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Effects of Tiered Instruction on Academic Performance in a Secondary Science Course

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The American public education system is facing major changes in the first quarter of the 21st century. State content curriculum standards and yearly growth requirements of the No Child Left Behind Act of 2001 (NCLB; Colorado Department of Education, 2000a, 2000b) have altered the design of classroom curriculum and requirements for accountability. At the same time, the public school system is facing an increasingly diverse student population, both in terms of student languages spoken and the cultural background represented.

With this increase in cultural and academic diversity in classrooms and the learning growth accountability required by federal and state mandates, schools and teachers are once again reexamining the use of differentiated instruction in mixed-ability classrooms (Baron, 2002). Over the past half century, many methods of differentiated instruction have been developed for different grade levels, with some methods better suited to specific topics. Differentiated instructional methods, which have

summary

Tiered instruction is grouping students for instruction based on their prior background knowledge in a given subject area. In this study, students were either in a control secondary science classroom or a classroom in which instruction was tiered. The tiered instruction was designed to matched to high, middle, or low levels of background knowledge on astronomy and Newtonian physics. The seven control classrooms received middle-level nontiered instruction, whereas the seven treatment classrooms delivered three levels of tiered instruction. The results of this study showed a significant difference between the scores of low background knowledge learners who received tiered instruction and low background learners who did not receive tiered instruction, indicating that tiered instruction may be especially beneficial for lower level learners. Through the implementation of this study, the researchers found that: (1) professional support for teachers is critical to the success of tiered instruction; (2) a strong background in the subject matter and a thorough understanding of the range of potential learning activities appropriate to the targeted levels of learners is essential; and (3) the implementation of a change of instructional and classroom organization, pedagogy, and expectations needs to be systematically introduced over time.

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their roots in the 1960s educational philosophy of constructivism (Benjamin, 2002; Crotty, 1998), have long been a favored instructional method in gifted education. The goal is to allow learners to advance from their existing skill and knowledge levels by connecting new skills and knowledge to those the learners currently possess (Nordlund, 2003; Tomlinson, 1995, 2003). These same methods could be beneficial in today's mixed-ability classrooms, where all learners must make one year's academic growth in one school year. In these classrooms, high-ability learners often tend to be left to their own devices, as teachers focus on improving lower performing students' achievement on yearly assessments. By differentiating instruction, teachers can better ensure that all learners are receiving respectful work, while they address the concepts required by the state content standards and make meaningful academic progress.

At the same time, teachers need to be able to manage both the instructional workload and diverse curricula to meet the needs of all learner groups. As a result, it is prudent to limit the number of differentiated levels or the number of flexible instructional groupings for a given concept to make instruction more manageable for the teacher. In a typical mixed-ability classroom, two to three instructional levels or tiers should address the majority of learners' levels for each instructional concept (Nordlund, 2003; Pierce & Adams, 2005). Each tier should be constructed to be respectful of learners and to facilitate understanding, matching the learner's challenge level, while addressing the curricular components of content, process, or product to be differentiated (Nordlund, 2003; Tomlinson, 1999). The purpose of this study was to compare the science achievement of students who received tiered instruction with the science achievement of students who did not receive tiered instruction. For the purpose of this study *tiering* and *tiers* refer to the definition of *tiered activities* adapted from Tomlinson (1999): Activities are developed using varied levels of content, process, and product to ensure that students' work with the same essential ideas (or concepts), at their appropriate level of challenge.

Background

Use of Differentiation

Methods of differentiated instruction often involve some type of grouping (Rogers, 1996; Tomlinson, 1995, 2003). The success of grouping is necessarily dependent on the curriculum used, and grouping with curriculum differentiation has been shown to be effective (Tieso, 2003). Groups that are set for differentiated lessons are not permanent. Rather, as learners are evaluated prior to instruction on their preexisting knowledge for each concept, the groups change to meet each learner's needs for the concepts and topics in the educational unit (Brimijoin, Marquissee, & Tomlinson, 2003; Rogers, 1996; Tieso, 2003). *Flexible grouping* is defined as placing students in instructional groups for a specific skill, unit of study, or other learning opportunity based on readiness, interest, or learning profile (Nordlund, 2003). These arrangements create temporary groups for an hour, a day, a week, or a month. Flexible grouping is not merely a new name for tracking of students (Fiedler, Lange, & Winebrenner, 2002). Tracking produces class-size groups, whereas skill or ability grouping takes place within a class and is designed to provide a common instructional level for each group based on the learner's existing skills and knowledge to facilitate connections to the new skills and knowledge (Fiedler et al., 2002). Flexible grouping can be skill-based clustering within a heterogeneous classroom. It is an effective method of providing for differences among students within a single classroom (Carlson & Ackerman, 1981). All students study the same topic, providing a common base; however, they diverge in terms of the specific skills to be addressed and in the depth and complexity of the topic based on their learning needs (Rogers, 1996). By knowing the learners' educational growth needs, a teacher is better able to target the needed skills and background information students will require to successfully complete the unit (Tomlinson, 1995).

