN ADVENTURE!!!

Role	**Audience**	**Format**	**Topic**
1. BMX Rider	Builder	Drawing with measurements	A new motocross course is being built and the starting ramp is being designed. A higher and longer ramp gives riders more speed to start the race. Draw a ramp that would have a length of at least 15 meters with an angle of elevation 30°. Include all measurements on your drawing.
2. Biologist	Community	Technical Report	A biologist wants to know the width of a river in order to properly set instruments to study the pollutants in the water. From point A, she walks downstream 100 feet and sights to point C. From this sighting, she determines that $\theta = 60°$. How wide is the river?

3. Lighthouse Keeper	Sea farer	Description/ Report	A vertical cliff is 50m above sea level. The angle of depression of a boat from the top is 45°. How far is the boat from the cliff?
4. Surveyor	Co-worker	Technical report	To determine the height of a radio transmission tower, a surveyor walks off a distance of 300 meters from the base of the tower. The angle of elevation is then measured and found to be 45°. If the transit is 2 meters off the ground when the sighting is taken, how high is the radio tower?
5. Historian	Students	Informative Report	One of the Original Seven Wonders of the World, the Great Pyramid of Cheops was built c. 2580 B.C. Its original height was 480 feet, 11 inches, but due to the loss of its topmost stones, it is now shorter *(Guiness Book of World Records)*. Find the current height of the Great Pyramid, using the information given in the illustration below. (Illustration

Varied activities such as group projects and research were also used to extend learning. A group of students made improvised clinometers and used them to measure the height of the buildings in the campus. Another group of students interviewed professionals like engineers, architects, and even criminology specialist to learn how Trigonometry was being used in their careers. Others made an interesting presentation on the common mistakes of students in Trigonometry. Students identified the misconceptions and offered ways to address the misconceptions. Each group was asked to evaluate their classmates' presentations.

Some students also kept learning journals to respond to guide questions every week. Anecdotal notes, portfolios, projects, and journal writing were some of the assessment tools used to monitor students' progress. Figure 3 shows some of the activity worksheets and students' outputs.

REFLECTION EXIT CARD

Name: ________________________________

What occupation were you focusing on in today's activity?

What does trigonometry have to do with the occupation that you looked at?

How do you find the activity given to you? Were you able to do it with confidence?

Is trigonometry easy for you?

Solve the given problem below.

At a distance from the base of a tower, it is found that the angle of elevation of the top of the tower is 28° 40'. After walking a distance of 142 meters closer to the tower, it is found that the angle of elevation of the same top is now 60° 20'. How high is the tower?

Figure 2. Sample Activity for Differentiated Learning with Reflection

Exit Card

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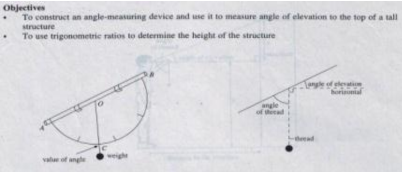
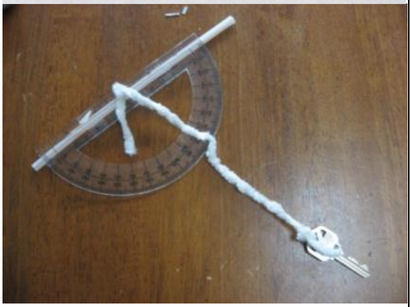
<td>



An example of clinometer students made to measure the height of some building on campus.</td>
<td>A Song to Remember

Sin 45 cos 45 square root of 2 over 2

Sin 60 degrees cos 30 degrees

square root of 3 over 2

Sin 30 cos 60 are equal (2x)

have the same in value (2x)

its ½ (2x)

Tan 45 (2x) equals 1 (2x)

