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Examing type and quality of preservice teachers' lessons based on children's literature

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A B S T R A C T
This qualitiative research explores the types and levels of mathematical lesson tasks that 60 future elementary and middle school teachers created during an undergraduate mathematics content and pedagogy course. Data collection consisted of 51 children's book inspired activities written by the preservice teachers. Using Stein et al.'s Task Analysis Guide as an assessment tool, the researchers coded the activities into 1 of 4 categories, as well as categorized each activity based on its mathematical content using the Common Core State Standards for Mathematics. Results showed that a majority of the PSTs wrote activities that were classified as *Procedures with Connections*. Also, a majority of the activities were geometry-based, specifically transformations and two-dimesional measurements. Implications for teaching include the fact that preservice elementary and middle school teachers can create mathematics lessons based on children's literature, which often can include mathematical tasks that are making connections to procedural mathematics or even higher order thinking tasks.

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1. INTRODUCTION

Oftentimes, preservice teachers (PSTs) may not enjoy mathematics (Philippou & Christou, 1998) or taking a mathematics or mathematics methods class. PSTs may also have low self-efficacy in mathematics (Bjerke & Eriksen, 2016; Cruz et al., 2019; Norton, 2019; Phelps, 2010) and can easily transfer these reservations to their students (Harkness et al., 2007). PSTs can have low confidence in teaching mathematics due to their own background with mathematics learning (Charalambos et al., 2008). Thus, PSTs may need the additional boost of confidence in this area by learning ways in which to integrate other subject matter into their mathematics lessons.

Developing interdisciplinary mathematics lessons based on children's literature may be a way to help PSTs not only engage more fully in mathematics content but help them boost their self confidence in teaching mathematics. This article examines the work of PSTs who developed mathematics lesson tasks based on children's fiction or non-fiction books. When preparing their lesson activities, the PSTs were creating and solving

mathematics word problems. Problem solving has generally been defined as having 4 stages, understand the problem, devise a plan, carry out the plan, and look back (Huang et al., 2012; Phillips et al., 2017; Polya, 2004). Extending this model, Yimer and Ellerton (2009) identified five phases for solving mathematics problems. They are engagement, transformation-formulation, implementation, evaluation, and internalization. Phillips et al.'s ACE-M model includes monitoring. Students should not just solve the problem but should monitor their understanding and actions throughout the process. A represents analyze the task, C is for create a plan, E is for execute the plan, and M is for monitor understanding and actions.

Working with PSTs, Amirshokoohi and Wisniewski (2018) implemented the three-phase constructivist model of mathematics instruction. Their model is based on a three-phase lesson format found in our course textbook by Van de Walle et al. (2018). The three phases are the before phase (introduction/setting the stage), the during phase (student exploration and thinking), and the after phase (discussion and concept introduction). Rofiki and Santia (2018) noted that there is a strong relationship between how PSTs represent and solve problems. In their study, students solved a well-posed problem using verbal and symbolic representations that led to the computation of the answer. Students then justified their answers verbally. The five-stage problem solving task model that we will describe is **S**elect children's literature, **D**evelop a problem-solving task, **C**ritique problem solving tasks of other PSTs, **R**evise problem-solving task, and **S**ubmit task for grading (see Figure 1).