The use of differentiation helps teachers focus on the significant concepts within the subject matter, enabling learners to understand the key information within an instructional unit (Renzulli, Hays, & Leppien, 2000; Tomlinson, 1999; Tomlinson, Burns, Renzulli, Kaplan, & Purcell, 2001). Differentiation allows for variation within content, process, and/or product in order to facilitate learner understanding (Nordlund, 2003; Pierce & Adams, 2005). Based upon state content standards, content must address the minimum concepts but allows for a wider scope or depth of study for that content. The intent of the content standards is to provide a comprehensive foundation that is not meant to be considered exhaustive, but to provide a basic starting point that then allows teachers and students to reach far beyond the standards for classroom activities. Utilizing the standards as a general topic guide, teachers can facilitate added depth of knowledge and universal connections for the gifted and high-ability learners in the classroom. The use of different thinking processes and products allows for a variety of ways for learners to gain an understanding of the new information and skills in ways that reconcile with their preexisting knowledge base (Tomlinson, 1995, 2000).

It is important that the processes and products the teachers select respectfully consider the learners' current levels of knowledge and understanding (Tomlinson, 2000). Determining a learner's level of knowledge before, during, and after the instructional period is critical to proper placement of the student in either a flexible learning group or on the learner's own work path. Flexible grouping by readiness, interest, or mixed groups or random assignment does not negatively track a learner's progress (Rogers, 1993; Tieso, 2003; Tomlinson, 2000). Flexible grouping is an "ad hoc" or one-time combination of learners for a specific topic or content section for the improved support of learning at that time (Rogers, 1993). Groupings are not set and can be changed as learners' needs change within a class. Skill-based grouping also ensures that all learners are working at their entrance point into the topic, as well as learning new information while achieving academic growth. This is an important educational step for many gifted learners who may spend a large part of their academic year reviewing material or helping classmates learn.

Tiering Methods

Tiered instruction facilitates concept learning, building on skills and prior knowledge through the use of flexible grouping (Rogers, 1993). The tiering of lessons allows required skills to be gained at a learning rate better matched to the students' instructional level. Tiered instruction is based on the existing skills and knowledge of the learners. Learner placement within a tiered level is based on a preassessment (formative assessment) score that measures the learners' background knowledge and the level of the required skills for the content application. Tiering supports learners with low skills and minimal prior knowledge in gaining meaningful academic growth. It provides learners with high skills and above-average background knowledge the opportunity to go beyond the basics and add depth, complexity, and universal connections to the content.

Tiering of instruction can be based on content, process, and/or product (Nordlund, 2003; Pierce & Adams, 2005; Tomlinson, 1999). Tiering is the use of the same curriculum material for all learners, but adjusted for depth of content, the learning activity process, and/or the type of product developed by the student. For example, all of the learners work on the same topic, utilizing their acquired skills with adjustments for depth of content. A facilitated discussion at the end of each activity or inquiry reintegrates the learning. This allows all learners to contribute to the class understanding of the scope of the topic. For the gifted learners in a classroom, the contributions by learners with lower skills and background knowledge in class discussions aid in making connections, lead to alternative solution methods, and provide different perspectives. Some researchers consider interests or learning styles as components in designing tiered instruction (Pierce & Adams, 2005).

For this study, the tiering of activities and instruction was based primarily on the depth of content and the process levels.

This appeared to be a good fit for the demands of standards-based instruction, and a more content-focused education at the secondary level. Although differentiated instruction has been a much-utilized method of instruction for the last several decades, there has been little experimental research concerning the effectiveness of this method of instruction. Research in this area is incumbent in order to validate curriculum differentiation as an effective method to improve students' academic achievement.

Methodology

Participants and Setting

The study's participants were members of the entire freshmen class of 388 students enrolled at the beginning of the semester in an urban school district in a Western state. The school was selected because the researcher had a relationship with the administration through previous employment, student demographics were representative of the diversity of the region, and the school administration supported differentiation of instruction in concept. The school employed a differentiation coordinator who noted that in practice some of the teachers applied their personal versions of differentiation to some of their courses. However, rarely did they apply it to all of the sections of a specific course.

The student population was highly mobile and students entering high school did not have the same skills and past learning experiences. Because the teachers had students of mixed academic and linguistic ability, it was hypothesized that providing differentiation of lessons on the same concepts could allow them to provide their students with a better chance of learning the material.

