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Differentiated Instruction in the High School Science Classroom: Qualitative and Quantitative Analyses

Jane Pablico
Walker High School
Walker, Louisiana, USA
Southern New Hampshire University
Manchester, New Hampshire, USA

Moustapha Diack and Albertha Lawson
Southern University and A & M College
Baton Rouge, Louisiana, USA

Abstract. This study aimed to determine the effect of Differentiated Instruction (DI) on learning outcomes of high school science students using a convergent, parallel, mixed method research. The qualitative component of the research was a phenomenological approach which explored individual beliefs, experiences and perceptions of teachers about DI. The quantitative part involved a comparison in the End-of-Course (EOC) performance of biology students exposed to DI versus those not exposed to DI. Personal interviews with six science teachers and survey results from 65 biology students revealed that teachers and students alike have positive perceptions of DI. The teachers perceived DI as an effective instructional method for improving student engagement and academic performance. More students scored Good/Excellent in the DI group (76.9%) compared with the Non-DI group (67.6%). However, analysis of covariance (ANCOVA) suggests that at 5% level, the DI group did not perform significantly higher than the non-DI group (p=.12). This implies that there is no significant effect of DI on student learning outcomes measured by EOC. Although the quantitative result of the study did not show a significantly higher EOC score in the DI group, differentiated instruction positively impacted the learning process by increasing student engagement in class.

Keywords: differentiated instruction, high school science, teachers' perceptions, teaching strategies

1. Introduction

Students come to class bringing with them their diverse cultural background, learning styles, interests, abilities and multiple intelligences. The diversity of

students in the classroom can result in a significant challenge for teachers when it comes to meeting the needs of all students. Some students may find the lesson too easy while some find it too hard; some may find the topic interesting while some find it boring. It is the goal of differentiated instruction (DI) to reach out to each student and approach the lesson in a way that fits their learning styles, interests, abilities or multiple intelligences.

Differentiated instruction has a strong theoretical basis that includes constructivist theory, brain-based research and multiple intelligences (Felder & Soloman, 2004; Gardner, 1993; Vygotsky, 1978). However, the philosophy of differentiation is lacking empirical validation (Ducey, 2011; Subban, 2006; Tulbure, 2011). Many of the studies are qualitative in nature indicating positive emotional outcomes in terms of motivation, task commitment, and excitement about learning (Burkett, 2013; Maeng, 2011). On the quantitative studies determining the effectiveness of differentiated instruction, some studies revealed the effectiveness of differentiated instruction over traditional instruction (Aliakbari & Haghigi, 2014; 2010; Dosch & Zidon, 2014; Joseph, et al., 2013; Stavroula, et al., 2011), but some showed no significant difference with the traditional instruction (Ducey, 2011; McCoach, et al., 2013; Maxey, 2013; Vincent, 2012). Studies on differentiated instruction are mostly focused on the elementary and middle-school level and are very rare on the high school level (Maeng, 2011). Furthermore, differentiated instruction occurs most often in reading, writing and math classrooms and is seldom applied to other subject areas including science (Eady, 2008; Tobin & Tippett, 2014).

The limited literature on the use of differentiated instruction in high school science classes and the conflicting results of previous quantitative research calls for more studies to be conducted. The gap in the literature has motivated the researchers to conduct this study.

2. Research Questions

A public school district in southern Louisiana began implementing differentiated instruction during the 2014-2015 school year. School administrators were first trained, who in turn, trained the teachers in their respective schools. Full implementation of differentiated instruction in the district occurred in the 2014-2015 school year. During that school year, differentiation strategies for content, process and product, were explicitly described in the teachers' lesson plans.

This study aimed to determine the teachers' and students' perceptions of differentiated instruction after their exposure to it, and to determine the effectiveness of differentiated instruction in improving student learning outcomes. Specifically, it sought to address the following questions:

1. What are the science teachers' perceptions of the effect of differentiated instruction on student learning?
2. What are the students' perceptions of differentiated instruction in their science classes?

3. Is there a significant effect of differentiated instruction on student learning outcomes measured by EOC (end-of-course) test scores?

3. Review of Literature

3.1 Theoretical Foundations of Differentiated Instruction

Differentiated instruction (DI) is a term introduced by Tomlinson in 1999 that has gained popularity in education. It is a teaching philosophy that provides different avenues in presenting the content, making sense of ideas and assessing learning outcomes (Tomlinson, 2001). Although it is relatively a new term to most educators in the regular classroom, DI is not a new concept at all (Tomlinson, 1999; Roe & Egbert, 2010). Dedicated teachers may knowingly or unknowingly practice DI in one way or another as they manifest their commitment in educating their students. In differentiating the content, process and product of instruction, the teacher needs to consider the students' readiness, interest and learning profile (Tomlinson, 1999; Tomlinson, 2001; Tomlinson & Imbeau, 2010).

Differentiated instruction is a philosophy of teaching based on well-established theories. One learning theory that supports DI is the Sociocultural Learning Theory which is based on the work of Lev Vygotsky (1978), a Russian psychologist. The Sociocultural Learning Theory holds that social interaction plays a fundamental role in the development of cognition. Another aspect of Vygotsky's theory is the idea of the zone of proximal development (ZPD). ZPD is an area of exploration for which the student is cognitively prepared and for which development is attained with the help of social interaction (Vygotky, 1978). The Sociocultural Learning Theory and the aspect of zone of proximal development (ZPD) are the theoretical bases in differentiating instruction by readiness level. There is a zone where the student is cognitively ready to do a specific task where he can be successful with the help of his social support system. If a student is not in that zone yet, the instruction needs to be adjusted to a level that the student is cognitively ready to take. Strategies that can help facilitate the intentional learning of a student include collaborative learning, discourse, modeling, and scaffolding (Tomlinson, 2001).

The constructivist learning theory is another theoretical basis of DI. It is a learner-centered theory that suggests that humans construct knowledge and meaning from their own experiences. A constructivist classroom provides opportunities for the students to experience multiple perspectives and emphasizes authentic assessment rather than traditional paper/pencil exams (Information Resources Management Association, 2015). Constructivism supports the practice of DI. It provides the theoretical basis for differentiating instruction by students' readiness and interest.

