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A Pre-Service Math Teacher's Analysis of Practice through the Lens of Research

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A Pre-service Math Teacher's Analysis of Practice through the Lens of Research

Abstract

Understanding the prior knowledge and schema students bring to a lesson is important (Veenman, 1984), and without that crucial understanding, a teacher can create a gap between what students can actually learn and what the teacher is trying to teach (Schraw, 2006). After a pre-service math teacher realized valuable instructional time was wasted when students could not follow his instruction, he undertook this study to examine scaffolding as a problem of practice. In a high school Algebra 1 class, he taught a series of lessons during a unit on rational functions with a focus on understanding student foundational knowledge and scaffolding student understanding through intensive instruction. He analyzed the results through pre- and post- assessments. Findings include a better appreciation for the cumulative nature of math and increased student understanding after scaffolded instruction.

Editor's Note: The first author in this article conducted this inquiry during his final semester in an undergraduate teacher education program. The second author of this article, served as his mentor in the writing of this paper and was his instructor for the senior seminar course that took place during the time of the inquiry.

Background

The purpose of this study was aimed at opening the discussion regarding the impact instruction has on student learning. Specifically, the impact that scaffolding has on student learning during the instruction of rational functions. I conducted this research in a high school Algebra I class during my final internship prior to graduation.

I began my internship with an open mind, but I was nervous about how I would apply all the theory from my coursework. Promising myself to treat the experience as an opportunity for growth helped to ease the nerves and allowed me to dive into my role. Throughout my time in internship I learned many things. Despite studying pedagogy for what feels like a substantial amount of time (two years), the deeper I dove into my pre-service experience the more I realized I did not know.

My experience was that the knowledge I received from clinical experience was called upon in a seemingly chronological manner. My internship began with establishing a benchmark of my own personal skills. I reflected on my ability to effectively apply all the theory I received from my education and my overall effectiveness in instructing. This benchmark helped me to understand what skills I already possessed and in which skills I could improve. I was able to identify the more surface level shortcomings very early on, things like writing notes on the board without covering the notes in depth, or organizing the notes I wrote on the board so they were clear for students. We never explicitly discussed these things in our classroom management course, but I picked up on them. As I became more comfortable with my basic responsibilities, I began to see much deeper underlying issues in areas like: different classes with widely varied skills, educational resource gaps, students missing necessary prior knowledge, and oversized classes (Veenman, 1984). These issues were largely extrinsic and would have taken serious consideration to remediate.

My education may not have specifically addressed those situations within my unique classroom, however it did empower me to apply active research to better my instruction. Combined with the mentorship of my collaborating teacher and the counsel of my peers, through a trial and error process, I aimed to give my students the confidence and abilities to be successful in mathematics. My peer circle consisted of classmates I met during my coursework. Our strong relationship benefitted our effectiveness in the classroom. We were able to share resources and discuss effective practices and issues we were facing in our classrooms.

One issue in particular which I found that I was very susceptible to making was not adequately bridging students' schema to reach competency in our objectives. I was overestimating students' background knowledge, and it was putting a large gap between my instruction and students' ability to follow the lesson (Schraw, 2006). A perfect example: in the middle of a certain unit, I noticed that two days of instruction had been used to show students material for which they had not been primed. A third day had to be dedicated to give them the fundamental basics of the concept. I was able to slightly improve student acquisition of the concept but the weird order of lessons had already largely confused students. This was a very frustrating moment in my internship. I had chosen between two less than ideal options. After this occurred, I reflected on the situation and decided to celebrate the practical experience gained and apply it proactively in my future planning. I wondered if better scaffolding instruction during an upcoming unit on rational functions would make a difference, so I decided to focus on doing so.

For the rational functions unit of instruction discussed in this research, appropriate scaffolding was at the foundation of my planning (Rumelhart &

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Ortony, 1976). One lesson in the unit was dedicated strictly for reviewing two skills, factoring and arithmetic with fractions, which would be fundamental in the problems encountered in this unit (Lave & Wenger, 1991). I chose to isolate those two skills each on their own day, instead of reviewing the skills while teaching a new concept. I believed for my students, this scaffolded instruction would come to be a huge advantage to them and ultimately help the class progress through the remainder of the chapter more fluidly. By investing extra time through scaffolding, I expected students to have better acquisition of the content.