Research Design

A quasi-experimental design was implemented in this study. Before the beginning of the term, the high school office staff randomly assigned 388 students to 14 freshman general science classes. Seven of the classes with 194 students served as treatment classes and seven classes with 194 students served as control classes. The 14 classes were conducted throughout the day and included a total of five teachers. Each teacher was assigned at least one treatment and one control class. Because the time of day could be a factor, the issue was addressed by having both control and treatment groups in every instructional period across the day.

During the pre-experimental phase, all participants were assessed for general skills and background knowledge for the content of the upcoming experimental astronomy unit, which was part of the third quarter integrated Earth science unit on astronomy/Newtonian physics. This procedure was termed as the tiering designation assessment. The treatment students were divided into three subgroups that received tiered curriculum based on this assessment of background knowledge of astronomy. The results of each participant's assessment determined in which of three instructional subgroups the students in the treatment classes would be assigned. Each of the seven treatment classrooms had students from each of the subgroups. The participants in the control group also took the tiering designation assessment. Their results were utilized in the postexperiment phase for comparative analyses. Prior to instruction, all of the students completed an astronomy unit pretest. Following the pretest, all of the students received 4 weeks of instruction in astronomy/Newtonian physics that was followed by a unit posttest (see Figure 1).

Tiering Designation Assessment

The tiering designation assessment covered the expected skills and background knowledge required for the entire astronomy unit, as well as skills and knowledge the learners would need to know to demonstrate proficiency of the content standards. For the purpose of this study, the students in the treatment were grouped as follows:

1. *Lower background knowledge learners* were those who scored in the lower 10–11% on the tiering designation assessment for

Pre-Experiment Phase

Before the beginning of the term, the high school office staff randomly assigned 388 students to 14 general science classes.

All of the teachers received professional development in tiered instruction 4 months before instructional unit.

Curriculum developed and reviewed by expert panels.

Treatment Group		**Control Group**
Seven Classes 194 students		Seven Classes 194 students
Tiering designation assessment administered 4 weeks before instructional unit to determine placement in treatment groups: T1: Lower background 10% T2: Midrange background 80% T3: Higher background 10%		Tiering designation assessment administered 4 weeks before instructional unit for use in later analysis
Astronomy unit pretest	**Experiment Phase**	Astronomy unit pretest
Tiered instructional units taught for 4 weeks to students in treatment groups T1, T2, or T3		Midrange instructional unit taught for 4 weeks to all students
Astronomy unit posttest administered to 150 students		Astronomy unit posttest administered to 143 students
	Analysis Phase	
		Tiering designation assessments are analyzed. Students and their scores are now distributed into subgroups for analysis using the same ratios as the treatment groups: C1: Lower background 10% C2: Midrange background 80% C3: Higher background 10%
Analysis of pre- and post-assessment scores by subgroup designation		Analysis of pre- and post-assessment scores by subgroup designation

Figure 1. Sequence of experiment and instructional design.

background skills and knowledge in astronomy for this school, in this grade, for school year 2004–2005. The lower background knowledge learners were classified as treatment subgroup 1 of the tiered subgroups (T1).

2. *Midrange background knowledge learners* were students with the middle range of prior subject knowledge, based on the tiering designation assessment. They composed about 80% of the subjects and represented the typical student for the school. The midrange background knowledge learners were classified as treatment subgroup 2 of the tiered subgroups (T2).

3. *High background knowledge or advanced learners* were those students whose general background knowledge as measured on the tiering designation assessment was above the midrange assessed subgroup. For the purpose of treatment tiering and analysis, the learners in this subgroup had the upper 10% of the scores on the tiering designation assessment. The high background knowledge learners were classified as subgroup 3 of the tiered subgroups (T3).

The rationale for the use of the 10% of high and low scores to determine subgroup score cutoff points was based on several factors. Upon the examination of the tiering designation assessment scores for each class, a natural break occurred in the range of scores at about 10% on both the upper and lower ends of the scores. Another consideration was that many of the school districts in the region of the high school identified the top 10% of a grade level for eligibility for enrichment services. Additionally, this school district had a policy that no more than 10% of a regular education classroom could contain students requiring special education accommodations without paraprofessional support. Students were not placed in one of the treatment subgroups based on formal identification for either special or gifted education services. It was based on background knowledge alone. The 10% level was utilized because it also provided a group of three to four students for both the low background subgroup (T1) and the high background subgroup (T3) in the treatment classrooms.

After placement of learners into the low and high background groups, teachers were consulted to verify that placement reflected the teachers' academic experiences with the learners. All students in the control group classes received the midrange level curriculum.