Learning styles are the ways in which learners prefer to learn. In 1987, Neil Flemming introduced the acronym VARK and it appeared in a publication in 1992 (Flemming & Mills, 1992). VARK encompasses four types of learning

preferences which stand for visual, aural, read/write and kinesthetic. These learning styles and modalities are being considered in differentiated instruction. In order to maximize learning for everyone, the lessons should be adjusted to accommodate these differences because learners with different styles might benefit from different ways of presenting the material (Willingham, 2009).

Another source of differences in the classroom is the students' multiple intelligences. Howard Gardner, a professor at Harvard University, published his theory of multiple intelligences in the mid 1980's (Willingham, 2009). He defined intelligence as a biopsychological potential to process information in certain ways. He proposed that there were seven multiple intelligences, and later turned into eight. The eight areas of intelligences include linguistic, logical-mathematical, bodily-kinesthetic, interpersonal, intrapersonal, musical, naturalistic and spatial (Gardner, 1993; Von Karolyi, Ramos-Ford & Gardner, 2003). Multiple intelligences inventory is a good way for teachers to get an initial assessment for the students. This could be a tool to be used is designing classroom activities that lead to differentiated instruction.

3.2. Related Studies

The studies being reviewed in this section range from 2007 to 2017, and are comprised of journal articles and doctoral dissertations. The qualitative results are presented first followed by the quantitative results.

In 2010, King examined teachers' knowledge and their perceptions regarding the implementation of differentiated instruction. She surveyed 220 high school regular education and special education teachers who were certified to teach core academic subjects (English, math, science, and social studies) from 10 high schools in middle Tennessee in Davidson and Rutherford counties. The findings revealed that factors such as content knowledge/skills, teacher-student ratios, availability of time and state standards and assessments, affect teachers' decisions to implement differentiated instruction (King, 2010).

Differentiated instruction occurs on a limited basis and only in a few content areas (Eady, 2008). The respondents in King's study expressed that their ability to differentiate instruction was impeded by their lack of knowledge regarding it (King, 2010). Differentiation is also perceived as time consuming and challenging due to diverse populations (Maddox, 2015; Wan, 2017). Studies then recommended professional development of teachers in the area of differentiated instruction (Koeze, 2007; Langley, 2015; Maeng, 2011; Robinson, 2013; Sizemore, 2015). According to Dixon, Yssel, McConnell & Hardin (2014), teachers who had more professional development in differentiation felt more efficient in differentiating instruction in their classes.

Whipple (2012) conducted a survey to explore teachers' understanding of differentiated instruction and their perceptions of their ability to implement differentiated instruction. Participants comprised of 88 teachers in grades kindergarten through sixth throughout the Leighton Public Schools in southern

Massachusetts. Overall, the participating teachers had a high level of understanding of the concepts of differentiated instruction and the methods of how to implement it in the classroom. The researcher also found that, although the teachers had a high level understanding of differentiated instruction, their rate of implementation was low. This shows a disconnection between understanding differentiated instruction and implementing differentiated instruction. In another study conducted by Wan (2017), the findings indicated that teachers were more inclined to use teacher-centered approach although they were generally ready for using DI strategies. University instructors also struggled with implementing differentiated instruction, despite knowing the importance of modeling it in a teacher education program (Lockley, J., Jackson, N., Downing, A., & Roberts, J. , 2017).

Martin & Pickett (2013) conducted an action research study to increase student motivation and engagement among 25 gifted students. During direct instruction, the math and music teachers noted several off-task behaviors (hyperactive, withdrawn, poor attention, disruptive, uncooperative). As an intervention, the teacher-researchers implemented differentiated instruction by flexible grouping and giving choices. After three months of differentiated instruction, student motivation and engagement has improved. More students felt that they were being appropriately challenged when they were given choices of assignments in class. The teacher-researchers concluded that the intervention positively impacted changes in students' perception of their engagement and motivation.

Quantitative Studies were also conducted to determine the effectiveness of differentiated instruction in different subject areas and at different levels. A study was conducted in a language institute in Iran to determine the effectiveness of differentiated instruction in enhancing reading comprehension among elementary students. This quasi-experimental research consisted of a control and an experimental group, with each group having one male and one female classroom. Results of ANOVA showed that students who received differentiated instruction outperformed those who were exposed to traditional instruction, with the female students performing better than the male students (Aliakbari & Haghighi, 2014).

Koeze (2007) conducted a study to determine if differentiated instruction had an effect on student achievement. The study consisted of both quantitative and qualitative parts where the quantitative part was used to frame the qualitative aspect of the study. Quantitative data were collected using student scores in the Michigan Educational Assessment Program (MEAP) in math, reading, and writing, and combined ELA scores. Correlation analysis and t-tests were conducted to determine if the number of occurrences of differentiation had an effect on student achievement. Qualitative data were gathered using classroom observation and interviews. The population consisted of 4th grade students and teachers in a public school in Michigan. T-test findings revealed that there were no significant differences in MEAP scores in math, reading, writing and ELA scores between the differentiated classroom and traditional classroom. However, regression analysis revealed that one independent variable, which is learning

style, was statistically significant to reading achievement. Since differentiating for learning styles may also be seen by students as differentiating for choice and interest, the researcher concluded that differentiating for choice, interest, and learning styles all likely have an impact on student achievement (Koeze, 2007).

A quasi-experimental study conducted by Stavroula, Leonides & Mary (2011) involving 24 elementary classes of 479 Cypriot students revealed that the classes who received differentiated instruction scored significantly higher in the posttest than those who were taught using traditional lecture method. Quantitative data were analyzed using a one-way ANOVA. The researchers also discussed how differentiated instruction promoted equity and quality for all types of learners.

Chamberlin & Powers (2010) examined the use of differentiated instruction in an undergraduate mathematics course for improving students' mathematical learning. The participants were elementary education majors enrolled in a mathematics course covering the topic of number and operations. The quasi-experimental part of the study utilized the pretest-posttest control group design. Results showed that students exposed to differentiated instruction performed significantly higher in the posttest than the control group.