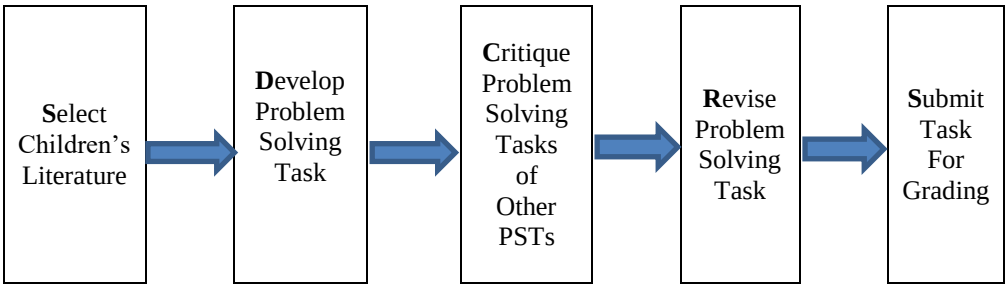

Figure 1. Five stage problem-solving task model

The purpose of this research was twofold: to investigate (1) what types and (2) what levels of mathematics lesson tasks inspired by children's literature elementary and middle school PSTs created. The assignments were developed and critiqued based on Stein et al.'s (2000) Task Analysis Guide (TAG). No such research about studying PST children's based lesson tasks is known to the authors so this type of study could be valuable to mathematic educators.

The foundation for TAG was laid by Smith and Stein (1998). TAG, which has been utilized in numerous research articles (e.g., Boston & Smith, 2009; Charalambos, 2010; Hsu & Silver, 2014; Kessler et al., 2015), as well as the course textbook (Van de Walle et al., 2018) provides a way to classify mathematics tasks into one of four quadrants of categories: *Doing Mathematics, Procedures with Connections, Procedures without*

Connections, and *Memorization*. Tasks classified as *Doing Mathematics* include conceptually based problems with no prescriptive procedure to solve the problems. Lessons labeled as *Procedures with Connections* include tasks that also have a high level of mathematical thinking but wide-ranging prescribed procedures which can be used to successfully solve the problems. Procedures are utilized but require more critical thinking than just rote procedural processes and make connections to the underlying mathematics. Tasks in this quadrant often can be characterized in various ways. Unlike *Procedures with Connections, Procedures without Connections* activities do not involve connections to the mathematics, merely algorithmic, low cognitive demand work with an emphasis on correct solutions, not explanations. Lastly, *Memorization* problems consist of problems that do not involve procedures, just stating mathematical truths and ideas with no original thought needed.

Using lesson activities based on children's literature and created by elementary and middle school PSTs as data, the researchers answered the following research questions:

RQ1: What categories of Common Core State Standards for Mathematics (CCSSM) lesson activities did preservice elementary and middle school teachers create based on children's books?

RQ2: Using Stein et al.'s (2000) Task Analysis Guide (TAG) as a tool for assessment, what classifications of lesson activities did preservice elementary and middle school teachers create based on children's books?

2. METHOD

The participants in the study originated from two freshman level three-credit hour classes taught by one of the authors at a public university in the south-central United States of America. The classes were for future elementary (PreK-6) and middle school (Grades 4-8) teachers and covered the mathematics content, as well as methods, for teaching conceptually-based mathematics in Grades 6-8. Future middle school teachers receive hands-on learning about content they may teach in the future, whereas, future elementary teachers may teach 6th grade and can also make connections with the content in elementary to middle grades.

For this study, 60 future elementary and middle school teachers were tasked with producing standards-based (NCTM, 2000) mathematics lessons (Grades 6-8) based on children's books of their choosing (see Figure 2 for the directions to the lesson task).

> Select one "non-math" themed children's book. Develop a hands-on math task associated with the theme of the book and a 6-8th grade math standard. Your math task must include an activity that students can complete on their own or in a small group. It cannot be a procedurally-driven ("plug and chug") worksheet. Your activity must be your own work and not copied from other sources. Include the title, author, and publisher of the book the activity was based, a copy of the activity with math standard, an answer key, and a photocopy of the cover of the book.

Figure 2. Lesson task description

The children's books could be fiction or non-fiction but could not be books purposely written to teach mathematics content, such as *The Greedy Triangle* (Burns, 1994) or *Sir Cumference and the Dragon of Pi* (Neuschwander, 1999). The reasoning behind not choosing all types of books was that the authors were hoping that students could see the value of using any type of children's book, not just books that have been heavily marketed as applicable for mathematics lessons.