Teacher Training and Assistance

One of the researchers started preparing the teachers of the freshman science classes 4 months prior to the implementation of the experimental instructional unit. She worked with them to facilitate their understanding of the operations of a tiered classroom and to provide them with samples of tiered lessons that matched the content they were currently teaching. The teachers in the freshmen science classes all used at least some of those tiered lessons in the semester before the study to acquaint themselves and the students with the process. Professional development workshops were conducted for the experimental teachers to discuss the elements and methods of differentiated instruction. Because the types of differentiation and the degree of implementation of differentiated instruction varied and because not all teachers who differentiated did so for all classrooms within the same course, the division of the classes into the control and treatment groups did not present a drastic variation from their usual instruction. The instructional difference for the treatment group was in the consistent, guided tiered instruction for the duration of an entire educational unit.

During the experimental unit, the researcher met with all the teachers twice-weekly in a cooperative planning period and with individual teachers as needed for information and support. During the meetings, the upcoming lesson activities were reviewed, labs practiced, and teaching prompts discussed. The researcher acted as a technical facilitator in all tiered classrooms, taking direction from the teacher and following that teacher's instructional style. The researcher set up and broke down all labs and hands-on activities for the 14 classes. All instructional materials and student worksheets were copied and placed into labeled boxes for each of the 14 classes for each week. The tiered classes had the materials not only grouped by day, but labeled and bundled for each tier group. All learning activities, labs, and assessments were graded daily by the researcher. Each activity, lab, and assessment had its own rubric for grading to ensure continuity in the implementation of materials and assessment.

Activities Within the Treatment and Control Groups

Learners were assigned to treatment groups T1, T2, or T3 within each treatment class based on their tiering designation assessment scores. Those identified for the T1 and T3 subgroups comprised their own work groups. The teachers in the treatment classes assigned the midrange students (T2) into work groups for learning activities. A group of three to four students was a workable number of students per work group for an assignment to be divided among the team members in a multitask activity. Each work group member had a portion of the activity or lab to complete and each work group in turn contributed to the class understanding of the concept or topic undertaken through facilitated discussions. The different learning tasks for the students in each work group were either randomly assigned or selected by the learners. All work groups reported the findings of each learning activity to the class. All students participated in a teacher-facilitated discussion on the findings of each group, thus exposing all of them all to content and applications addressing the scope of the tiered activity. All the learners in the control classrooms used the activities and labs designed for the midrange learners in the treatment group. The learners in the control classrooms were also placed into work groups designed so that each member of the group had tasks to accomplish. Within the control classrooms, all of the groups also reported their findings to the class and participated in a discussion on the results of their findings. The difference between the treatment and the control classes was that the control classrooms did not have the tiered levels found in the treatment classrooms.

Instructional and Curricular Design

One of the researchers produced the instructional materials for the study. She held advanced degrees in life science and gifted education and taught science education courses in a university teacher preparation program. She developed all of the assessments and curricula that were then reviewed by expert panels in science education and gifted education. Field tests were administered prior to the study with students who were at the same grade level and had a similar demographic profile. Adjustments were made based on the results of the field tests.

The development of the tiered curriculum began with establishing the basic curriculum intended to be used for the entire control group and the midrange background knowledge learners in the treatment group (T2). These core instructional materials were developed from the state content standards and topics in the astronomy unit that were typically used in classes. The instructional materials were adjusted slightly and augmented to support the Learning Cycle Model of instruction (Abraham, 1997). For example, the teachers wanted to include a project involving a possible asteroid strike on Earth as part of the unit, thus activities were included to support student understanding of causes and identification of craters and effects of asteroid impacts. The instructional materials developed for the midrange treatment group (T2) served as the curriculum for the entire control group (see Table 1).

Based on the midrange curriculum, the materials were then differentiated for students with a higher level of background knowledge (T3) as determined by the tiering designation assessment, as well as for those students with a lower than average level of background knowledge (T1). Tiered activities and labs were designed so that every member of each work group had challenging and respectful learning activities. The science lab and other learning activities were developed to address the differences in student background knowledge and previously learned skills. A master list of all activities, videos, reading assignments, and other instructional delivery methods was compiled and approved by the pedagogy, content, and standards committees. The tiering variations in instruction occurred in one or more of the areas of curriculum content level, the process method(s), or the type/complexity/depth of product. Table 1 describes the ways those dimensions were differentiated for the three tiers.

Analysis

The data analyzed in the study included the pre- and postinstruction assessment scores from all learners who had completed the tiering designation assessment, instructional unit, and both the pre- and postinstruction assessments. By the end of the study, 95 students were lost to attrition, resulting in 293 completing all parts of the study. Table 2 shows how many completed the study in each group. Each treatment subgroup (T1, T2, T3) and the control group as a whole had their pre- and postinstruction scores pooled for cross comparisons of improvement in learner achievement.