A study of differentiated instruction in a teacher education setting was conducted by Joseph, Thomas, Simonette, & Ramsook (2013). The researchers compared the final grades at the end of the semester of the students taught using differentiated instruction (DI) and those taught using the traditional whole-group instruction. A total of 434 students in the curriculum studies course on two education campuses participated in the study. Findings of the study revealed that the majority of students in the differentiated classrooms demonstrated sound understanding of major concepts taught in the curriculum studies course. The DI group performed better than the non-DI group based on their semester grades.

Dosch and Zidon (2014) conducted a mixed-method research study to explore the implementation of differentiated instruction in higher education. The participants were two different sections of the same Educational Psychology course taught by the same instructor. Thirty-nine students were in the experimental group (DI group) and 38 were in the control group (NDI group). The control group was taught in a teacher-centered, traditional lecture format with students taking notes and did not have choices on how to complete assignments. The experimental group was taught using a constructivist, student-centered format with many hands-on activities, choices for completing assignments, and instruction altered based on formative assessments. Results of independent-samples t-tests revealed a significant difference in the aggregate mean group scores on the six assignments and the three exams. This implied that the experimental group outperformed the control group. The students in the experimental group also shared that they appreciated having choices and they felt it improved their learning of the material.

Not all studies on differentiated instruction revealed its dominance over non-differentiated instruction. In 2011, Ducey (2011) conducted a study to determine the effectiveness of differentiated instruction as a classroom methodology for high school physics students. Findings revealed that differentiated instruction provided no significant advantage when compared to traditional instruction for this group of students, regardless of course level (honors or standard). Additionally, the students were surveyed regarding their perception of match of the received differentiated instruction to their educational needs and values. Ducey determined that differentiated instruction provided no significant difference in student perception of match to educational needs and values.

An action research study entitled, "The Effects of Differentiating Instruction by Learning Styles on Problem Solving in Cooperative Groups" was conducted by Westbook (2011). A pretest-posttest control group design was used in the study, with 28 students in both of the groups. The subjects of the study were ninth grade students taking a Math I class taught by the same teacher. Students in the treatment group were clustered by learning styles (auditory, kinesthetic, and visual) and were exposed to differentiated instruction. Data analysis revealed that the treatment group did not perform significantly higher in the posttest compared to the control group.

In 2012, Vincent studied the effects of implementing differentiated instruction on learners' reading achievement. A quantitative, ex post facto design was used in the study. The reading scores of a treatment group comprised of 3rd and 4th grade students from one school, were compared to the reading scores of a control group comprised of the same grade levels from another demographically-similar school. The students in the treatment group were taught using the mandated implementation of differentiated instruction in one school. The Tennessee Comprehensive Assessment Program (TCAP) reading achievement scores were compared for the control and treatment groups, taking the 2nd grade Stanford Achievement Test Series 10 (SAT-10) result and socioeconomic status as covariates. Results of analysis of covariance (ANCOVA) revealed no significant difference between the reading achievement scores of the treatment group and the control group.

Williams (2012) conducted a quantitative quasi-experimental research study to examine the effects of differentiated instruction on seventh grade student performance on standardized mathematics assessments using a repeated-measures design. The study was inconclusive due to inconsistent results on the test of significance on the difference in performance between the experimental and control groups.

Using a causal-comparative design, Maxey (2013) examined the effect of differentiated instruction in math achievement of students in primary school on a U. S. military base overseas. Ten sections (about 20 students each) of second-grade students and 12 teachers participated in the study. Five sections were assigned as the experimental group that received differentiated instruction while the other five served as the control group. The STAR Math posttest scores of the

two groups were compared using ANCOVA, with the pretest scores taken as the covariate. The researcher also examined math achievement of students in the three ability groups within the treatment group to see if there was any difference in the amount of progress students made over the course of the school year. Results of ANCOVA revealed that there was no significant difference in the math achievement between the control and experimental groups. This indicates that differentiated instruction did not make a difference in end of the year achievement for these students.

McCoach, Gubbins, Foreman, Rambo, & Rubenstein (2013) examined the impact of implementing pre-differentiated mathematics curricula in algebra, geometry and measurement, and graphing and data analysis on the achievement of grade 3 students, after controlling for pretest achievement scores. After a series of three-level regression modeling using the Hierarchical Linear Modeling (HLM 7.01) software, the study concluded that, in general, the post-Iowa Tests of Basic Skills (ITBS) scores of students in the treatment group were equal to those in the control group. However, it appeared that high-achieving students in low-achieving schools benefitted more from the differentiated curricula.

In 2011, Tulbure synthesized previous empirical studies from 1985 to 2010 and investigated the impact of differentiated instruction upon the results obtained in tertiary education. Among 16 studies, 10 concluded that differentiated instruction based on personal learning styles leads to an improvement in the level of learning results. Three of the studies found that differentiated instruction based on learning styles does not affect the level of learning, and the other three concluded that the lack of concordance between learning styles and didactic strategies stimulates and makes the learning process flexible. At the time of the research by Tulbure (2011), the results of studies concerning the impact of differentiated instruction upon the academic success on the level of tertiary education were controversial despite figures showing more research results in favor of differentiated instruction.

Just like the reviewed studies in Tulbure's synthesis research, the empirical studies reviewed in this section also have different findings. In the quantitative studies determining the effectiveness of differentiated instruction, some studies revealed the effectiveness of differentiated instruction over traditional instruction (Aliakbari & Haghigi, 2014; Chamberlin & Powers, 2010; Dosch & Zidon, 2014; Joseph, et al., 2013; Koeze, 2007; Stavroula, et al., 2011), while some showed no significant difference with the traditional instruction (Ducey, 2011; McCoach, et al., 2013; Maxey, 2013; Vincent, 2012; Westbook, 2011; Williams, 2012). The limited literature on the effectiveness of differentiated instruction and the conflicting results of previous research called for more studies to be conducted.