Context of Study

The study was conducted within Rogers High School (pseudonym), specifically within two Algebra 2 sections. The first section of the course had 15 students. The second section had 21 students. I chose to conduct the study across these two sections to increase the sampling of data. These two sections had relatively similar demographics but the culture of each classroom was very different. The first section, because it was smaller, was a very intimate class with very interactive students. Due to student absences, some of the data could not be used because either a pre- or post-assessment was missing. Ultimately, the study finished with 21 students who completed both a pre- and post-assessment. The high number of students who were missing at least one of the assessments is representative of the student absences I observed during my internship. The frequent absences were another challenge in the effectiveness of my instruction.

I designed the unit using the school district's online learning management portal. Through the portal, the county provides curriculum guides which are aligned with the Florida Mathematics Standards. To further focus instruction, I designed problems from the aligned standards and used them to direct the path of instruction. I was privileged to have had a cooperating teacher who facilitated my trying different methods. After outlining the path of instruction, I used resources from the Holt McGraw and Pearson text to develop a problem set for instruction.

A major issue of instruction I encountered was the lack of required foundational knowledge. In order to accommodate for this issue, during unit planning, I aimed to scaffold instruction to bridge student knowledge and maintain a fluid progression of knowledge acquisition. I discovered the missing foundational knowledge through formative assessment conducted earlier in the academic year. Once I began using these diagnostics they became invaluable in guiding my instruction.

The unit of instruction was discussing rational functions and was designed to help students prepare for college-oriented tests as well as help them receive a mathematics credit towards their graduation requirements. These skills extended into the following unit of instruction, and for students' continued success in the course, mastery was critical.

I introduced students to the concepts by having them first examine them on the graph to construct a concrete understanding of what these concepts represented as suggested by Piaget (as cited in Ormrod, 2017). After I placed significant emphasis on the conceptual meaning of these items, the standards then required students to solve for these items algebraically. Students were first introduced to the procedures to solve for the asymptotes and zeros and then for the domain and range. Asymptotes are locations on a graph where functions will never go, and solving for zeros involves factoring polynomials and then using the zero product property to solve for the value of a missing variable. The domain represents all possible input values that can be plugged into a function, and the range is all possible output values that can be produced from a function. During instruction for solving for asymptotes and zeros, a required skill is factoring, which I hoped my students had mastered. Factoring involves finding the products that create a polynomial, and I dedicated a day of instruction to reviewing this skill. The intended purpose was to scaffold the material to prevent students from feeling overwhelmed and ensure students had adequate opportunity for success (J.W. Moore & Edwards, 2003). I was aiming to remedy students disengaging and becoming bored when the material was not appropriate for their current mathematical level.

Methods

I worked on my problem of practice, scaffolding instruction, during a unit about rational functions. I began by having students focus on the graph of rational functions and examine some of their characteristics and transformations. Specifically, I opened the unit with the description of rational functions in parent function form. This allowed students to develop a visual relationship between the algebraic and graph representation of the function. I then proceeded through instruction to introduce the inverse variation function. The standards require students to explore inverse variation within the overall context of variation, meaning students were required to examine direct and inverse variation functions. I placed a major emphasis on applying the relevant variation formulas and solving for the constant of variation. This topic was based heavily on rearranging equations and retrieving information from graphs. After variation, I specifically shifted the unit back towards instruction which focused more directly to rational functions. Instruction would then lead into students examining the concepts of asymptotes, zeros, domain and range. The district curriculum assumes these concepts are review; however, I estimated that my students would not have a

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strong foundation in these areas. Based off my past work with the students, I believed these skills were relatively more involved then what students were comfortable with.

On day one of instruction, the purpose of the lesson was to arm ourselves with some tools that would allow us to isolate the characteristics of the functions. These skills included graphing and the characteristics of a function on a graph. Students practiced their graphing skills and examined definitions and characteristics which serve to examine graphs. Concepts included: y-intercept, x-intercept (zeros), slope, asymptotes end behavior, domain and range. On day two of instruction, students explored the topic of variation. I had students specifically explore inverse variation and direct variation. The graph of an inverse variation function relates to the graph of a rational function. Students used language from the prior lesson to examine variation functions. On day three of instruction, I introduced how to find the horizontal and vertical asymptotes, zeros, domain, and range algebraically. This was an introduction on the application of these concepts. On day four of instruction, I reviewed fundamental algebra skills that were integrated within the rational function problems. The purpose of this lesson was to review two specific algebraic tools which would be necessary for students' success in the following chapters. I was scaffolding their being able to solve for the characteristics of rational functions by reinforcing factoring polynomials and adding fractions with unlike denominators. On the final day of instruction, students reviewed material from the previous two days.

