Science, Standards, and Differentiation:

It Really Can Be Fun!

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Teaching in a regular classroom has become more complicated than ever with increased student diversity and pressure to connect learning experiences to educational standards and test preparation (Brighton, 2002). Although teaching to the middle is often what occurs in traditional classrooms to meet required standards, it is neither an appropriate nor meaningful method of instruction with the inclusion of both students who are gifted and/or have learning disabilities or other disabling conditions. Differentiation of instruction, although challenging for the classroom teacher, is an effective approach that may resolve egalitarianism in education, where all students receive exactly the same educational experiences rather than "everyone having an equal opportunity to actualize their learning potential" (Winebrenner, 1999, p. 12). Our work in an inclusive third-grade classroom shows promise and a sense of hopefulness from both students and teacher alike with regard to meeting varied educational needs in science while still addressing mandated educational standards.

What Is Differentiation?

In the practice of education, differentiation is defined as working to address the abilities, interests, and needs (both perceived and real) of individuals. Differentiation provides students with opportunities to approach curriculum from their strengths, as varied as these might be. From this firm footing, limitations can be addressed without developing negative perceptions of self-ability or self-worth. Tomlinson (2000a) discussed four ways of differentiating: content, process, product, and environment[1]. In addition, she focused on students by recognizing that readiness, interest, or learning profile (basically preferred learning styles) are key considerations when exploring differentiation options.

Content, or what is intended to be learned, often is dictated by a course of study based on average performance at grade level. Content can be differentiated by providing materials at varied ability or grade levels in one classroom. This commonly is done in language arts, for example, by using graded texts. Students take a pretest to identify their reading level and are then provided with reading materials that address course content, but are written at a level matched to student test performance. A common example is the Accelerated Reader® program.

Process differentiation (how the content is taught and hopefully learned) refers to use of diverse activities that are varied to meet student interests or preferences for learning. For example, when learning about butterflies, some students have opportunities to explore using the Internet while others either read texts, set up a butterfly habitat, or even interview a biologist to gain information. Process differentiation is commonly used by all teachers throughout the course of a year to help students exercise higher order thinking skills.

Differentiating via product means that students have some choice in how they will show the teacher, class, or other audience what they have learned. The use of project choices is a common way of product differentiation used to express the required learning objectives or outcomes sought by a teacher.

Providing students with both quiet and group work stations and the ability to move around or sit still are ways the learning environment can be differentiated. Altering the methods of instruction or organization of the classroom to facilitate learning are other common means of differentiating the environment to help learners be successful.

In this article, we present and discuss a third-grade differentiated unit on simple machines. The unit, taught over the course of 3 weeks, addressed all four forms of differentiation: content—students learned different material based on their ability level; process—using a hands-on approach to learning

Table 1
State of Ohio Third Grade Science Standards Addressed in Unit

Standard	Organizer	Grade Level Indicator
Physical Sciences	Forces and Motion	• Describe an object's position by locating it relative to another object or the background. • Describe an object's motion by tracing and measuring its position over time. • Identify contact/noncontact forces that affect motion of an object (e.g., gravity, magnetism, and collision). • Predict the changes when an object experiences a force (e.g., a push or pull, weight and friction).
Science and Technology	Abilities to do Technological Design	• Use a simple design process to solve a problem (e.g., identify a problem, identify possible solutions, and design a solution). • Describe possible solutions to a design problem (e.g., how to hold down paper in the wind).
Scientific Inquiry	Doing Scientific Inquiry	• Discuss observations and measurements made by other people. • Read and interpret simple tables and graphs produced by self/others. • Record and organize observations (e.g., journals, charts, and tables). • Communicate scientific findings to others through a variety of methods (e.g., pictures, written, oral, and recorded observations).

Note: Standards in English/Language Arts and Social Studies can be mapped into the unit as well. Our focus, however, was directed toward science standards only by the teacher and district personnel in this study.

or reading from a book based on a student's preference; product—choice in end product to turn in to teacher; and environment—quiet independent study areas and small group work areas.