4. Methodology

4.1. Description of Subjects

Six high school science teachers and 65 students in a public high school in southern Louisiana participated in the study. The teachers (four female and two male) implemented differentiated instruction in their classes as required by the school administration during the school year 2014-2015. All of the six teachers are certified to teach one or more areas of science in the state of Louisiana and have good knowledge of the tenets of differentiated instruction.

The student-participants were in three sections of biology classes taught by the same teacher in the Spring of 2015. Out of 82 students, 65 of them participated in the survey. The biology classes were purposely chosen since biology is the only science course that undergoes the state-mandated End-of-Course (EOC) testing. The EOC results were used by the researchers to measure student learning outcomes.

The EOC results of the three sections of biology classes in Spring 2015 (82 students) were compared with the EOC results of three sections in Spring 2014 (74 students). Students in Spring 2015 were exposed to differentiated instruction while the students in Spring 2014 were not.

4.2 Research Design

This study employed both qualitative and quantitative methods of research. It particularly used the convergent, parallel, mixed method of research. In this research approach, both qualitative and quantitative data are collected, separately analyzed, and results are compared to see if they confirm or disconfirm each other (Creswell, 2014). The qualitative part involved a phenomenological approach that focused on individual beliefs, experiences and perceptions of teachers about differentiated instruction. The quantitative part focused on the effect of differentiated instruction on student learning. Figure 1 shows a flow chart that represents the research framework.

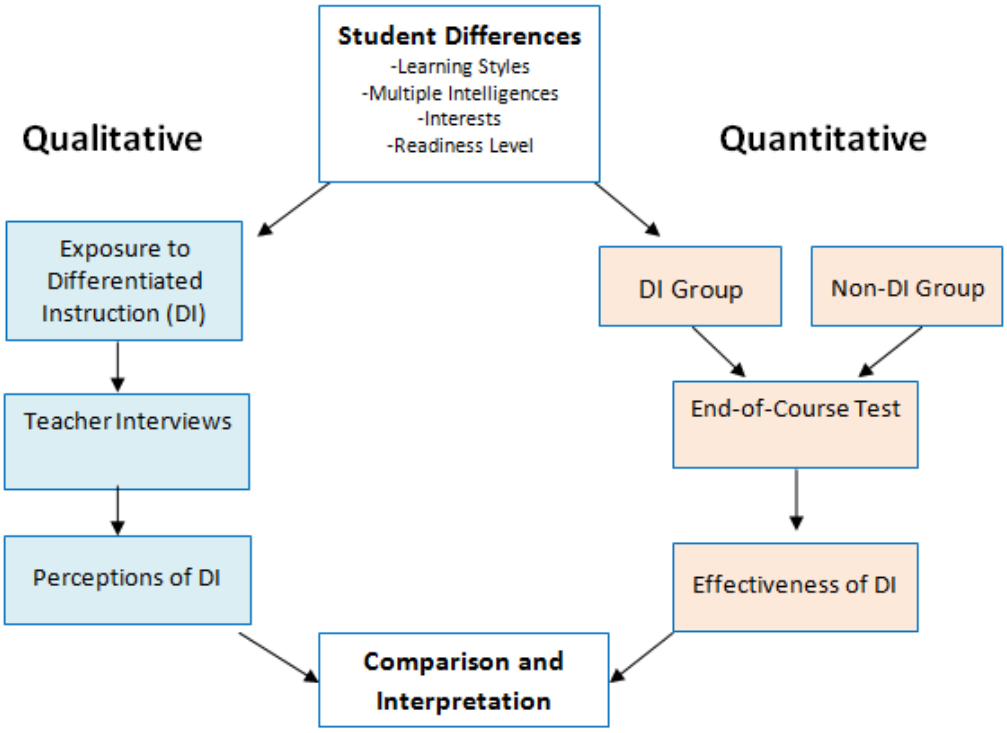

Figure 1. The Research Framework.

Phenomenology is a qualitative approach in research that seeks to describe rather than explain the experiences and perceptions of individuals from their own perspectives (Lester, 1999). Qualitative phenomenological research aims to describe a "lived experience" of a phenomenon. According to Creswell (2014), a typical phenomenological research has participants that range from three to ten.

A variety of methods can be used in phenomenologically-based research, including interviews, conversations, participant observation, action research, focus meetings and analysis of personal texts (Lester, 1999). In this study, personal interviews and review of documents such as lesson plans were used to gather qualitative data. After implementing differentiated instruction, the teachers were interviewed to explore the strategies they used, the factors that influenced them to implement DI and their perceptions of DI based on their experience.

At the start of the semester, the students in the three sections of Biology class were asked to complete learning styles and multiple intelligences inventories. Fleming's VARK Questionnaire (Fleming, 2014) and McKenzie's Multiple Intelligences Inventory (McKenzie, 1999) were used. These inventories provided insight for the teacher as to the appropriate grouping and activities that fit the students' learning preferences. At the end of the semester, after being exposed to differentiated instruction, the students completed a survey questionnaire that explored their perceptions of differentiated instruction.

The purpose of the quantitative study was to determine if the implementation of differentiated instruction had an effect on student learning outcomes as measured by the EOC scores. The EOC scores in Spring 2015 were compared with the EOC scores in Spring 2014, when DI was not yet fully-implemented. To establish the comparability of the two groups, the same textbooks were used and the same teacher used the same scope and sequence and the same lesson materials. The only variation was the implementation of DI during Spring 2015 as opposed to traditional delivery during Spring 2014.

4.3. Statistical Treatment

A Survey Questionnaire on Student Perceptions of Differentiated Instruction was validated by research and education experts and was found reliable after pilot-testing to a group of high school students. The Cronbach's alpha coefficient resulted to .808, which suggests that the instrument is appropriate for research. Mean was used to analyze student responses to the survey.

To establish the comparability of the DI group to the non-DI group, initial conditions such as the students' Science LEAP (Louisiana Educational Assessment Program) scores and proficiency pretest were compared using t-test. The t-test resulted to no significant difference in the Science LEAP scores (p=.272) of the two groups and a significant difference in their proficiency pretest scores (p=.021). Table 1 shows the t-test summary.