As part of the assignment, the PSTs listed bibliographic information about the book, provided a factual summary of the book, and included a fully developed lesson task with a corresponding standard addressed in the activity. The lesson had to be original and contain an answer key for the task. PSTs were encouraged to create lessons that were standards-based (NCTM, 2000) with conceptually based tasks, not rote memorization worksheets. The class the PSTS originated from included standards-based tasks as daily examples, which helped the PSTs understand what types of lessons to create. The PSTs had not previously created lessons as part of the course.

During the eighth week of class, PSTs shared their lesson drafts with fellow classmates and the instructor for constructive feedback before the project was submitted during the tenth week of class. In addition to class time, PSTs reflected in a written assignment during week 8 about their progress on their lessons. During the ninth week, the instructor addressed questions and/or concerns PSTs expressed in their reflections. PSTs turned in their final lesson draft during week 10.

Participants could work by themselves or in groups of up to three people. Forty-three future teachers worked by themselves. The remaining participants included one group of 3 and 7 groups of 2. Thus, from the 60 participants, 51 lesson activities were created.

For RQ1, lesson tasks were categorized by the standard covered for each lesson. A spreadsheet of CCSSM standards (CCSSI, 2010) for the group are included in the Results section. For RQ2, lessons were coded using the TAG (Stein et al., 2000). PSTs did not utilize the TAG. It was used exclusively by the researchers for coding purposes.

Each author independently coded the 51 lesson tasks. Each author compared the created lesson tasks to the TAG categories and coded each into 1 of the 4 quadrants. Coding groups were compared with discrepancies discussed between authors and resolved to 100% agreement. Of the 51 lesson activities, 6 were excluded for 1 of 3 reasons. Three did not address a middle school CCSSM. Two were not based on a children's themed book, and the last did not include an activity based on a children's book.

3. RESULTS AND DISCUSSION

3.1 RQ1: CCSSM lesson types

Table 1 includes a breakdown of each domain covered by the lesson tasks, as well as activity types.

Table 1. Categories of PST lesson tasks

CCSSM by Domain	n	Type of Lesson Task	n
The Number System	7	Classify Sets	1
		Perform Operations	1
		Locate Numbers on a Number Line	2
		Solving Real World Problems	3
Ratios and Proportional Relationships	8	Ratios	7
		Graph Proportional Relationships	1
Expressions and Equations	0		
Geometry	25	Transformations	7
		Plot Points	6
		Volume/Surface Area	4
		Perimeter/Area/Circumference	7
		Pythagorean Theorem	1
Statistics and Probability	5	Probability	2
		Data Representation/Mean, Median, Mode	3

Fifty-six percent of the lesson tasks created were geometry-based, the most popular domain of CCSSM. Of the 56%, more than half pertained to either transformations or two-dimensional measurements, such as area and circumference. The second most popular CCSSM-based activities (at 18% each) were *The Number System* and *Ratios & Proportional Relationships* domains. The least popular CCSSM domain was *Expressions and Equations*, with no PSTs creating lesson tasks for that domain.

3.2 RQ2: Breakdown of lessons based on the TAG (Stein et al., 2000)

For RQ2, the researchers were investigating what types of lesson activities were created by PSTs. Table 2 shows coding findings that displays how PSTs created lesson tasks that spanned the 4 quadrants of the TAG (Stein et al., 2000). A detailed description of examples from each quadrant follow.

Table 2. Categories of PST lessons

Category	Frequency	Percent (%)
Doing Mathematics	9	20.0
Procedures with Connections	25	55.6
Procedures without Connections	6	13.3
Memorization	5	11.1

3.2.1 Doing mathematics lesson example

Nine PST lesson tasks were *Doing Mathematics* that consisted of tasks where PSTs allowed students to have more control over their own learning. Some PSTs had students research the mathematics topic before completing the mathematics, such as creating three dimensional houses and calculating the surface area of each. Other PSTs had students create circles and investigate the relationships between measurements, such as diameter to circumference.

An example of a *Doing Mathematics* lesson task was a geometry-based lesson utilizing the book entitled *Mr. Pine's Purple House* (Kessler, 2014). In this book, Mr. Pine wants his plain, white-colored home to be unique, so he paints it purple. For this lesson activity, students were tasked with designing the interior of their own unique dream houses on graph paper (see Figure 3 for sample student work).