The primary focus of this article is on exploring process differentiation (tiered lessons and options in expressing required learning) in the context of a flexibly grouped learning environment. Our goal is to help teachers gain perspective and insight about effective differentiation in elementary classroom settings and that science is a natural means of connecting curriculum to students' lives.

A Collaborative Effort

We were recruited by a school district to provide in-service sessions on differentiating instruction at the elementary (K–4) level. As part of the process, we requested the opportunity to model the theories and discussions in a live classroom environment so faculty and staff would not only experience the theory behind differentiation, but also see it happen with their children.

The district viewed this approach as novel; a third-grade teacher volunteered her classroom as the "demonstration site." We asked the teacher to provide a content area or specific topic she wanted differentiated. She chose science—specifically a unit on simple machines—stating it was one of the hardest subjects for her students, and that she wasn't very comfortable teaching it.

The three of us collaboratively worked on the design of tiered lessons and a differentiated product assessment for the unit to fit the vast array of ability needs in the classroom (26 students: 13 special needs in reading, math, or both; 2 gifted). Although we were bound by the state-mandated educational standards, our primary concern was not the standards themselves, but rather how to "vary . . . teaching of those standards to insure [teaching was] a good fit for a wide range of learners" (Gould, 2000, p. 74). Looking at the standards not as *the* curriculum, but rather reflected *in* the curriculum (Tomlinson, 2000b) allowed us to create a unit that was more meaningful and appropriate for students of all ability levels (see Table 1 for state science standards addressed in the unit).

For each of the simple machines in the unit (wheel and axle, wedge, screw, inclined plane, lever, and pulley), tiered activities were planned at three levels: knowledge, application, and exploration/evaluation. A tiered lesson is "a differentiation strategy that addresses a particular standard, key concept, [or] generalization, but allows several pathways for students to arrive at an understanding of these components based on their interests, readiness, or learning profiles" (Pierce & Adams, 2004, p. 60).

Students all began with the knowledge level—an introductory and basic lesson of understanding for a particular simple machine. Students were grouped by ability. Each group worked through the knowledge les-

Name: ______________________ Date: ____________

Inclined Plane

Materials:
6 books
Small bag filled with 1 cup of rice
Spring Scale

Prediction-Hypothesis-Question:
Circle which will be easier—moving the bag using the inclined plane or moving it by lifting straight up? Why do you think your choice is the easiest?

Procedure:

1. Holding the end of the spring scale, lift the bag straight up to the top of the books.
2. Record the force used to do this in Table 1.
3. Stack 5 books.
4. Lean the 6th book against the stack to make an inclined plane.
5. Attach the spring scale to the bag of rice.
6. Put the bag at the bottom of the inclined book.
7. Hold the end of the spring scale and *slowly* pull the bag up the plane.
8. Record the force needed to pull the bag up the inclined plane when it is at the top of the inclined plane in Table 1.

Moving Bag	Force Needed
Straight Up	
Inclined Plane	

Table 1.

Question:
In your own words, what is an incline plane and how does it make our lives easier?

____

____

____

Figure 1. Tier 1 knowledge level activity: Inclined planes.

EXTENSION CONNECTION

The INCLINED PLANE in Action

You are familiar with steps, and ramps. Let's think on a bigger scale. Suppose you are a road engineer. You are in charge of building a road that goes over a mountain (10,000 feet high). The road will be traveled by cars, tractor-trailers, and recreational vehicles.

Using INCLINED PLANES, how should you build the road to reduce the amount of force needed to go over the mountain so all vehicles can make it?

For You To Do:

Make a diagram of your engineered design. Give as much detail to your diagram as you can. In your journal, tell why and how your engineered design is the best one to use to build the road. Think about and discuss building costs, distances to travel, cost of gasoline (or diesel fuel), and impact on the environment.