Tangent 30 degrees (2x)

square root of 3 over 3

Tangent 60 (2x) square root of 3 (2x)

and the other functions (2x)

are reciprocal

A song about special angles that the students composed and sang during a class discussion.</td>
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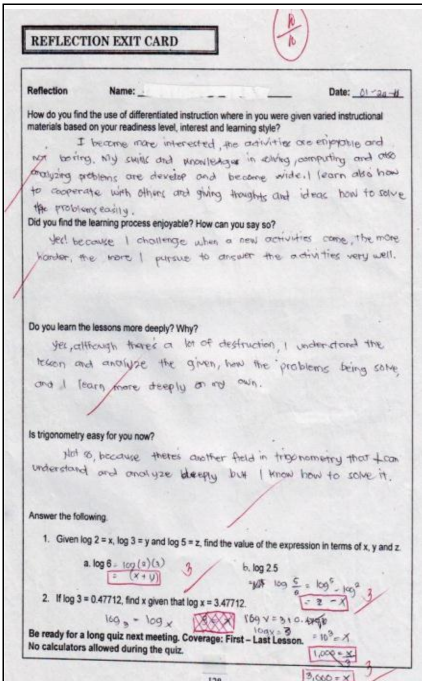

REFLECTION EXIT CARD

Reflection Name: Date: 01-20-11

How do you find the use of differentiated instruction where in you were given varied instructional materials based on your readiness level, interest and learning style?

I become more interested, the activities are enjoyable and not boring. My skills and knowledges in solving, computing and also analyzing problems are develop and become wide. I learn also how to cooperate with others and giving thoughts and ideas how to solve the problems easily.

Did you find the learning process enjoyable? How can you say so?

Yes! because I challenge when a new activities come, the more harder, the more I pursue to answer the activities very well.

Do you learn the lessons more deeply? Why?

Yes, although there's a lot of destruction, I understand the lesson and analyze the given, how the problems being solve, and I learn more deeply on my own.

Is trigonometry easy for you now?

Not so, because there's another field in trigonometry that I can understand and analyze deeply but I know how to solve it.

Answer the following.

1. Given log 2 = x, log 3 = y and log 5 = z, find the value of the expression in terms of x, y and z.

a. log 6 = log (2)(3) = (x + y)

b. log 2.5 = log 5/2 = log 5 − log 2 = z − x

2. If log 3 = 0.47712, find x given that log x = 3.47712.

Be ready for a long quiz next meeting. Coverage: First – Last Lesson.
No calculators allowed during the quiz.

An example of a reflection exit card of a student.
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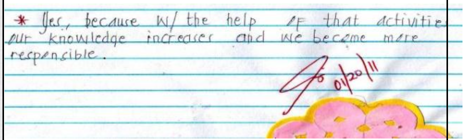
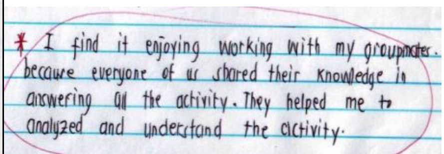
Learning Journal

Question: Are you looking forward to having more activities like this?



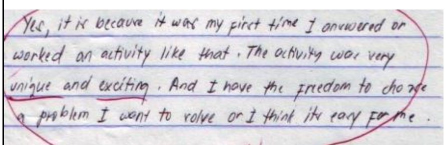
* Yes, because w/ the help of that activities our knowledge increases and we become more responsible.

Question: How do you find working with your group?



* I find it enjoying working with my groupmates. because everyone of us shared their knowledge in answering all the activity. They helped me to analyzed and understand the activity.

Question: Do you prefer to have activities like this wherein you are given the chance to choose how to acquire the knowledge presented to you?



Yes, it is because it was my first time I answered or worked an activity like that. The activity was very unique and exciting. And I have the freedom to choose a problem I want to solve or I think its easy for me.
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Figure 3. Sample Worksheets and Student Outputs

Students in the control group, on the other hand, were taught using the traditional lecture-discussion method. The teacher-researcher discussed the lessons in the lecture-format and students were given seatwork and written activities. Some students were also asked to explain to class their solutions in a particular word problem in Trigonometry. Furthermore, students were given a written quiz at the end of each chapter.

RESULTS AND DISCUSSIONS

To determine the students' achievement in Trigonometry in the differentiated and lecture-discussion instruction groups, the pretest and posttest mean scores of the students including the standard deviations were obtained.

