Using Differentiated Instruction in Teacher Education

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ABSTRACT

The article discusses using differentiated instruction in mathematics education for pre-service teachers, including background information and details on a differentiated unit on fractions and integers. In addition, a study was conducted on this lesson and results are included which suggest that students who received the differentiated lesson did better than those students who received a more typical lesson. Survey results, however, show that not all students were satisfied with the differentiating.

INTRODUCTION

Many mathematics courses for pre-service elementary teachers include units on fractions, probability, and the manipulatives used to teach these subjects in primary education. The two-semester Concepts of Math for Teachers class at UNIVERSITY is no different. When teaching the course, it was dismaying, however, to find that students who struggled with fractions in the first semester of the course, were still unable to work with fractions as required in probability exercises in the second semester. What about the course needed to be changed to reach these students? How would changing the course affect those students who were already successful? What could be done to help ALL students be successful, especially on the unit with fractions?

Samples of student work from several semesters showed that students coming into the course had a wide range of mathematical abilities. There were students who had a deep understanding of fractions and integers. Other students were unable to perform successful operations on these number systems and had little understanding of the properties of these systems and how they apply to our world. After considering these issues, it was decided that creating a differentiated lesson for the unit on fractions and integers would be appropriate.

What affect would the differentiated lesson have? A research study was planned to help answer this question. First, great care was taken to develop a differentiated lesson that

conformed to current models on learning theory and research into differentiated instruction. Next, a study was designed where one group of students would receive the differentiated lesson and a second group would serve as a control and would receive the lesson as taught in other semesters. Normal course components could be used as measures of student learning, but we also wrote pre and post-surveys to help learn about student reactions. As a final step, the data was analyzed and the two sections compared. The rest of this article and related links give details on the design of the lesson, the lesson itself, the pre and post-measures, the data analysis, and a conclusion of the results.

BACKGROUND

What is differentiated instruction? There have been many debates about this throughout the years, so, for the purpose of this paper, differentiated instruction (DI) is a way to "match instruction to student need with the goal of maximizing the potential of each learner in a given area" (Tomlinson, 1999). In this process, teachers vary activities, content, assessments, or some combination of the three to help each student be successful (Tomlinson, 1999). Good (2006) describes DI in the following way:

> *It's a way of thinking about teaching and learning that advocates beginning where individuals are rather than with a prescribed plan of action, which ignores student readiness, interest, and learning profile. It is a way of thinking that challenges how educators typically envision assessment, teaching, learning, classroom roles, use of time, and curriculum. It is good teaching focused on key concepts and skills based on those concepts. All students, regardless of ability or readiness, should be challenged to make sense of these essential understandings.*

What is important to note from these definitions? It is the teacher's job to vary the learning strategies of the classroom so that the students reach maximum learning potential. However, the teacher begins with the student's individual needs, and does not focus on where the teacher is going, but where the students need to go. Therefore, DI is teacher-based and student-centered.

With the implementation of No Child Left Behind and the integration of students with special needs into regular classrooms, differentiated instruction has become very important for educators to fully understand, and properly apply to their lessons. So when did differentiated instruction begin? "Differentiated instruction has been a buzz word and research-based best practice in educational circles for a little under a decade, but is a concept most effective teachers have unintentionally done in their classrooms for centuries" (Pollnow, 2008). Though differentiated instruction has been the focus in education since IDEA passed, it has been around for a while. This is because good teachers don't need a class to tell them that their students are different. Even in a homogeneously grouped classroom, a teacher will be faced with a diversity of learners. A good teacher has been recognizing this for many years before the term "differentiated instruction" was a focus in education, because that is what a teacher must do to effectively teach his or her students.

What are some difficulties with implementing DI? Most of the issues surrounding DI are centered on heterogeneously grouped classrooms. In the heterogeneously grouped classrooms, "mathematics teachers work with students who evidence a wide range of abilities and prior knowledge" (Reed, 2004). All students learn differently, and in a heterogeneously grouped classroom, a teacher will have not only different types of learners, but also learners with a wider range of cognitive abilities. It is possible for teachers to have a range as wide as from gifted and talented students to students with IEPs that have teacher aids. This issue is a large concern for all teachers because how can you meet the needs of all students with such a diverse range? The initial solution is to individualize instruction. However, this is not possible, especially in larger classes. To this issue, Reed (2004) states:

> *In reality, individual instruction is rarely possible: Teaching to the lower level of a class perpetuates the problem of low mathematics achievement, along with boredom and disengagement on the part of the middle and high-end learners. Teaching to the middle level causes the less-prepared students to struggle and fall farther behind, while the better prepared students, who remain unchallenged, lose their motivation to learn. Teaching to the high end also seems untenable, given the probable struggle and likely disengagement by less-prepared students.*

Furthermore, Shore and Delcourt (1996) found that gifted children, placed in a typical classroom, receive less than 20% of the teacher's attention and no curricular differentiation in 84% of their learning activities. Therefore, though the teacher can give individualized instruction, most of the attention will go towards the lower-level students because they need more instruction in order to progress to the level on which they should be learning. When this happens, the gifted and talented student, or the higher-level student is left bored, and unmotivated.

What if the teacher has a homogeneously grouped classroom? Most of these issues will no longer be a concern. However, there are still some obstacles that can affect a teacher's ability to effectively differentiate instruction. One of them includes, "lack of staff development, lack of accessible materials, and lack of time to create and implement activities" (Good, 2006). This issue is of particular concern for new teachers who often don't have the experience to know what type of materials are needed, and how much time must be put into a lesson in order for the teacher to effectively differentiate instruction for all of the students. Even experienced teachers "need access to training and opportunities to network with colleagues" (Good, 2006).

There are many steps and procedures that must be taken for teachers to be able to effectively integrate differentiated instruction into the classroom, and most of them are student centered. Teachers should, "begin by developing a broad and thorough understanding of their students" (Keck, Kinney, 2005). Along with this initial condition, "teachers must know students' ability levels in order to scaffold their learning with appropriate materials and placement" (Good, 2006). To learn the students' ability levels, teachers must assess their students to see what type of learners he or she has in his or her

classroom because this is how differentiation can occur. This assessment helps the teacher to know the students' "understandings central to a unit" and then the teacher can "purposefully modify activities to eliminate repetition and drill for those who already demonstrate mastery" (Reed, 2004).

Once the students have been pre-assessed, the teacher must construct an "analysis of what is being compared, examples of how to differentiate instruction in different math topics universally taught" (Emanuelsson, Clarke, 2004). After the students' scores are analyzed, the teacher has the ability to categorize his or her students upon ability level, or any other way that the teacher desires to differentiate instruction. There is more than one way that a teacher can effectively differentiate instruction. The teacher can either choose a teacher–based or a student–based method. It does not matter; the method that he or she selects is his or her choice. Ultimately, the decision should depend on what method will get the most effective results with student learning. Some examples of differentiated instruction include, "teacher-based: curriculum, content, process, product, student differences, student based: readiness, interest, learning profile" (Good, 2006). This means that with teacher–based differentiation, the teacher can differentiate instruction either through curriculum, content, process, product (what the teacher wants the students to learn), or student differences (this is more heterogeneously grouped). The same goes for student–based differentiation. Another suggestion is that "the teacher may work with the whole class, small groups, individual students, or a combination of all three" (Good, 2006). Again, this shows that DI is teacher – based.

It is important to remember that once the students are grouped appropriately, the assessment cannot stop. How does a teacher know that his or her students are learning? The students must be assessed. Effective teaching and differentiation "requires that teachers reevaluate classroom structures and functions in their entirety" (Good, 2006). Furthermore these "ongoing assessments should measure both what students have learned and what weaknesses remain" (Good, 2006). This way the teacher knows what is left to be learned, and what, possibly must be re-taught in a different way.

An effective DI device is group work. Horn released a case study on the effects of group work, projects, and real world comparisons in a mathematics classroom in 2005. She found that by integrating projects, group work, and real world comparison, the schools "succeeded in creating more equitable environments for teaching and learning" (Horn, 2005).

THE LESSON

During Summer 2008, the content in the integers and fractions unit (which is the fourth of five units for the course) was examined and divided into 5 categories or levels of learning based on work by Hilda Taba that appeared in Schiever (1991): facts, principles, attitudes, skills, and concepts. Goals were written for each of these levels.

It was decided that the attitudes and skills of all students would be affected by work in the other three areas. For this reason, the content was divided into facts, principles, and concepts. A lecture guide was written to correspond to each of these levels of material.

Based on previous work with students in this course, it was believed that some students would already be proficient with the goals written for the facts level, and that a smaller subset of these students would also be proficient with the goals written for the principles level. Since the goals written for the concepts level involve pedagogical skills and understanding of models and manipulatives, it was assumed that students would not have seen this material before and hence this part of the lesson would not be specifically differentiated.