Data Gathering

I gathered data through a single formal pre- and post-assessment. I designed the assessment to model the assessments students are familiar with from the course. The assessment was designed to minimize multiple choice responses to isolate student understanding. I was specifically looking to see students' mathematical path towards solving for concepts like the asymptotes. The assessment featured five questions. Among the five questions, there were a total of 20 points students could earn. I hoped to measure each skill in isolation. By design, the assessment was intended to measure three components, specifically, a student's ability to find the horizontal asymptote, vertical asymptote, zeros, domain and range of rational functions; a student's ability to recall the notable transformations of a rational function in parent function form; and a student's ability to apply the concepts of direct and inverse variation. The first component of the test accounted for 75% of the test. The second component (recalling transformations) accounted for 15% of the test. Finally, the component measuring variation topics, accounted for 10% of the test.

The assessment was structured in this format to be representative of instructional time. Variation received the least amount of instructional time, transformations were given slightly more time, and the first component received the bulk of instructional time (Green, 2010). This pacing allowed me to focus on scaffolding the content strategically for the students' benefit.

Results

Comparison of the Pre- and Post- Assessment Results

Figure 1 depicts the gains in students' raw score as well as the increase in questions attempted. The average gain in raw points was approximately 4.2 points. There were two students of the 21 who lost points from the pre-assessment to the post. The highest gaining student gained 14 points. Most students attempted at least one more problem than their original attempt. The consistent increase in problems attempted was very interesting. Students were more willing to attempt problems despite not being certain or producing accurate answers after instruction.

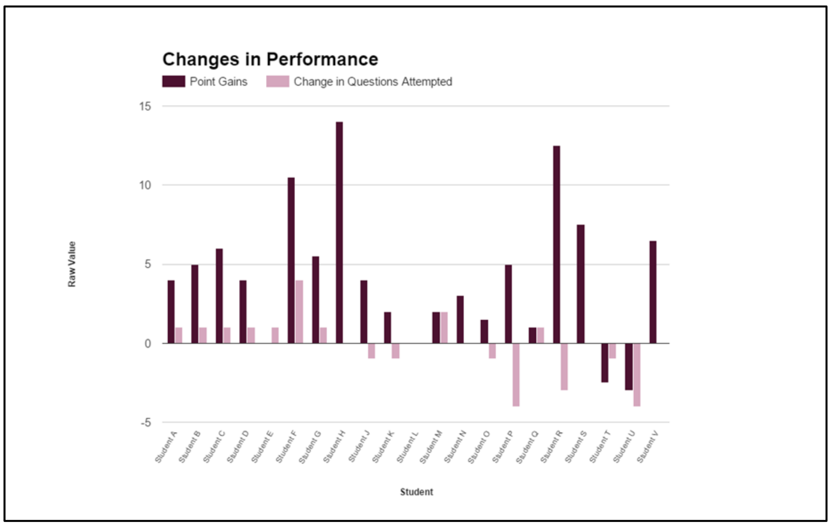

Figure 1. Raw scores and changes in questions attempted

Figure 2 depicts the number of questions students attempted on the pre-assessment and the post-assessment. The chart is included to highlight the increased willingness to produce an answer despite the answer's accuracy as mentioned in the paragraph above.