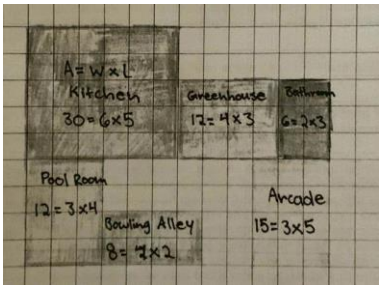

Figure 3. Sample student work

As part of the directions for the activity, the house had to contain 4-10 rectangular-shaped rooms. Once completed, students were then tasked with calculating the areas of their homes. This kind of lesson task was classified as *Doing Mathematics* because of its non-prescriptive style of problem, where students were free to design their own houses and then perform calculations of their creations.

3.2.2 Procedures with connections lesson example

The most popular lesson task type was *Procedures with Connections*. Like *Doing Mathematics*, PSTs who created lesson activities of this type still had students make connections with the mathematics, but the connections were directed by the PST. These lesson tasks took on many forms, such as having students investigate the lengths of certain objects by hand or with the internet, looking at the multiple forms these measurements can take, or having students graph the data in multiple ways. Other PSTs had students do procedural-based mathematics but then examine the mathematical concepts that they just calculated to see relationships with the numbers.

An example of a *Procedures with Connections* activity is a geometry-based lesson task used with the book entitled *The Dot* (Reynolds, 2003). This book is about a girl named Vashti who receives reassurance from a teacher about her dot drawing. That encouragement turns into Vashti creating many dot drawings and ultimately helping another child feel invigorated to draw for himself. For this lesson activity, the teacher would read the book and then have students create their own circular dot works of art (see Figure 4 for sample work example).

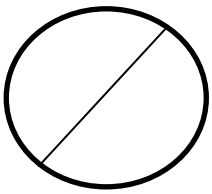

Figure 4. Sample dot

Students would then take a piece of string that is the length of the diameter of their dot and use it to measure the circumference of the dot. Through a series of questions, a student would conclude that three diameters are about the circumference of his or her circular dot. This type of lesson was classified as *Procedures with Connections* since students are doing procedurally based work that included some thought as to the mathematics behind the processes being described.

3.2.3 Procedures without connections lesson example

Thirteen percent of PSTs created *Procedures without Connections* lesson takss where PSTs had students complete procedurally based mathematics with no real connection to the underlying mathematics being completed, such as plotting points on a coordinate grid and calculating the circumference/area of circular objects. An example of a typical *Procedures without Connections* task is the Willems' (2010) inspired activity from the book entitled *Can I Play Too?* In the story, three friends, a pig, an elephant, and a snake, are playing catch. For the activity, the student is tasked with plotting the ever-changing positions of the three friends on different coordinate planes (see Figure 5 for a sample problem from the student lesson).

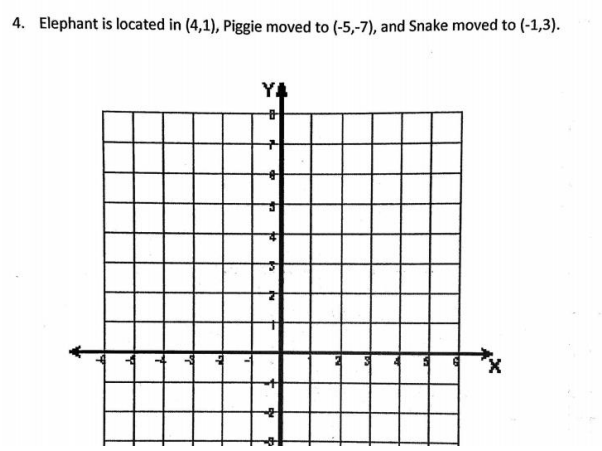

Figure 5. Sample student problem

The problems are straightforward with students only needing to know how to plot points, a procedurally based activity with no connections to the underlying concepts needed.