Before beginning the chapter on integers and fractions, students would be given a pretest to assess student knowledge of these subjects. The pretest items were written to test the material at the first four levels of Bloom's Taxonomy: knowledge, comprehension, application, and analysis. Questions were also included that asked students to self-report preferred learning style and their confidence level in working with integers and fractions. When differentiating, pretest scores would be used to place students into one of three groups: pink, green, or blue.

Based on their assigned group, students would then be given Project Menus that included instructional looping, differentiation of content, process, and product, and differentiation for different learning styles for the four-day lesson. The last day of the lesson would incorporate group presentations, to which all students would be required to respond. Homework assignments, called Practices, were written and an attempt was made to include the levels of Bloom's Taxonomy and Gardner's Multiple Intelligences in these assignments. These ideas were also taken into account when projects were developed for the different groups. *Any of these materials, including the pretest, lecture guide, project menus, practice assignments, etc. are available from the first author.*

THE STUDY

Two sections of the course were offered in Fall 2008, and one of these was randomly selected to receive the differentiated lesson, while the other was regarded as the control. Students were not randomly assigned to the sections. All students in the course were given a pretest prior to the lesson. For the students in the Differentiated Section, the results of the pretest were used to place them in appropriate groups. Students in both sections took two posttest measures, which allowed the sections to be compared. Students in both sections also took anonymous pre and post-surveys. The unit was taught as had been taught in past semesters for students in the Control Section.

Participants in the study were 39 undergraduate students enrolled in two section of a Concepts of Math for Teachers course open only to students who plan to major in elementary education. For the majority of these students, this study took place during their first semester in college. The Differentiated Section had 20 students and the

Control Section had 19 students. Both classes were taught by the same instructor who had taught the course previously.

The online BlackBoard homework quiz for the unit and the final exam for the course were used as posttest measures and were taken by all students in both sections. Students were also given an online pre and post-survey asking their feeling on mathematics teaching and learning. The pre-survey was given at the beginning of the semester. The post-survey was available immediately after the unit. Both surveys were anonymously available on BlackBoard and a small number of bonus points were given for completing the surveys. A few additional, short answer questions were given to students on the post-survey. The survey questions are included as an appendix.

THE QUANTITATIVE RESULTS

To compare the groups, a one-way analysis of variance (ANOVA) was conducted on the pretest scores to see if a significant difference existed between the sections before the intervention. An ANOVA was also used to compare the BlackBoard quiz scores in the two sections. It was found that there was no significant difference between the sections on the pretest or on the BlackBoard quiz.

A one-way analysis of variance (ANOVA) was completed on the final exam scores. There was a significant difference between groups on final exam scores, $F(1, 38) = 5.536$, $p < 0.05$, with the Differentiated Section ($M = 170.1$, $SD = 22.732$) outperforming the Control Section ($M = 149.947$, $SD = 30.395$). Table One summarizes this analysis.

Table One: ANOVA on Final Exam Scores

Group	N	Mean	SD	F
Control	19	149.947	30.395	5.536*
Differentiated	20	170.100	22.732	

Note: One asterisk denotes a significance level of $p < 0.05$.

In response to most survey questions, students responded on a Likert scale of 1 (strongly agree) to 5 (strongly disagree). One-way analysis of variance (ANOVA) tests were used to compare the Likert scale responses to the post-surveys between sections. Many of these analyses were not found to be significant, so are not discussed here. One significant difference was found on the "Working with fractions is easy" item, $F(1, 33) = 4.379$, $p < 0,05$, with the Differentiated Section ($M = 3.778$, $SD = 1.166$) answering more negatively than the Control Section ($M = 3.059$, $SD = 0.827$). Table Two summarizes this analysis.

Table Two: ANOVA on responses to "Working with fractions is easy."

Group	N	Mean	SD	F
Control	17	3.059	0.827	4.379*
Differentiated	18	3.778	1.166	

Note: One asterisk denotes a significance level of $p < 0.05$.

Thus students in the Differentiated Section found working with fractions more difficult than students in the Control Section. This result inspired us to conduct an ANOVA to compare the Likert scale responses from the pre-survey to the post-survey in the Differentiated Section on this item. There was a significant difference from the pre to post-survey, $F = (1, 35) = , p < 0.01$, with the students responding more positively on the pre-survey ($M = 2.632$, $SD = 1.065$) than on the post-survey ($M = 3.778$, $SD = 1.166$). Table Three summarizes this analysis.