Table 1. T-test Results Comparing the LEAP Scores and Proficiency Pretest Between Non-DI Group (2014) and DI Group (2015)

Initial Conditions	Non-DI Mean Score	DI Mean Score	t-Computed	t-Critical	p-Value
LEAP	66.18261	67.61538	-1.10235	1.97823	0.27233
Proficiency Pretest	30.86301	34.63077	-2.05629	1.98422	0.02119

The analysis of covariance (ANCOVA) was used in comparing the EOC scores, taking the proficiency pretest scores as covariate. This is due to the significant difference in the proficiency pretest scores of the two groups. By using ANCOVA, the comparability of the two groups is established by eliminating any effects of the difference in the proficiency pretest. Science LEAP scores were not anymore used as covariate because the t-test result revealed no significant difference between the two groups.

4.4 Hypothesis

The following hypothesis is tested at 5% level of significance: There is no significant effect of differentiated instruction on the learning outcomes of students based on EOC test scores.

5. Results

5.1. Science Teachers and DI Strategies

Six science teachers currently implementing differentiated instruction in a public high school in southern Louisiana were interviewed for this study. The sample was composed of two male and four female teachers. For the purposes of this study, each participant was assigned a label to protect their identity.

Teacher A is a male teacher and has been teaching for twenty-four years, the last five of which were in the current school. He has a bachelor's and a master's degree and is certified to teach General Science, Health and Physical Education. He has taught Physical Science, Environmental Science and Physical Education at the high school level. Teacher A describes differentiated instruction as "teaching to the individual's learning style, interest or readiness level." He says "it's different from traditional lessons in the fact that individuals are given choices and it is not a group lesson."

Teacher A differentiates the process of instruction by grouping students according to readiness level and then assigning questions to each group based on their readiness. He uses formative assessment as his basis for student grouping. He also differentiates according to student interest by having different roles within a group such as organizer, presenter and artist.

Teacher B is a female teacher who has been teaching for twelve years in the current school. She holds a bachelor's degree in Animal Science and received an alternative teaching certification from Louisiana State University. She has taught eight-grade Earth Science, high school Environmental Science, Anatomy and Physiology, Biology I and II, and Advanced Placement Biology. Teacher B describes differentiated instruction as "being able to offer a child a different option from what is considered traditional teaching method."

Teacher B differentiates the product of instruction mostly by providing choice using a tic-tac-toe board. She also differentiates the process by using Socratic Seminar on some relevant topics. She finds it difficult to differentiate content because to her argument, science is such a "content-based field." She said "with science, they (students) still have to know the information." "It's really hard to find DI stuff for science. It's not readily available like for English stuff, and it's really disappointing." She added "it can be a challenge, but it's getting better."

Teacher C has a master's degree in education. She is certified to teach elementary grades as well as high school general science and biology. She has been teaching for ten years and has taught students ranging from elementary, middle and high school. She has taught Physical Science, Life Science, Earth Science, Chemistry, and Biology I and II. She has been in the current school for three-and-a-half years. Teacher C describes differentiated instruction as "providing students with a choice in their work." She adds "it's different from traditional lessons where students complete the same assignments."

Teacher C provides choice in some of her lessons as to the format of their assignments. Students are given the rubric and guidelines and they choose what they want to do for their project or activity such as making a poem, song, skit, and others. She differentiates by readiness level by assigning different levels of scientific articles to read, reflect upon, and discuss. She uses differentiated roles in group and laboratory activities. To accommodate different learning styles, teacher C also differentiates the mode of instruction by using video clips in teaching and assesses students regularly by using different closing activities.

Teacher D is a female teacher who has been in the teaching profession for nine years. She has a bachelor's degree and master's units in Agricultural Science. She has taught Agricultural Sciences and Environmental Science in the current school. Teacher D describes differentiated instruction as "varying instruction by student interest."

Teacher D differentiates product by student interest. She lets the students choose a topic to work on. One example was when she made the students choose traits from 16 breeds to cross. She claimed that the students liked it. Teacher D said she differentiates instruction depending on the topic and on the type of students. "If the students are weak, I don't differentiate the content," she said.

Teacher E has been teaching for five years and is in her first year teaching at the current school. She holds a bachelor's degree in Secondary Education with a concentration in Biology. She has taught sixth-grade Science and high school Chemistry and Biology. Teacher E describes differentiated instruction as "providing a variety of instructional strategies based on the needs of students, or their interests and readiness." Her ideas of differentiated instruction include "providing the students a choice or assigning them assignments based on what they need."

Teacher E differentiates by choice of assignment, choice of format of assignment, by varying the complexity of questions, and by having different roles within a group. She sets up small stations for the students to work in small groups. Teacher E said, "On a test, I give several questions that are asking the same concepts and the students choose the questions to answer. Sometimes, even just the wording of the question can make a difference for the student." Reviews of lesson plans from Teacher E also revealed that she uses flexible grouping by assigning students of varied ability levels in a group in order to facilitate peer tutoring. Her lesson plan also reflects her use of Bingo activity to provide her students with a choice of assignments.

The sixth teacher, ***Teacher F***, is the second male teacher in the sample. He has been teaching for one-and-a-half years at the current school. He has a bachelor's degree in Life Science. He teachers Robotics and Biology I. Teacher F describes differentiated instruction as tailoring his teaching and assessment strategies to meet the diverse learning styles, needs and academic abilities of his students. He

said that differentiated instruction "does not use a 'shotgun' teaching method where all of the students are learning and being assessed the same way."

Teacher F differentiates the process of instruction by using tic-tac-toe menus. Each student must pick a low, intermediate and advanced assignment to complete from a list. The students then choose depending on their interest and learning styles. Teacher F also uses flexible grouping. He assigned heterogeneous groups to allow for the possibility of peer tutoring.