The tiering designation assessment had been administered to all participants 4 weeks prior to the experimental unit. For those in the treatment group, the results determined into which of the treatment subgroups the students were placed. For those in the control group, the scores of the tiering designation assessment were not analyzed until the posttests were completed. We rank ordered the scores into groups corresponding to the grouping designations of the treatment subgroups (lower 10%, C1; midrange 80%, C2; and higher background knowledge 10%, C3) for purposes of comparison with the treatment subgroups. This enabled the comparison of the growth of the learners in the control group who all received instruction at the midrange level versus the growth of the learners in the treatment subgroups who received tiered instruction, based on their initial knowledge and skill levels.

Table 1

Tiered Assignments: Curriculum Characteristics of Each Level

Component of Lesson or Assignment	Low Background Learners	Average Background Learners	High Background Learners
Depth of Content	Basic information to meet content standards. Simpler explanations and examples provided.	Basic information to meet content standards.	Greater depth of content. Greater level of detail and related information included.
Degree of Structure in Process			
Dependence level of subgroups	Higher teacher involvement, instruction, and feedback with frequent checks for understanding and skill development.	Directions and background information provided. Teacher checks final product for understanding and skills.	More independent and self-directed. Teacher is in facilitator role.
Number of steps	Content broken down into short inquiry/labs. Example: Star characteristic labs—Each lab addresses one or at most two of the characteristics of stars (e.g., size and color), with the Hertzsprung-Russell (H-R) diagram. Students are provided with the star, and its color and size. This allows students to use one dimension of the H-R diagram.	Content is chunked into related units. Example: Star lab where a number of stars with the valuable characteristics are provided to the students. Characteristics are increased to include intensity and age to classify stars with H-R diagram with age inclusions. This allows the students to use two dimensions of the H-R diagram.	Learners apply the content given to them prior to assignment or lab and use skills to find additional content to aid in completion of project from the resources the teacher provides. Example: 12 randomly selected stars assigned for identification. Students are provided with a star atlas to find the star's characteristics. The number of characteristics is increased to include gas content, luminosity, distance to facilitate use of formulas to classify stars and find expected life-spans.

Skills used or new skills learned	Prior knowledge and skills assessed to ensure correct understanding. New skills addressed and used in the project or assignment as each skill is required.	Little review of prior skills. New skills addressed and then used in the project or assignment.	Review of prior skills if indicated by preassessment. New skills addressed and then used in the project or assignment.
Length of time on task	Short time frames for each step with feedback at the end of each step.	Longer time periods to work. Less review of work done than lower background learners. Major components of assignment checked and returned with feedback.	Entire assignment time given to student who then determines the best use of time to complete the assignment.
Sophistication of product	Lower or about age and grade level. Work reflects possible lower skill experience that is supported by scaffolding up to grade-level quality.	At age and grade level.	Above age and grade level. Product completed with greater care and finer details.
Resource materials	Information from one or two possible sources. Basic level without elaboration.	Information from more than two sources. Materials align with content and product form.	More information used from student-found sources. Materials well-incorporated to align with content and product form.

***Note*. Adapted from Nordlund (2003) and Tomlinson (1995, 1999).**

Table 2

Number of Students Completing Study

Experimental group	Number of students
Control total	143
Treatment total	150
T1	31
T2	91
T3	28

Research Design Discussion of Analysis Methods

The appropriate analysis of a two-way factorial design includes an analysis of variance (ANOVA) or a regression analysis (Hicks, 1973; Hicks & Turner, 1999; Trochim, 2006). Traditionally, in the sciences, an ANOVA is performed to identify those variables of interest and then a least square means regression is undertaken to account for analysis of unequal groups in calculating means.

Regression in statistics is a mathematical method used to examine the relationship between the dependent and independent variables (Dallal, 2007; Lewicki & Hill, 2006; Ott, 1977; Ott, Ott, & Longnecker, 2001). Linear regression models the relationship between the dependent and independent variables with the result being an equation that fits a straight line though a set of points (Dallal, 2007; Lewicki & Hill, 2006; Ott, 1977; Ott et al., 2001). The factors or parameters of the regression equation can be estimated in several ways. The method of least square means (LSM) is used in general regression models (Hicks, 1973; Hicks & Turner, 1999; Maxwell & Delaney,1999). Least square means is a simple linear regression method that is designed to minimize the sum of the squared differences or residuals between the actual and predicted values of the dependent variable (Levine & Stephan, 2005).