3.2.4 Memorization lesson example

The least written type of lesson activity was *Memorization*, where PSTs had students complete mathematical activities that did not require conceptual mathematics or procedures, just understanding of memorized facts. An example of this type of lesson activity was inspired by the book *Those Darn Squirrels Fly South* (Rubin, 2015). As its name implies, the book details the adventures of a group of squirrels that fly south. For this transformation-based activity, students match a squirrel picture that has been transformed with the correct terminology: translation, reflection, rotation, or dilation (see Figure 6 for a sample student problem from the lesson).

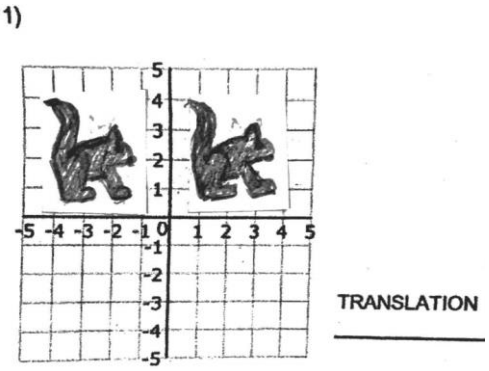

Figure 6. Sample student problem

This line of questioning is based on memorization of previously learned facts. Thus, the researchers categorized this type of lesson task as *Memorization.*

4. CONCLUSION

Based on the findings for RQ1, most PSTs created lesson tasks for sixth grade students, the lowest grade level of lesson activities PSTs could make. This is not surprising since many PSTs struggle with mathematics anxiety (Bekdemir, 2010; Hembree, 1990) and may feel that lower level lessons would be easier to create than seventh or eighth grade tasks. PSTs also overwhelmingly created more geometry-based lessons than any other CCSSM domain. This may be due to the fact that students may have felt hands-on, conceptually based mathematics tasks can be more easily created for geometry topics, such as plotting points, performing transformations, and calculating area.

In regard to RQ2, most activities created were considered *Procedures with Connections*, one of the two higher level cognitive demand categories. This may be because the PSTs were enrolled in a standards-based mathematics (NCTM, 2000) education course, where most of the activities the future teachers worked with were higher level thinking tasks that included hands-on, thought provoking activities. The PSTs turned in their work during the tenth week of the course so they would have had a significant amount of exposure and practice with quadrant 3 and 4 level tasks. These results are similar to the findings for the types of activities in the one "alternative" series of textbooks researched by Jones and Tarr (2007, p.12) who studied various textbook curricula about probability topics utilizing the TAG (Stein et al., 2000). All other textbooks in their study were comprised of lower cognitive demand tasks.

Implications for mathematics teacher educators include the idea that elementary and middle school PSTs cannot only create their own middle school level mathematics lesson activities based on popular fiction and non-fiction books but can create activities of higher cognitive demand. This is a significant finding, since many textbooks include lower cognitive demand mathematics tasks (Jones & Tarr, 2007). PSTs can know that if they do not like activities that they are presented, they can create their own mathematics lesson tasks that are conceptually-based and challenging for students. PSTs utilize textbook knowledge greatly in their own teaching (Bush, 1986). If PSTs can realize they can make their own lesson activities instead of having to rely heavily on textbooks, they

could create engaging, high level tasks that their students may like even more than what they have been presented with in the past.

Non-mathematics themed children's books are often utilized in non-mathematics settings so bringing their content into mathematics education classes can yield interdisciplinary connections among different teachers and subjects. Activities like these can open up the world of possibilities to help PSTs see that they can be imaginative and create mathematics lesson tasks from some unlikely sources, which might help PSTs, as well as their future students, become more engaged in mathematics.

For future work, the researchers plan on investigating how PSTs can produce a lesson task categorized as a *Doing Mathematics* lesson. PSTs would be given sample lesson activities from all four categories, classify them according to the TAG (Stein et al., 2000), and then try to make a higher-level activity, similar to work done by Sherman et al. (2017).

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