5.2. Teachers' perceptions of the effect of DI on student learning

Teacher A perceives differentiated instruction as an effective way of promoting student engagement and class performance. He said, "Over time, I noticed that some students perform better when they have a choice." He believes that student engagement has increased because the students had an opportunity to express themselves. He also noticed that their grades improved, which means learning has increased.

Teacher B thinks that DI has a positive effect on student engagement. Her students got to choose their research and some topics, and according to her, they really enjoyed it. "I do see how the kids take ownership of their learning," she pointed out. "I think they got to show their creative side, and that increases their engagement in the assignment." It was her first time to fully implement DI and she self-reported not having issues or problems with it aside from the time requirements. She just wished there were more DI strategies in science available for reference. She likes doing it in her classes and she really thinks it (DI) has merit.

Based on her experience with implementing DI, ***Teacher C*** said that DI promotes a more positive learning environment. She said that students react to assignments better when they have a say in what they are doing. The students are more engaged in class if they get to choose an area of interest to them. She definitely agrees that DI has increased student engagement in her classes.

Teacher D also noticed that DI has a positive effect on student engagement. When she let the students choose a topic to work on, the students liked it. There are more "aha" moments and the students get more out of it than the regular uniform instruction for all. Teacher D said that "kids are getting more into it, they are learning more, they have less questions, and they are more engaged." She has no issues in implementing DI. She said, "I like doing it and the kids like it too."

Teacher E thinks that students are more likely to buy in if they feel that they are part of the decision-making process. She explained, "If it's just you telling them what to do, they have the tendency to not care that much. If you're giving them a choice, even though the questions are the same but just worded differently, they care more and they engage more." She said that the hardest part of DI is it requires some creativity to plan activities. The pressure of time is also an issue

because of all the topics that need to be covered in the curriculum. Implementing DI is sometimes time-consuming. Teacher E, however, said that DI is good and she likes it. "I definitely think it benefits the students and it's worth the extra time you have to put in to creatively plan something -- it's definitely worth it," she said.

Teacher F said that not every DI lesson is successful, but each time he tries, he learns more about how to implement it more effectively. He has seen positive effects on both student interest and academic achievement when he uses DI strategies. He said, "I find that when I use more DI strategies when teaching a difficult topic, the test scores are generally higher than those of lesson in which I don't use DI, or only use it sparsely." An issue he has with DI is finding the time to do it effectively. He is positive, however, that the more experience he has with DI strategies, the faster it will become to implement in his class.

Table 2. Summary of Teachers' DI Strategies and Perceptions of the Effect of DI on Student Learning

Teacher	DI Strategies	Perceptions of the Effect of DI
A	-Assigning questions of varying difficulty -Formative assessment -Flexible grouping -Differentiated roles	Improves student engagement Improves academic performance
B	-Tic-tac-toe menus -Socratic seminar	Improves student engagement
C	-Choice of assignment format -Assigning different levels of assignment -Differentiated roles -Various teaching modes -Formative assessments	Promotes positive learning environment Improves student engagement
D	-Choice of assignment	Improves student engagement More student learning
E	-Choice of assignment -Choice of assignment format -Varying complexity of questions -Differentiated roles	Improves student engagement It benefits the students
F	-Tic-tac-toe menus -Varying complexity of assignment -Flexible grouping	Improves student interest in class Improves academic performance

5.3 Emergent Themes

Qualitative data analysis (QDA) involves the transformation of qualitative data into some form of explanation, understanding or interpretation. It is based on interpretive philosophy that aims to examine the meaningful and symbolic content of qualitative data (Taylor & Gibbs, 2010). Qualitative data analysis for phenomenological research involves the analysis of significant statements, the generation of meaning units, and the development of an essence description (Creswell, 2014).

After analyzing the statements from the six science teachers, common themes were found to fully describe the teachers' experiences with the implementation of differentiated instruction. The following major themes emerged from the study.

Differentiated instruction improves student engagement and academic performance in class. All six teachers claimed that students were more engaged in class if they used differentiated instruction. Teacher A mentioned that students performed better when they have a choice. He added that student engagement increased because the students had an opportunity to express themselves. Teacher B thinks that there is positive effect of DI on student engagement. She added that when she uses DI, "the kids got a chance to show their creative side." Teacher F specifically said that he had seen a positive effect on both student interest in class and academic achievement when he used DI strategies in his lessons.

Differentiated instruction motivates the students. The teachers claimed that the students enjoyed learning when the lesson was differentiated. Teacher B said the students took ownership of their learning when they had a choice on their research topic. Teacher C said that "students react to assignments better when they have a say in what they are doing." She added that differentiated instruction promotes a more positive learning environment as they are given a chance to choose an area of interest to them. Teacher D mentioned that there were more "aha" moments for the kids when the lesson was differentiated. Teacher E stated that differentiated instruction helps with assessment. She explained that "For students who do not do well in multiple-choice questions, they have the opportunity to demonstrate their learning or progress." These statements from teachers all point to the idea that differentiated instruction is beneficial for the students. Through differentiated instruction, students enjoy learning and are more empowered in the learning process.

Differentiating by choice is the most common way to differentiate. Five of the six science teachers indicated their use of differentiation by choice. Teachers B and F used tic-tac-toe menus to provide students with options according to their learning styles, interests and multiple intelligences. Teachers D and E indicated their use of assignment choices. Teachers C and E mentioned that they utilized a choice of assignment format. In a lesson plan provided by teacher E, she used a Bingo activity to provide her students with choices of assignments to do.

Teacher A did not explicitly mention differentiating by choice when asked about his differentiation strategies, but he mentioned in his observation that "some students perform better when they have a choice."

Administrative support has major influence in the implementation of differentiated instruction. Teachers A, B and E said that they implement differentiated instruction because of the school administration. Teacher B expressed that she implements differentiated instruction mainly because the administration requires the teachers to do it. The school administration has conducted professional development trainings dedicated to educate teachers about differentiated instruction and to equip them with strategies to implement differentiated instruction. Teachers A and E mentioned that the professional development trainings helped them to gain more knowledge about implementing differentiated instruction. Teacher E said that her concept of differentiated instruction was different before the school provided professional development sessions.