Journal Questions:

1. *Where are the inclined planes located in your designs?*
2. *How do they work?*

Hint:
Ramps and stairs might help you plan your design. Try more than one way before deciding which is best.

Up For a Challenge?

Many roads are built with lots of curves when going over mountains. Why do you think this is so? Explain your answer in your journal and get a few pictures from the internet or magazines that show curvy roads in action.

Figure 3. Tier 3 exploration/evaluation activity: Inclined plane.

Here to There (or Up, Up, Up We Go)

Raising an object requires a lot of force and energy. In this activity, you'll explore INERTIA and FRICTION as they relate to the INCLINED PLANE.

Repeat the experiment, but this time, very slowly pull on the Spring Scale as you attempt to move the bag of rice up the incline. What is the measure on the Spring Scale JUST BEFORE the bag begins to move? Explain what is going on!

What happens to the Spring Scale measure JUST AFTER the bag begins to move? (Does the number stay the same, go up, or go down?) Why?

Change the experiment...

Find a book with either a rough or smooth surface. Repeat the experiment with the bag of rice, recording your measurements in a table in the Guide sheet.

Repeat the experiment using a wooden block instead of the bag of rice. Record your measurements and observations in the table on the Guide sheet.

Journal Questions:

1. Based on your experiments, define FRICTION in your journal.
2. Based on your experiments, what is INERTIA?
3. In what ways could you make inclined planes work with lower friction?
4. Is inertia always the same for all objects? Explain.

Figure 2. Tier 2 application level activity: Inclined plane.

son at their team's pace. Groups able to understand the concept faster than others moved on to the application lesson and possibly the exploration/evaluation lesson. Grouping was flexible and often changed based on student needs as each simple machine was introduced and students showed interest or strong ability levels with the content.

To successfully meet the state standards, it was necessary for each student to at least master the initial knowledge lessons. Application and exploration/evaluation activities were available for students ready for higher level thinking or more depth, allowing them to explore educational experiences well beyond the standards.

Not all students received the *same* science education in this simple machines unit, therefore the content varied. Students having difficulty with the knowledge lessons received additional assistance from the classroom teacher, and students mastering content more quickly moved ahead and experienced in-depth explorations. All students did, however, receive a *fair* science education that took their academic needs and ability into careful consideration, allowing them to feel appropriately challenged without frustration from lessons being overly repetitive, too easy, or too complex.

We include a sample tiered lesson for inclined planes used during the classroom demonstration. Figure 1 is the knowledge-level activity addressing the content standards. Figure 2 is the second tier, where students apply their knowledge from Tier 1 to explore the topic in deeper and different (more personal) ways. Note that students get more choice in how to approach the activity at the Tier 2 level. Figure 3 is the highest tier for the lesson. Students are presented with a challenge and asked to apply their knowledge about inclined planes, plus other life experiences to solve a dilemma they might never have considered. Not all students tried the Tier 3 activity, but the few who did were excited and independently worked on this activity at home (although there was no requirement to do so).

Process differentiation for this unit also took form in a Rube-Goldberg-type culminating activity. Students were all presented with the same basic problem of creating a complex machine made from a series of simple machines that would do *work* (how to lift a lion—which linked to a language arts story they were reading in the classroom). The intent of this activity was to provide a means for all students to apply their knowledge beyond minimum content knowledge—beyond basic standards.

Students then had the choice of working alone or teaming up with others to complete the final product. The assignment was very flexible, with students deciding the types, number, and seriation of simple machines used to do the work. As well, the students were able to choose the type of work to do (deciding what lifting a lion meant to them) and report their finished results to one member of the teaching team.

We provided a wide array of materials in boxes that students could use to devise unique simple machines that linked together to form a complex machine. Materials included paper towel tubes, string, paper cups, paper clips, various pieces of wood, wheels, circles of cardboard, pulleys, paper plates, and a loose assortment of fasteners (e.g., screws, tacks, nails).