Least square means statistical technique minimizes the sum of squares distances from the observed points of the fitted straight line. A comparison of means assumes that all of the

Table 3

Preinstruction Least Square Means Analysis
Between Experimental Levels

Experimental Group	Level	Experimental Group	Level	*p* value
Control	1	Treatment	1	0.61
Control	2	Treatment	2	0.51
Control	3	Treatment	3	0.93

Note. Subgroup: 1 = low background; 2 = midrange background; 3 = high background.

sample sizes are equal (Statica, 2003). The least square means analysis is used to reduce the size effect of each group on the means for each group (Dallal, 2007; Gall, Gall, & Borg, 2003; Hicks, 1973; Hicks & Turner, 1999). Least square means analysis is utilized when working with treatment groups or other situations where the number of observations per group may vary or is not within the researcher's ability to control. The least squares means (LSM) method removes the analysis noise due to sample size and provides a clearer view of the relationship between and within the data groups. LSM calculates the confidence intervals and is valuable in providing a closer examination at the confidence intervals of 90% and higher.

In the first step of analysis for this study, the means of the preinstruction scores were examined for each experimental group. A two-way analysis of variance conducted on the data for the control and treatment groups showed no significant difference between the control and treatment groups before the instructional unit (see Table 3). The lack of significant difference remained intact when learners were removed from the data set due to failure to complete the postinstruction assessment within the assessment window. The difference in the number of students completing the postinstruction assessment from those taking the preinstruction assessment may be partially explained by the number of learners leaving several weeks early for spring break. The unit utilized for the experiment was scheduled to fit into the

Table 4

Experimental Subgroup Means and Standard Deviations

Treatment	Subgroup	*n*	Means Posttest	Standard Deviation
Control	1	22	11.39	6.27
Control	2	95	18.20	6.66
Control	3	26	23.66	2.69
Control	Combined	143	18.14	7.01
Treatment	1	31	17.37	5.19
Treatment	2	91	19.50	4.90
Treatment	3	28	23.86	2.51
Treatment	Combined	150	19.87	5.05

curriculum to avoid confounding factors such as the annual state assessments and spring break.

Results

Postinstruction Assessment Means

Table 4 presents an overview of the postinstruction assessment means. The mean scores, disaggregated by subgroup, suggest that the treatment had the greatest beneficial influence on the academic achievement of the lower background learners. The treatment groups showed slightly less variation within groups than the control group. From examination of the means, the gap between the academic achievement of the low background learners and the midrange background learners appeared to be smaller in the treatment group than in the control group. It is also noteworthy that the postassessment means of C2, T1, and T2 are very similar. Figure 2 graphically presents the raw means and standard deviations of the treatment and control subgroups.

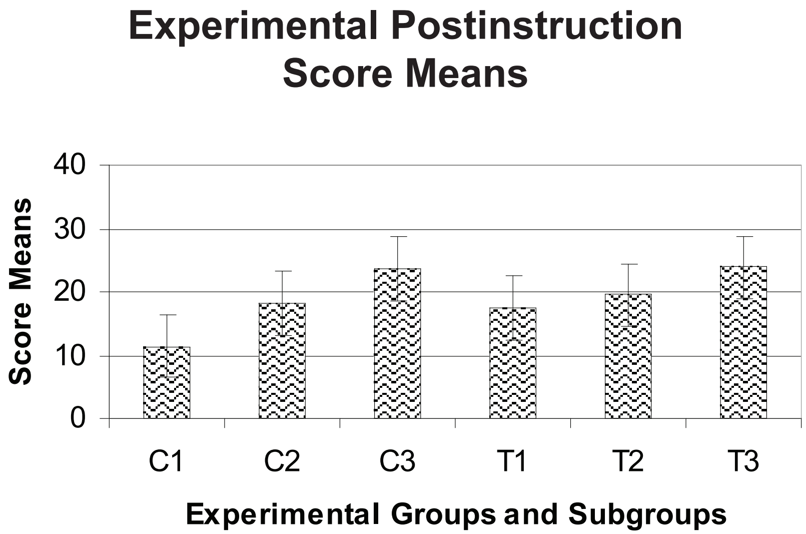

Figure 2. Graph of means and standard deviations for the postinstruction scores.

Analysis of Variance Results

An analysis of variance (ANOVA) was conducted to determine if there was a significant difference between the pretest achievement of the control and treatment groups. The preassessment ANOVA was nonsignificant (p = .79), which provides evidence that the control and the treatment groups were essentially the same prior to intervention (see Table 5).

Use of the statistical method ANOVA to examine the differences in postinstruction scores between the control group and the treatment group on the Tiering Assessment provided evidence that there was a significant difference between the treatment group and the control group (see Table 6). In addition, there was a statistically significant interaction between treatment group and instructional tier (p = .01), indicating that the treatment exhibited differential effectiveness across the three tiers of students.