Table Three: ANOVA from pre to post for differentiated on "Working with fractions is easy"

Group	N	Mean	SD	F
Pre-Survey	19	2.632	1.065	9.763**
Post-Survey	18	3.778	1.166	

Note: Two asterisks denote a significance level of $p < 0.01$.

THE QUALITATIVE RESULTS

The answers to the short-response survey questions were read for idea blocks. Many of the answers given to these questions were not identifiable as having to do with the differentiated unit, but rather the course as a whole. The third question, however, was more specific and asked the students what they think of differentiated instruction in mathematics classes.

In the responses given by the Differentiated Section, three idea blocks were found. One idea block was that students thought that differentiating gave them more time with the instructor. For example, one student said, "I liked it because it was geared to how much we knew at the beginning of the lesson. The students got more time with the teacher to master the material and the students who already understood the material had the opportunity to take the material one step further and apply it." A second idea block in the Differentiated Section was the idea of being challenged, which is also supported by the previous quote. A third idea block was that the differentiated lesson was a waste of time. For example, one student said, "I didn't like it. I knew how to do the math, but I still felt like I didn't learn anything in my group." In general, the survey answers to this question were mixed between positive and negative comments.

In the Control Section, answers to this question were also mixed, but most of the responses described differentiation in a positive way, with just a couple of students answering negatively. A typical response in this section was, "I think it is good idea to do differentiated instruction because students learn differently." There were no other identifiable ideal blocks.

CONCLUSIONS

While the surveys showed that some students felt negatively about differentiating, students in the Differentiated Section still outperformed students in the Control Section on the final exam. Furthermore, students in the Differentiated Section became more

negative about their ability to work with fractions, from the pre to post-survey and as compared to the Control Section. Follow-up and future studies should be completed to further study these differences and to see what effect experiencing differentiation as a student has on future teachers.

From the lesson itself, there are a few practical considerations for differentiating. In a college classroom, it is very difficult to differentiate by preparedness and not have the students know into which level of group they are being placed. In the short-answer survey questions, students from both sections mentioned that differentiating can hurt students' feelings. In the lesson used for this study, care was taken to make all groups feel valued and the students' own interpretation of their ability level was taken into account. These precautions, however, do not seem to be enough.

In the short-answer survey questions, students in the Differentiated Section responded both positively and negatively to differentiation. It is worth noting, however, that many of the students who made positive comments cited the increased attention of the teacher. Many of the students who made negative comments mentioned being in one of the two more advanced groups that did more work on their own. Several students in the more independent groups seemed concerned that their grade would suffer because of spending less time with direct instruction. It can often be a struggle to help students in mathematics classes see other types of instruction, besides lecture, as beneficial. More work should be to help these advanced students feel supported and challenged at the same time.

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APPENDIX – SURVEY QUESTIONS

Survey Questions Common to Both the Pre and Post-Survey

On these survey items, students responded on a Likert Scale as follows:
1. Strongly Agree 2. Agree 3. Neither Agree nor Disagree 4. Disagree 5. Strongly Disagree 6. Not Applicable

1. In general, I like mathematics.
2. When teaching mathematics a teacher should tailor the material and presentation to suit the needs , preferences, and readiness of the students.
3. I only learn mathematics when the teacher shows me how to complete exercises.
4. I like to work independently or with a small group on mathematics assignments.
5. Working with fractions is easy.
6. Working with negative numbers is easy.
7. I think that I will enjoy the unit on fractions and negative numbers.
8. I understand why we add, subtract, multiply, and divide fractions the way that we do.
9. I understand why we add, subtract, multiply, and divide negative numbers the way that we do.
10. Mathematics teachers should give students projects and other forms of assessments besides exercises and tests.
11. Fractions and negative numbers play an important role in our everyday lives.
12. I think it is important to provide mathematics students with choices about how to learn and exhibit their learning.
13. There is really only one way to teach mathematics.

Additional Short Answer Survey Questions from Post-Survey

1. Have your feelings toward mathematics changed because of this course? If so, how? What in the course affected your feelings?
2. Have your ideas about how to teach mathematics changed because of this course? If so, how? What in the course affected your ideas about how to teach mathematics?
3. What do you think of differentiated instruction in mathematics?
4. Do you think the material and assignments in the course were appropriately challenging? Were there units or parts of the course or assessments that were too easy or too hard for you? Please be specific.
5. Did the course incorporate assessments that allowed you to use your strengths to exhibit your understanding? Why or why not? Did the assessments for the course help you to grow as a learner?