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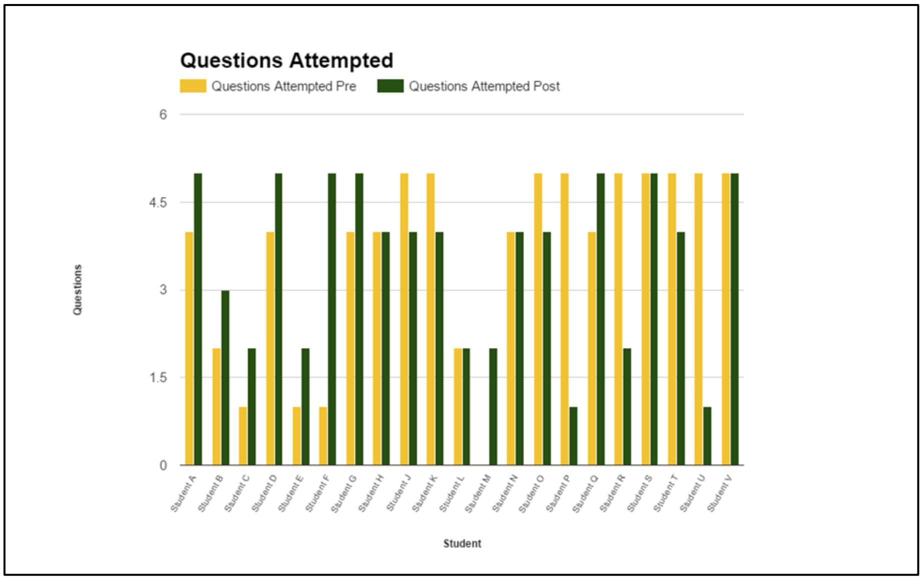

Figure 2. Change in number of questions attempted.

Figure 3 highlights points scored on the pre- and post-assessment. It is visibly shown that many students did not earn any points on their initial attempt at the assessment. This made it fairly easy to demonstrate gains in performance. Although students showed significant gains, students still did not finish performing at the expected level. The highest score on the post-assessment was a 14 out of 20 for a score of 70%. This raises questions on the design of curriculum and/or the effectiveness of instruction. The bell curve produced from the data places the 50th percentile earning a raw score of 4.2 points; a score of 21%.

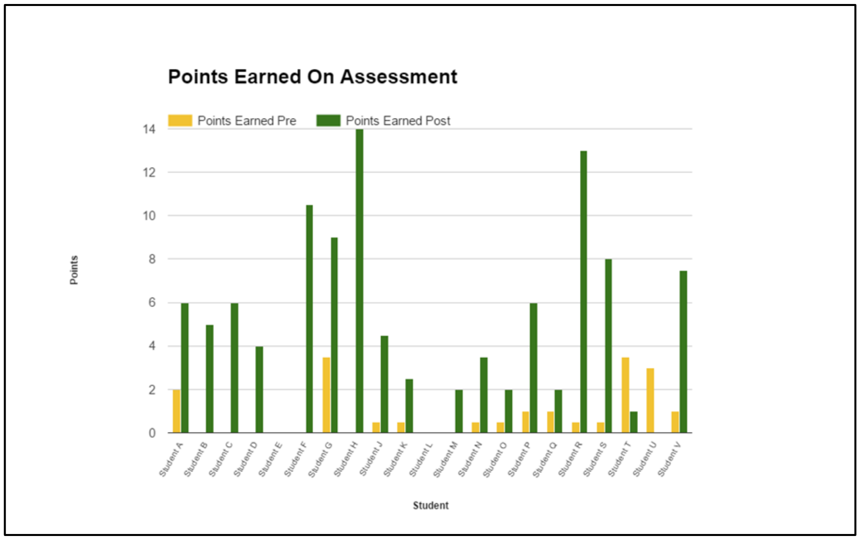

Figure 3. Change in points earned from pre- to post-assessments.

Overall, the results of the data seem to bring to light more questions than answers. One of my criticisms of my research method is the lack of a control group to isolate the impact that specified scaffolding had on instruction. It is difficult to isolate the cause of an abnormal distribution because there exists no reference point to truly make a comparison. In its current isolated state, the data can really only be described through qualitative means.

Finding 1: The cumulative nature of math

The three students (H, R and F) who were well above the average in raw gains, exhibit character qualities which are beneficial for their progress in the class. These students have perfect homework scores as compared to the other students who occasionally do not submit homework. In class, these three students tend to be very engaged and ask meaningful questions during lecture. It seems more likely that those three students had preferable results due to intrinsic skills that are outside the control of short term teacher influence.