Table 5

Analysis of Variance for Preinstruction Achievement Scores Between Experimental Groups

Source	*df*	Mean Square	*F* value	*p* value
Preinstruction Score	1	14909.42	746.39	<0.0001
Treatment Group Score	1	1.42	0.07	0.7902
Error	290	19.98		

Table 6

Analysis of Variance of Postinstruction Achievement Scores for Experimental Treatment Groups

Source	*df*	Mean Square	*F* value	*p* value
Treatment	1	219.27	7.57	0.0063
Tier	2	2174.42	37.52	< 0.0001
Treatment Tier	3	270.52	4.67	0.0101

Analysis of Means Results

For comparison, we also computed Cohen's *d* effect sizes (see Table 7 and Table 8) to examine the practical significance and magnitude of our research findings. Cohen's *d* represents the standardized difference between two means. Overall, there is a small difference in the postinstruction scores between the treatment groups (d = .28). However, an analysis of the subgroups reveals a large difference between the treatment and control groups in the lowest instructional tier (d = 1.06), a small difference between the treatment and the control groups in the middle instructional tier (d = .22), and a near-zero difference between the treatment and control groups in the highest instructional tier (d = .08).

Table 7

Cohen's *d* Effect Size Between Treatment and Control Subgroups

Treatment 1	*n*	Mean	Standard Dev	Treatment 2	*n*	Mean	Standard Dev	Cohen's *d*
Control overall	143	18.14	7.01	Treatment overall	150	19.87	5.05	0.28
C1	22	11.39	6.27	T1	31	17.37	5.19	1.06
C2	95	18.20	6.66	T2	91	19.50	4.90	0.22
C3	31	23.66	2.69	T3	28	23.86	2.51	0.08

Note. **C1 = control low background; C2 = control midrange background; C3 = control high background; T1 = treatment low background; T2 = treatment midrange background; T3 = treatment high background.**

Table 8

Cohen's *d* Effect Size, Between and Within Treatment Subgroups

Control	*n*	Mean	Standard Dev	Treatment	*n*	Mean	Standard Dev	Cohen's *d*
Control overall	143	18.14	7.01	Treatment overall	150	19.87	5.05	0.28
C1	22	11.39	6.27	C2	95	18.20	6.66	1.03
C1	95	11.39	6.27	C3	31	23.66	2.69	2.18
C2	26	18.20	6.66	C3	31	23.66	2.69	1.11
T1	31	17.37	5.19	T2	91	19.50	4.90	0.43
T1	31	17.37	5.19	T3	28	23.86	2.51	1.57
T2	91	19.50	4.90	T3	28	23.86	2.51	0.98
C1	22	11.39	6.27	T2	91	19.50	4.90	1.56
C1	22	11.39	6.27	T3	28	23.86	2.51	2.74
C2	95	18.20	6.66	T1	31	17.37	5.19	-0.13
C2	95	18.20	6.66	T3	28	23.86	2.51	0.95
C3	31	23.66	2.69	T1	31	17.37	5.19	-1.52
C3	31	23.66	2.69	T2	91	19.50	4.90	-0.93

Note. **C1 = control low background; C2 = control midrange background; C3 = control high background; T1 = treatment low background; T2 = treatment midrange background; T3 = treatment high background.**

Table 9

Postinstruction Least Square Means Analysis of Control and Treatment Groups' Levels

Experimental Subgroup	Experimental Subgroup	*p* value
C1	T1	0.0013
C1	T2	< .0001
C1	T3	< .0001
C2	T1	0.9787
C2	T2	0.5545
C2	T3	< .0001
C3	T1	0.0003
C3	T2	0.0090
C3	T3	1.00

Note. C1 = control low background; C2 = control midrange background; C3 = control high background T1 = treatment low background; T2 = treatment midrange background; T3 = treatment high background.

Regression: Least Square Means

A cross comparison of the treatment subgroups (T1, T2, T3) with their counterpart control subgroups (C1, C2, C3) is provided in Table 9. There was a significant difference between the low background knowledge learners (T1, C1) for the two treatments. However, for midrange learners (T2, C2) and high background learners (T3, C3), the differences between the treatment group and the control group were not statistically significant. Interestingly, the control midrange learners (C2) and treatment low background learners (T1) were not statistically significantly different from each other on the postinstruction assessment scores.

The treatment low background and midrange learners performed similarly on the postinstruction assessment (see Table 10). It appears that tiered lessons may have enabled the low

Table 10

Postinstruction Least Square Means Analysis
Within Treatment Level

Experimental Subgroup	Experimental Subgroup	p value
C1	C3	< .0001
C2	C1	< .0001
C2	C3	< .0001
T1	T3	< .0001
T2	T1	0.3919
T2	T3	0.0036

Note. C1 = control low background; C2 = control midrange background; C3 = control high background; T1 = treatment low background; T2 = treatment midrange background; T3 = treatment high background.

background learners to make up lost academic ground and work at the level of the midrange student for the grade level.