Implementation of differentiated instruction increases teacher efficiency. Teachers C and D indicated that they implement differentiated instruction because of Compass evaluation. Compass is an instrument used in the state of Louisiana to evaluate the performance of teachers. This is used by the school administrators when they observe classes. The instrument includes differentiation and student engagement on the areas to be rated. This means that if the teacher is implementing differentiated instruction at the time of class observation, the teacher is likely going to have a higher efficiency rating.

Differentiated instruction requires more time and creativity. Teachers B, E and F expressed that the time required for preparing and implementing differentiated instruction is a major issue. Teacher B mentioned that sometimes, she does not have time to implement differentiated instruction, especially with seniors having to leave two weeks prior to everybody else. Teacher C stated that, "the greatest challenge is the pressure of time, getting through the curriculum and covering all the lessons before the students have to take the proficiency test." Teacher F expressed that the obstacle he is facing with DI is finding the time to do it effectively. Aside from the issue of it being time-consuming, according to Teacher B, DI strategies are hard to find for science. She exclaimed, "It's not readily available like for English stuff, and it's really disappointing." Because of the limited availability of DI strategies for science, Teacher E said it requires some creativity to be able to plan and design differentiated lessons.

5.4. Students' Perceptions of Differentiated Instruction

A survey questionnaire was used to determine the level of students' perceptions of differentiated instruction. Sixty-five students in three sections of high school Biology class participated in the survey. The survey questionnaire was validated by research and education experts and was found reliable after pilot-testing to a group of high school students. The Cronbach's alpha coefficient resulted to .808, which means that the instrument is appropriate for research.

The survey consists of 10 items describing perceptions of differentiated instruction, each of which was rated using a five-point Likert scale described as follows: 1 = strongly disagree ; 2 = somewhat disagree ; 3 = no opinion/not applicable ; 4 = somewhat agree ; and, 5 = strongly agree. Table 3 shows the mean of students' responses on the survey.

Table 3. Student Perceptions of Differentiated Instruction

Perceptions of Differentiated Instruction	Mean Student Rating
1. I learn more effectively if the lesson is delivered using my own learning style.	4.06
2. I like it when my teacher uses materials that present content in a variety of format (e.g., text, video, audio, web-based).	4.12
3. I feel challenged when my teacher presents content at varying levels of complexity.	3.39
4. I like being grouped with students who have similar interest and abilities as me.	4.35
5. I am more engaged in the learning process if I am given a choice of assignment to do.	4.13
6. I like working in a variety of group format in completing assignments (e.g., small group, partners, individual).	3.81
7. Learning is more fun if activities/assignments have format options (e.g., write a paper, create a model, design a poster, give a presentation).	3.94
8. All teachers should be aware of their students' interests, readiness and learning profiles.	4.31
9. All teachers should consider students' interests, abilities and learning profile when preparing lessons and assignments.	4.46
10. The use of differentiated instruction has stimulated my interest in the class.	3.72
Overall Mean	4.03

The mean ratings suggest that students liked the features of differentiated instruction, such as having lessons delivered using their own learning styles (mean=4.06) and in a variety of formats (mean=4.12). They liked being grouped

with students having similar interests and abilities (mean=4.35). They also liked being given a choice on the assignments (mean=4.13) and on the format of groupings (mean=3.81) and assignments (mean=3.94). The students agreed that all teachers should be aware of their students' learning preferences (mean=4.31) and that they should consider those learning preferences when preparing lesson plans and assignments (mean=4.46). It is interesting to note that students neither agreed nor disagreed when asked if they feel challenged when their teacher presents content at varying levels of complexity (mean=3.39). Overall, the students agreed that differentiated instruction has stimulated their interest in the class (mean=3.72).

To interpret the students' perceptions of differentiated instruction, the following scale was used: 1.0 – 1.4 = strong negative; 1.5 – 2.4 = negative; 2.5 – 3.4 = neutral; 3.5 – 4.4 = positive; and 4.5 – 5.0 strong positive. Table 3 reflects an overall mean of 4.03 which implies that students have positive perceptions of differentiated instruction.

5.5. Effect of Differentiated Instruction on Student Learning Outcomes Measured by End-of-Course Test Scores

The end-of-course test scores served as a measure of student learning since it is a standardized test administered at the end of the school year. In this study, the researcher wanted to find out if the students in spring 2015 (DI group) scored better than the students in 2014 (Non-DI group) in their EOC test. The statistical test was based on the null hypothesis that there is no significant effect of differentiated instruction on student learning outcomes as measured by EOC test.

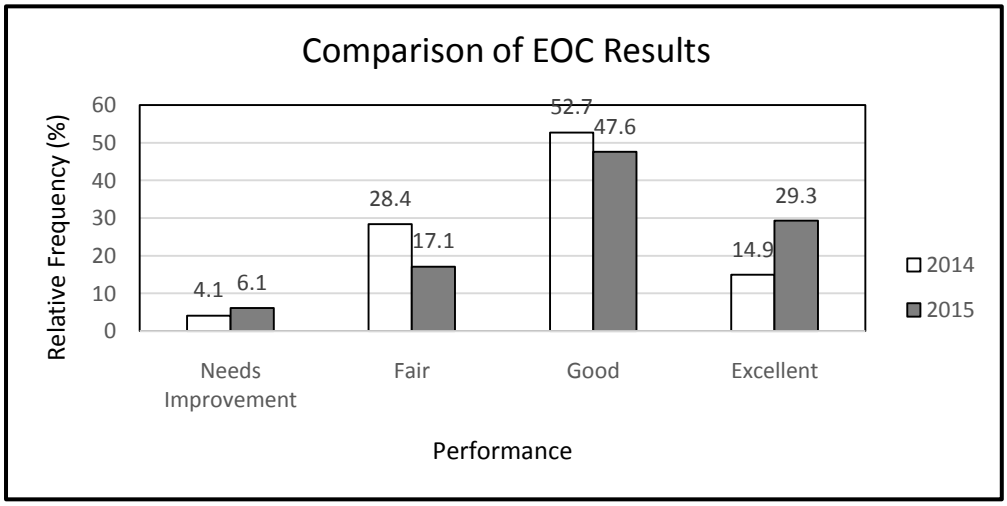

Figure 2. Comparison of EOC test scores between DI Group (2015) and Non-DI group (2014)

Figure 2 shows that more students scored Good/Excellent in the DI group (76.9%) compared with the Non-DI group (67.6%). The mean EOC score in 2014

was 88.95 while it was 90.05 in 2015. T-test results reflect a p-value for one-tailed test of 0.046 ($p<0.05$) which suggests that the DI group performed significantly higher than the Non-DI group at 5% level of significance. Table 4 shows a summary of the t-test results.

