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Differentiating Mathematics Instruction

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Abstract: The importance of teaching students based on their levels of development and ability, or differentiated instruction, has been used in Language Arts classes increasingly over the last decade. However, it is only recently that attention in research has been given to the use of differentiated instruction in a mathematics lesson. This paper aims to explore what research is being done to not only improve mathematics instruction in the classroom, but to better prepare future teachers for teaching mathematics using a variety of strategies. Further, this paper aims to explore what some more specific methods are that have been found to work in the classroom when helping students, both struggling and in general, to succeed in mathematics. The study first explores two pieces of research on what is being taught to future teachers in the university and if those strategies are being implemented in the classroom. It then focuses specifically on different types of instruction being explored in the field of mathematics instruction and the benefits these have for a variety of students. The fourth section draws some conclusions from these articles and makes a brief suggestion for further development of this topic.

Key words: Differentiated Instruction, Mathematics Instruction, Teacher Training

1. Introduction

Mathematic ability has always been seen as having some of the greatest importance in the education field for the economy of a nation when compared to other school subjects (Drew, 2011). It is not only a skill need to function in everyday life, but also a way to understand the world. Even with this realization of the importance of mathematics by many, and even with the gradual improvements that have been reported as being made in the States, they are still behind many other countries (Drew, 2011). Some studies indicate that mathematics scores "for U.S. students were lower than the average scores of the broader sample" (Coyne, 2010, p. 150). Some reasons provided for this data include the fact that often "mathematics education lacks a strong research base that could provide broadly generalizable answers," and that the research that is being done is "lacking on the topic of low-achieving learners who struggle to learn math" (Coyne, 2010, p. 150).

When considering mathematics instruction for the current generation of students, it is beneficial to consider the varying abilities and difficulties of the students as well as the instruction itself. Differentiating instruction to help students at all levels of math achievement is often perceived as being one of the best ways to help all students succeed (Small, 2012), but how, if at all, is this being accomplished? Vaughn, Bos, and Schumm (2010) go so far as to report that "many students with disabilities perform poorly in mathematics because of low expectations for success and poor instruction" (p. 371). Vaughn et al. further report that the National Mathematics Advisory Panel has stated that "mathematics instruction is broken and needs to be fixed" (p. 372). The current study hopes to answer two main questions by looking at research previously performed in the field. First, the current study will explore what research is being done to not only improve mathematics instruction in the classroom, but to better prepare future teachers for teaching mathematics in an age where the instruction is “broken?” The second question asks, what are some more specific methods that have been found to work in the classroom when helping students, both struggling and in general, to succeed in mathematics?

2. Improving Mathematics Instruction

In order to get a better idea of how teachers are being prepared to teach mathematics in the current classroom, the current study turned to research performed by Jackson (1999). During her study, she followed university students into the classrooms during their student teaching semesters, where they were trying to find evidence of teaching strategies studied at the university level being used in their classroom lessons. The major types of instruction that the researcher was looking for were the use of manipulatives, choice of textbook, and instructional delivery systems. Jackson (1999) mentions that the use of manipulatives was stressed “to help the elementary students learn various concepts concretely,” and that this is a part of a teaching method that focuses on “concrete first, semiconcrete second, and abstract third, starting with three-dimensional objects, moving to visuals or pictures, and then just using the symbols orally or in writing.” This emphasis on the shift from concrete to abstract instruction during a class designed for teachers in training reflects the opinions of Vaughn et al. (2010), who state that “the most important thing to remember as a teacher is to begin with the concrete and then move to the abstract when you are teaching new concepts or when a student is having difficulty learning a math concept” (p. 385).

Despite such comments and how these students were instructed to teach, Jackson (1999) observed that while the manipulatives were found in the classroom, they were often not used as they are intended. The teacher is reported as only using the manipulatives during the instruction of the new math concept, and some teachers are even reported as not wanting their students to use them due to time constraints and the effort involved on the part of the teacher. A teacher with this type of mind frame is particularly unfortunate for those students with learning problems, as they may need a more concrete, hands-on way of learning a topic than other students. An example can again be found in the text of Vaughn et al., where they state that these “students with learning problems are unlikely to learn fractions, however, unless they are taught directly and symbolically” (p. 393). Vaughn et al. further mention the importance of including a wide range of elements to illustrate math concepts and specifically refers to the use of manipulatives as the first step in understanding the more difficult concept of fractions.

Although Jackson’s (1999) research seems to emphasize the use of manipulatives as being one of the major ideas being taught to students, the article does not go into much depth of how mathematics instruction, particularly for those students requiring differentiated instruction, is being taught in the current classroom. For this reason, the current study turned to a second article that focused more on discovering how prepared experienced teachers were for teaching problem solving to students of varying levels using a variety of strategies. This idea of choosing the right strategy for the right situation and the ability of a teacher to evaluate the effectiveness of a strategy used in the class may be perceived as some of the most difficult aspects of teaching, so it follows that any research performed on this topic would first look to the ability of the teacher when looking for weakness in differentiating mathematics instruction. Coyne, Carnine, and Kame’enui (2010) also comment on the difficulties of these strategies when stating that “a major challenge of instruction-perhaps the major challenge-is to develop just-right strategies from interventions with those students who do not develop strategies on their own, including, but not limited to, diverse learners.” Coyne et al. also mention the Law of Parsimony, which suggests that a good strategy is one that “results in the greatest number of students successfully solving the greatest number of problems or completing the broadest range of tasks by applying the fewest possible strategic steps" (p. 157).