Table 1. Comparison of the Pretest and Posttest Mean Scores (N = 30)

Groups	Pretest			Posttest			t - value
	Mean	VI	SD	Mean	VI	SD	
Differentiated Instruction	13.2	S	4.57	26	VS	4.68	23.05
Traditional Instruction	17.2	S	5.65	22.2	VS	5.71	8.12

VI – Verbal Interpretation
SA – Strongly Agree, A – Agree, U – Undecided, D – Disagree, SD – Strongly Disagree

As Table 1 shows, the computed t-value of the comparison of the pretest and posttest scores of the students in the DI group was 23.0 indicating that their posttest mean score was significantly higher than their pretest mean score. This result implies that modifying instruction is more likely to result in greater student engagement and increased achievement.

To determine if there was a change in students' attitude towards Trigonometry, the mean scores of the students in each group were obtained before and after the experiment. These results are shown in Table 2.

Table 2. Comparison of the Students' Attitude Mean Scores Before and After the Instruction (N = 30)

Groups	Pre-attitude			Post-attitude			t-value
	Mean	VI	SD	Mean	VI	SD	
Differentiated Instruction	3.62	A	0.52	3.71	A	0.51	0.82
Traditional Instruction	3.64	A	0.56	3.70	A	0.53	0.41

Table 2 shows that the computed t-value of the comparison of the mean scores of the students in the differentiated instruction group revealed no significant difference. This indicates that their attitude remained the same even after the experiment. A possible explanation for this lack of change in their attitudes is the short period of experimentation. Students' attitude and behavior towards mathematics take a longer period to change and improve. However, the students' learning journals revealed that they found differentiated instruction to be challenging, enjoyable, interesting and a unique learning experience.

When asked about their perception on the use of differentiated instruction, here are some of the unedited entries in the students' journals:

> "Enjoyable, because I learned the lesson well. And we express well our learning by using our own learning style. I find it interesting and quite challenging like when we have Think-Tac-Toe we have freedom to choose what we are going to answer."

> "I became more interested, the activities were enjoyable, not boring. My skills and knowledge in solving, computing and also analyzing problems were developed and become wider."

> "I find it easier because my degree of interest in learning is leveling up, I don't get bored and the lesson and learning was within my ability and capacity."

To determine whether there was a significant difference in student achievement between the differentiated and lecture-discussion instruction groups, the Analysis of Covariance (ANCOVA) was utilized using the pretest scores of the respondents as a covariate.

The computed F-value (19.17) indicates a significant difference between the posttest mean scores of the differentiated and the lecture-discussion instruction groups. This result implies that differentiated instruction can better improve students' achievement than the lecture-discussion method. Teachers are therefore challenged to provide students with varied, rich and worthwhile learning experiences as such approach seems to improve their achievement. As this study has shown, the need to differentiate instruction is true even for college students.

To determine if there was a significant difference between the attitudes of the students in the differentiated and lecture-discussion instruction groups, the analysis of covariance (ANCOVA) was also utilized with the pretest attitude scores of the respondents as the covariate.

The computed F-value (0.33) of the posttest attitude mean scores of the two learning groups revealed no significant difference. This result indicates that the experiment had no effect on the attitude of the students in the two learning groups. Differentiated instruction did not improve nor change the attitude of the students towards Trigonometry during the experimentation.

Lastly, to determine if there was a relationship between the students' achievement in and attitude towards Trigonometry in the differentiated and lecture-discussion instruction groups, the Pearson Product Moment Correlation was utilized. Based on the computed Pearson test statistic value of 0.15, there is no sufficient evidence to support that the attitude and achievement of the students in the two learning groups are related. This implies that when DI was used, students' achievement might improve regardless of their attitude towards the subject.

CONCLUSION

The findings of the study indicate that differentiated instruction can better improve students' achievement in Trigonometry than traditional lecture-discussion method. Clearly, even college students benefit from engaging in a variety of activities that consider their readiness, interest level and learning profile. However, using differentiated instruction or the lecture-discussion method within a short period such as two months causes no significant change in the attitude of the students towards Trigonometry. The study suggests that differentiated instruction helps improve students' achievement in Trigonometry regardless of their attitude towards the subject. To explore more the effects of DI further researches are recommended using longer time frame of experiment and evaluation of the learning journals from the control group.

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