Table 4. T-test Results Comparing EOC Scores Between Non-DI Group (2014) and DI Group (2015)

Result	Non-DI (2014)	DI (2015)
EOC Mean Score	88.95	90.05
t Stat	-1.6947778	
t Critical one-tail	1.6550074	
P(T<=t) one-tail	0.0460894	

The result of the t-test implies that at 5% level of significance, the EOC test scores in the Spring of 2015 (DI group) are significantly higher than the scores in 2014 (Non-DI). However, a previous t-test also revealed that the students in the Spring of 2015 had a higher proficiency pretest than the students in the Spring of 2014 ($p=.021$). This makes the two groups statistically not equivalent because of the significantly higher pretest scores in the Spring of 2015. In order to make the two groups statistically comparable, analysis of covariance (ANCOVA) was performed, taking the proficiency pretest as a covariate. This statistically eliminates any possible effect of the pretest scores on the result of the EOC on the two groups. Table 5 presents a summary of the ANCOVA test.

Table 5. ANCOVA Summary Comparing EOC Scores Between Non-DI Group (2014) and DI Group (2015)

Source of Variation	Adjusted *SS*	*df*	Adjusted *MS*	*F*	P-value	*F crit*
Between Groups	0.0388999	1	0.03889987	2.42301	0.121672	3.9042017
Within Groups	2.4081539	150	0.01605436			
Total	2.4470538	151				

The adjusted mean in the EOC scores in the Spring of 2014 was 87.81, while it was 87.78 in the Spring of 2015. The ANCOVA test resulted in a p-value of .12, which is higher than the selected level of significance ($p>.05$). This means that there is not enough evidence to reject the null hypothesis. Thus, there is no significant difference in the EOC scores in the Spring of 2014 and in the Spring of 2015.

6. Summary of Findings

The following are the salient findings of the study.

1. Data analysis indicated that teachers have positive perceptions of differentiated instruction. Teachers feel that differentiated instruction improves student engagement in the class as they are being empowered to choose activities that suit their interests and learning preferences. Just like the other studies in the literature, differentiating by choice is a common practice among the teachers in the study. A common issue found was the amount of time required to plan and implement DI strategies. The teachers need to be creative because there are not many available resources for differentiating in the science classroom. The following were the major themes that emerged from the qualitative part of the study:
    a) Differentiated instruction improves student engagement and academic performance in class;
    b) Differentiated instruction motivates the students;
    c) Differentiating by choice is the most common way to differentiate;
    d) Administrative support has a major influence on the implementation of differentiated instruction;
    e) Implementation of differentiated instruction increases teacher efficiency; and,
    f) Differentiated instruction requires more time and creativity.
2. The student survey revealed an overall mean of 4.03 which means that the students have positive perceptions of differentiated instruction. Students have positive or strong positive perceptions on nine out of 10 components of differentiated instruction on the survey.
3. More students scored Good/Excellent in the DI group (76.9%) compared with the Non-DI group (67.6%). However, t-test also revealed that at 5% level of significance, the proficiency pretest of the DI group is significantly higher than the Non-DI group (p=.021). Because of this, the proficiency pretest was used as covariate in comparing the EOC scores of the two groups. The mean EOC score for the DI group was 90.05 while the mean for the Non-DI group was 88.95. A t-test revealed that at 5% level of significance, the DI group scored higher in the EOC than the Non-DI group (p=.046). However, when an analysis of covariance (ANCOVA) was employed taking proficiency pretest as covariate, the adjusted means changed to 87.78 for the DI group and 87.81 for the Non-DI group. The ANCOVA resulted in a p-value of .12 which implied that there was no significant difference in the EOC scores between the DI group and the Non-DI group.

7. Conclusion

Based on the qualitative findings of the study, it can be concluded that teachers have positive perceptions of differentiated instruction. When teachers use varied

differentiated instructional strategies, student engagement and performance in class are improved. Students also have positive perceptions of differentiated instruction. They feel that they learn more effectively if the lesson is delivered using their own learning styles and if assignments are in varied format. They feel more engaged in the learning process if they are given a choice on what assignment and activities to do, and on what type of group format to work with. They agree that teachers should be aware of students' learning preferences and should use that information to design activities suited for them.

On the other hand, the quantitative findings did not confirm that differentiated instruction improves student performance. The ANCOVA result suggests that although the DI group performed higher on the EOC, their exposure to differentiated instruction did not contribute to their higher EOC scores. At 5% level of significance, there was not enough evidence to reject the null hypothesis. Thus, it is concluded that there is no significant effect of differentiated instruction on student learning outcomes measured by EOC.

8. Recommendations

Based on the results of the study, the following recommendations are made:

1. More teacher-training should be conducted focusing on DI strategies for science classes. The science teachers in the study differentiated mostly the process and product of instruction but seldom on the lesson content. Teacher training should focus more on strategies to differentiate science content.
2. Track student performance in the End-of-Course test for the next three years. The effect of newly introduced teaching strategies may not be seen in a year and may require a long term study.
3. Differentiated instruction should be continually implemented in high school science classes. Although the result of the study suggests that differentiated instruction did not significantly increase student learning outcomes as measured by the End-of-Course test, it positively impacted the learning process by increasing student engagement in class.
4. Further empirical studies should be conducted to determine the effectiveness of differentiated instruction in improving student learning outcomes.

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