This study was inspired by identifying a problem of practice. The problem which was purposefully tackled was addressing insufficient background knowledge through increased scaffolding. Mathematics has a cumulative nature, in that, progression requires strong understanding of fundamentals (Thompson, 2008). I identified that many students did not recall or have strong knowledge in their fundamentals. My proposed remedy was to skillfully scaffold instruction for the purpose of bridging student schema to reach the level required for competency (Brenner, Mayer, Moseley, Brar, Durán, Reed, & Webb, 1997).

In my opinion, it appears as if the scaffolding helped students to reach a level where basic or preliminary understanding was established, but scaffolding in the short term could not remedy issues which have been developing throughout students’ academic careers. The data demonstrates clear academic gains from students, however they were still far from competency. I witnessed the poor foundation manifesting in the form of students unintentionally delaying lessons. Students spent much of instructional time asking questions about associated skills rather than the specific skill which was being taught. A specific example would be the number of questions regarding basic algebraic operations, which are necessary to apply the more involved skills. These questions remove instruction from the more involved skills, the actual topics being taught, and shift the focus towards missing fundamentals.

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Finding 2: More scaffolding equals better understanding

Overall students were most successful in applying the concepts related to the graphs of the rational functions. Specifically, this included finding the asymptotes and zeros of a function. I believe the reasonable explanation for this was the amount of instructional time dedicated to this concept as well as the location of these skills relative to the assessment. These skills were saved until the end of the unit and were taught leading into the assessment.

Students performed weakest on the concepts of variation. The least gains were demonstrated on the variation problems. As per Bloom's Taxonomy, I identified that students were able to recall the variation formulas, but did not understand the formula or demonstrate acquisition of higher learning goals (Bloom, as cited in Green, 2010). I was able to identify this because students would write the formulas corresponding to either direct variation or inverse variation but could not apply them to correctly answer the question. Correlating this finding back to my instructional strategy, very little time was spent practicing this skill and I did not facilitate students becoming comfortable with the skill and committing it to long term memory (Sweller, 2010).

Students were most successful in applying the concepts related to the graphs of the rational functions. Specifically, this included finding the asymptotes and zeros of a function. I believe the reasonable explanation for this was the amount of instructional time dedicated to this concept as well as the location of these skills relative to the assessment. These skills were saved until the end of the unit and were taught leading into the assessment as suggested by Beckmann, Thompson, & Rubenstein (2010).

The results of the assessment were very logical in nature. Students performed better on the skills that were dedicated more resources (instructional time) and worse on the skills which were given less resources as suggested by Sweller (2010). Students were also given more questions and weight per question on the skills which they performed better on. Students were informed of the weighting and may have dedicated more time on these questions to score higher points.

Discussion

I believe my instructional strategies were very effective with the preparation I had in place for my planning, but the preparation for my planning could be largely improved. My formative assessment was very weak and gave me poor understanding of prior student knowledge. This led to virtually an estimation of where to begin my scaffolding. Although at the time I believed I appropriately bridged my student's schema, without a control group, I do not know for a fact. I can rely only on comparison of the pre- and post-assessment scores, but I do believe student motivation to study, complete homework, and ask meaningful questions in class were factors. The type and frequency of questions students' asked during scaffolded instruction should also provide indications where additional instruction might be needed, but I did not design my study to capture or account for those questions. I do have the sense that scaffolded instruction improved student learning but that it cannot overcome student disposition or the accumulation of poor math study habits over time. Finally, I did not account for my lowest level students who might have needed even further development of basic skills and scaffolding.

Conclusion

In future units of instruction, I believe it is necessary to have a firm understanding of the knowledge students are bringing into the lesson. For my own future classroom, I will make an effort to integrate formative assessment into the class structure so it becomes a norm for students to take a formative assessment regularly. I believe paying attention to student background knowledge is key to being able to strategically plan where additional scaffolding instruction makes the most sense. Formative assessments would help me gauge that and help me understand which scaffolds to put in place.

If I were to teach the unit again I would save the variation topics for the end of the unit. The curriculum guide suggested to teach them early in the unit because they lead into the more elaborate rational functions, but students did not make that connection. Teaching them early was not effective in that manner, and reordering the curriculum may be key when scaffolding is considered. I believe focusing on rational functions first, addressing required background skills, and scaffolding toward variations will help students to grasp the concept of variation more proficiently.

As evidenced by the improvement in my students' scores, scaffolded instruction is important and relevant in the Algebra classroom, and pre-service math teachers should intentionally focus instructional time on it.

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