In line with the above ideas, the second article chosen for the current study and developed by Soylu (2010), looks both at those strategies used in the current day classroom for mathematics instruction and measures whether or not the strategies chosen are appropriate for varying levels of students to help them in achieving competency, particularly in developing problem solving skills. Soylu asked teachers in an open ended survey which strategies they would use when teaching a particular math concept and to explain why they would choose those strategies. It was found that, for the most part, teachers would use strategies that were not really appropriate for students at certain levels, and that would be especially difficult for those students who already struggle with the subject. More specifically these students, who according to Piaget's stages of cognitive development are still in what is called the "concrete operational period" (Driscoll, 2005, p. 197) and are still not capable of thinking hypothetically, were often being taught in an abstract manner. In conclusion to the research performed, Soylu (2010) goes so far as to say that "it might be stated that while solving verbal problems in the first level of elementary school, elementary school teachers are not skilled enough to use models that are appropriate for the students' level" (p. 36).

Soylu (2010) also goes into the importance of modeling, referencing the manipulatives that have been mentioned in both the previous article (Jackson, 1999) and both textbooks (Coyne et al., 2010; Vaughn et al., 2010) explored above. Soylu (2010) accounts part of the reason that teachers cannot sufficiently use models in instruction to the fact that they lack knowledge of a variety of strategies. More specifically, it is found that teachers "limit the use of models to a certain group of problems" (Soylu, 2010, p. 37) and some refuse to agree that models could be used outside of those groups of problems. One final interesting finding in this article is that many teachers interviewed "attributed the reason why they used or did not use models when solving verbal problems to the education they received or the habits they acquired during their school years" (Soylu, 2010, p. 37).

3. Differentiating Strategies

Although the research performed by Jackson (1999) and Soylu (2010) have given some light into the types of questions that are being raised by researchers in the field of mathematics instruction, it does not explain very many types of strategies actually being used in the classroom. The use of manipulatives appears to be stressed for all students, particularly those low-achieving students, but as there is a great variety in students with mathematical learning disabilities, it would only follow to have a variety of teaching methods beyond only manipulative use. Vaughn et al. (2010) provide a variety of strategies that can be used in the classroom with low-achieving students (such as seriation, estimating, the FAST DRAW strategy), but the third article chosen for the current study goes into more detail about improving student development of number sense. This understanding of numbers at their barest is essential in understanding how to manipulate the numbers to solve more complex mathematical problems. What is perhaps more alarming than the fact that many students' problems with math stem from a simple lack of understanding what a number is, is the fact that many teachers or parents may be unaware of the problem in the first place. Vaughn et al. (2010) go so far as to warn to "not assume that because students can count or identify numbers that they understand the value and meaning of the numbers" (p. 390).

In an effort to show the effects of a developed number sense, De Smedt and Gilmore (2011) looked at the differences in student improvement when instructed in a symbolic and a nonsymbolic format, comparing the improvement in students with mathematical learning disabilities, low-achieving students, and grade level achieving students. The study used number lines as one strategy for teaching number sense in a nonsymbolic format, as the authors mention it is "considered to be [a] reliable indicator of children's understanding of numerical magnitudes" (De Smedt & Gilmore, 2011, p. 280). The study found that those children with mathematical difficulties were impaired with symbolic tasks given them, but had little to no difficulty with the nonsymbolic tasks. Further, due to this explicit instruction in nonsymbolic problem solving, the disabled and low-achieving students were able to close the gap in ability between them and their grade level peers.

The results of the study showed that children with mathematical learning disabilities required more attention and perhaps different types of instruction than their peers at grade level to retain the strategies presented in class. Vaughn et al. (2010) also stress this point in a list of guidelines for helping students with disabilities. It is not only mentioned that "students with disabilities may need more support," but also that they "may not have adequate fluency with basic math facts and may need additional practice and opportunities to acquire this proficiency" (p. 374-375). De Smedt & Gilmore's (2011) study also shows that the inclusion of such programs as Number Worlds and linear number board games are proven to be effective in lower SES students. This cannot, however, be said for students with disabilities as the authors indicate the need for further investigation in such cases. It may be concluded, however, that the inclusion of these systems as a form of intervention can be considered beneficial to at least some students who have difficulties with math and general number sense. Further, the number line was seen to be a "powerful representational tool to forge connections between symbols and the quantities they represent" (De Smedt & Gilmore, 2011, p. 290).

4. Conclusion

By comparing what was stated in the textbooks by Vaughn et al. (2010) and Coyne et al. (2010) with the findings of some recent research (De Smedt & Gilmore, 2011; Jackson, 1999; Soylu, 2010), some answers to the questions for the current study were found. In terms of the first research question, looking to find what research is being done to not only improve mathematics instruction in the classroom, but to better prepare future teachers for teaching mathematics in an age where the instruction is "broken" (Vaughn et al., 2010, p. 372), the first two articles gave some insight. The use of manipulatives has been proven to be an effective method and is often taught to pre-service teachers, but the actual implementation of this method was not really seen in the field. What is more, the explored research has shown that many teachers are still unprepared to teach to a variety of students at a variety of levels, and that more training in differentiating instruction may be required for appropriate mathematics instruction in a classroom with students at different levels of understanding.

As for the second research question, looking for some more specific methods that have been found to work in the classroom when helping both struggling and average students to succeed in mathematics, the third article looked in great detail at one method. It revealed that the best method for not only struggling students but grade-level students as well was to teach in a more concrete and explicit manner. The use of nonsymbolic methods should be used to ensure understanding of numbers at even the most basic level, and this understanding will serve to help students, especially those with learning disabilities. Vaughn et al. (2010) mention a great number of other methods that have been seen as effective for differentiating instruction, such as the use of peers to support instructional practice and instruction in establishing appropriate goals, but most research defending these methods appears to have been performed more than five years ago. For future analyses of this study's second research question, more research on the larger variety of those methods mentioned by Vaughn et al. (2010) would serve to aid not only that study, but the field of mathematics instruction overall.

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