Our rationale was that science does not require complex apparatus. Most (if not all) "scientific instruments" can be made from common household "junk" with a little creativity and imagination. This approach to science activity promotes creativity, use of imagination, and higher order and critical thinking in school, where students are not accustomed to doing such natural things.

The assessment process and products not only allowed the teacher to see if her students understood how simple machines worked in isolation, but gave her the chance to see if learners could apply this knowledge in the construction of a unique complex machine. This took the focus of the content beyond the minimum performance level because complex machines were not discussed in the class.

Students with varying abilities were able to meet the basic objective of this assessment if they had mastered the minimal knowledge lesson. However, opportunity was given to students who had mastered the application and exploration/evaluation lessons to express their deeper understanding of simple machines by creating more sophisticated complex machines that did some form of *work*.

Student Reflections

Students were interviewed in small groups. Questions were asked about their feelings and attitudes toward the differentiated simple machines unit compared with other science lessons they had in the classroom. A vast majority reported liking the differentiated simple machines unit better than the science they did before. The major reason for preferring the differentiated unit was because it was more "fun" doing activities and working on their own:

> Simple machines was [*sic*] more fun because we did things instead of reading only about it. It was cool to make our own way of putting things together. I liked it because it was fun.—third-grade boy

> I like doing stuff more than reading and answering test questions. I like to be able to move around and come up with my way of doing things. It was nice with you here to get things opened for us. We normally don't do this. [Our teacher] helps us get vocabulary, but I like doing to learn things.—third-grade girl

In other cases, students described science before as "boring" due to the textbook reading, seat work, and lack of experimentation. During the focus group interviews, the boys took the lead when it came to discussing "boring," which we had the students define if the term came up (which it did often):

> I don't like science because we read and take tests. This is boring.—third-grade boy

> Boring to me is when we read and take tests. All the science this year is this way. This is the first time it's not. I really like this way better. It's not boring to be doing it [science] and I want to do more science this way.—third-grade boy

Although most students favored the differentiated science unit, there were five students who enjoyed learning about science through both differentiated and traditional lessons. As one girl shared, "Sometimes it's just easier to read and answer questions. Doing the simple machines made me think more and I'm not sure I'd like this more in science." One student preferred the traditional lessons over differentiated. This young boy felt that traditional science lessons were "easier to focus on . . . nothing could distract you from it. In simple machines you could end up playing with stuff."

As in all diverse classrooms, no one method of teaching will meet the needs of every student. This is as it should be, respecting and honoring the varied needs and diversity of interests children have in an educational environment.

Table 2 breaks down student responses into the positives and negatives about science before and during differentiated lessons. We chose to include it to give a broader view of responses received from the entire class rather than rely on the vignettes above as the representative sample for the entire setting. Some children were very open and verbal—sharing their insights freely with us. Others were more introspective, sharing only head nods or a brief statement here or there during the focus group interviews.

Table 2
Student Perspectives of Science: Differentiated vs. Traditional Teaching Approaches

Differentiated	
Positives	Negatives
• more fun	• needed to learn to work in small groups
• choices	• teacher had to do a lot of prep work
• learned more/better understanding	• distracting*
• work at own speed	
• experiment and create	
Traditional	
Positives	Negatives
• easier to focus*	• boring
	• too easy
	• don't do anything
	• work as whole class all the time
	• no experiments—only book reading and worksheets
	• didn't understand science this way

Note. Student views in the table are representative of the majority of the class.
* indicates a student perspective representative of only one child.

Teacher's Perspective

Although the teacher found the process of differentiating lessons "much harder than expected . . . and a lot of [additional] planning and preparation" time was needed, "actually teaching the lessons was great and really pretty easy." She noticed the responsibility for learning shifted over to students as they were given choices and took the initiative to explore and learn without constant teacher direction.