Discussion

NCLB (2001) requires that all learners, including gifted and high-ability learners, make yearly academic gains within a school year. The use of differentiated instructional methods and materials should allow gifted children to spend the entire school year learning new content, thus adding to existing schema, rather than merely reviewing content or "zoning out." In this study, we did not find this. Our results show grouping learners based on prior background knowledge resulted in different achievement, especially at the lowest level of prior knowledge. The study supports curriculum differentiation through tiered assignments as an effective way to increase academic achievement for lower achieving students. Grouping was on a short-term basis and as a result of the respectful, appropriate lessons of the curricular design, no learners were labeled within the classroom.

In the treatment classes, the procedures for instruction and learning were altered. Learners in all groups had to contribute to the conclusions of each activity in the lesson plan and the tiering may have reduced the tendency of students to hide behind the learning efforts of others within the classroom. The change of classroom instruction procedures supported the use of the tiered lessons. Making the adjustment of addressing the background knowledge levels of the students and the scaffolding of the activities may have allowed the learners to have a sense that they could learn the new information as it was attached to skills and information they already possessed. The spiral design allowed for repeated use of old and new skills and information, reinforcing the new learning while applying it in related but different situations.

This research suggests consideration of several elements regarding the implementation of differentiated instruction with tiered lessons:

1. Professional support for teachers is critical to the success of curriculum differentiation strategies. In this study, support included professional development before the implementation, regularly scheduled meetings, and the availability of the researcher to help solve problems as they arose.
2. A strong background in the subject matter is required in order to tier or differentiate curriculum at this grade level (Nordlund, 2003; Tomlinson, 1999). The individual designing the curriculum also needs a thorough understanding of the range of potential learning activities appropriate to the targeted levels of learners. Experience working with learners of different knowledge levels and skill backgrounds is beneficial for those implementing a differentiated curriculum.
3. The implementation of a change of instructional and classroom organization, pedagogy, and expectations needs to be systematically introduced over time. Higher ability students who may be accustomed to lower teacher expectations and exerting low effort to achieve good grades

> may need to be explicitly taught how the expectations and procedures are different from before. Lower ability students may need to be cued that they will experience success from this new system.

The grouping of students for a unit of study based on their prior skills and subject background knowledge for instruction was most academically useful for the lower skill and background knowledge learners. The lower background learners as a group achieved as well as the midrange background learners within the tiered instruction and better than the control group's median learners.

The high background learners in both groups performed equally well on the postassessment. This was possibly the result of past classroom learning experiences in school. They would typically have more time to do learning tasks as the teacher would normally pace the instruction to the students in the midrange of ability. Students may not have developed appropriate time management skills and maintained the expectation that they would still make top grades no matter how their classmates performed. Alternatively, the high-tier curriculum may not have been challenging enough for the highest students. Ceiling effects on the postassessment for the highest ability group may also help to explain the similarity between the treatment and the control groups in the highest tier. Finally, it is possible that tiered instruction is most beneficial for lower achieving students.

Educators need to do more to "raise the bar" of expectations and ensure that the brightest of each classroom are as challenged as their classmates in each subject. By starting the instructional paradigm shift at the beginning of the school year, and continuing it throughout the school grades, the higher ability learners may be academically challenged, thus learning more content with greater depth. Differentiated instruction has the potential to help develop a broader, integrated understanding of the content and develop the corresponding methods and skills used by practicing professionals in the particular field. However, further research needs to be conducted to determine the effectiveness of tiering with average and high-ability students.

Limitations

The study has three limitations: (a) The study is limited to information available in the literature and the data collected by the test items, (b) the study is limited to the freshmen class entering the Fall 2004 school year at an urban high school in a Western state with five general education science teachers, thus the findings from the study should not be generalized to any other student population, other than the district of the study, and (c) the teachers may not have uniformly implemented the treatments in the appropriate classrooms.

The research design for this study attempted to minimize the confounding variables such as time of day and teacher effectiveness by systematically assigning course classrooms across time of day and teachers. Teacher effect was reduced by having all teachers present the same activities and provide the same background information to all classes within treatment groups. However, differences among teachers may still have influenced the results of the study.

Potential ceiling effects on the postassessment represent a major limitation of the present study. The pre- and postinstruction assessments were designed with a wider range of questions and questions requiring thought and analysis in an attempt to avoid a ceiling effect on the postinstruction scores. The fact that many of the students in the high background groups did score between 90% and 100% may indicate that the effort to avoid a ceiling effect was not completely met on the pre- and postinstruction assessment. The challenge was using questions with sufficient depth, but no so deep that students would give up and not apply themselves on the postassessment. Designing an assessment without a ceiling for the highest achieving students would likely take several rounds of administration and revision. Future researchers should ensure that their postassessments have adequate room to detect differences among the highest ability students.

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