There were functional issues, though, as students took on a new approach. For instance, the teacher shared there was "some arguing within ability groups at first, [but] it ended much better as they [students] grew more comfortable working together and with things they weren't used to."

This teacher plans to continue the process of differentiating lessons. "The students would be disappointed if [I didn't]. And I would also personally feel some disappointment if [differentiation] didn't continue."

Based on this teacher's experiences differentiating science lessons and assessments, her suggestion for other teachers interested in differentiating is to "start with a comfortable subject area or topic . . . and first do a small unit."

Final Thoughts

Differentiating instruction to meet the needs of a wide range of ability levels is an extended process; not something that should be expected to occur overnight. Much of the existing focus on differentiation (during in-service sessions and existing in the literature) ignores the complex process of planning that needs to be considered when setting out to change classroom environments and instructional design.

Planning and preparation are essential ingredients in the recipe for quality differentiation that meets state standards, but more important are student needs. Also, knowing what strengths, interests, and learning preferences your students have is essential before setting out to alter the classroom environment.

We offer the following set of practical guidelines to any teacher interested in beginning the process of differentiated instruction:

- use content you feel comfortable teaching;
- do not attempt to differentiate every lesson you teach—you will get frustrated and feel burnt out;
- begin slowly, with maybe only one or two differentiated units a year;
- invite parents or classroom aides into the classroom to assist with

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Special Focus

Gifted African American Millennial Students: Implications for School Planning and Policy

This special issue of *Gifted Child Today* focuses on millennial students of color. According to the extant literature (Howe & Strauss, 2000), millennials (born between 1982 and the present) represent the current generation of students, most of whom are found in our P–16 institutions. There are clear distinctions that can be made between millennials' attitudes, behaviors, and values and those of the generations (Generation X, Boomers, G.I. Generation, and Silents) that have preceded them. However, scant literature in the field of gifted education specifically addresses the needs of millennial students in general and of African American millennials in particular—leaving a number of critical questions about how to best meet the needs of these students unanswered. For example, does the term "millennial" even apply to African American students? What role does pop culture (e.g., hip hop) play in the development of identity for this population? What does it mean to be African American, millennial, and gifted? Are our current developmental theories applicable to this group? These questions and a number of others will be addressed in this issue.

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differentiated activities until your classroom becomes accustomed to the change;

- ask for assistance and/or advice from other teachers already differentiating lessons, district curriculum specialists, or nearby university faculty when you begin to feel overwhelmed or unsure of what to do next., and
- don't give up. Differentiating is a process you learn by experience. Any effort we as teachers take to provide students with opportunities to learn in meaningful ways encourages them to succeed.

Creating differentiated lessons can be challenging. The guidelines above can help you decide not if, but how, to be successful in your efforts. Seek out other teachers who are already in the process of differentiating units and share activities. This way you enable differentiation to grow in your classrooms without having to do all of the work yourself.

Our experience shows that it is helpful to model the planning and implementation process for teachers to support dabbling. It isn't often an option provided by consultants, but should be something your district asks for when deciding to focus on differentiation as an educational and professional development process.

Overall, the positive outcomes from the process overcome the initial learning curve. Students gain a broader and deeper connection to curriculum and are able to apply their learning beyond the content area or classroom walls. In addition, teachers gain satisfaction in watching students take charge of their learning. It's a win-win situation for everyone. **GCT**

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End Notes

[1] Tomlinson excerpted and adapted her original discussion from Maker. See Maker (1982) for comparative purposes and a fuller reading behind the types or stages of differentiation.

[2] Both special needs and gifted students were identified by the school district based on students' demonstrated ability in previous years' standardized achievement testing and formal assessments by professionals trained to identify disabling conditions. Our host teacher was viewed by the special education faculty as having a welcoming and caring attitude toward special-needs learners. Therefore, her classroom was designated as the preferred inclusion site for special-needs students in the third grade.