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RESEARCH ARTICLE

Examining Personalized Learning and Differentiation in Mathematics Classrooms

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The purpose of this exploratory study was to examine how primary-grade teachers reported how they used personalized learning and differentiation in elementary school classrooms. The first author conducted classroom observations of primary grades' mathematics classrooms, as well as interviews with both teachers and students. Findings from an inductive qualitative analysis indicated that teachers consistently used centers and a process of rotating through various locations in their classroom to have students do multiple mathematics activities. At the table with the teacher and in some other locations there was clear personalized learning occurring based on classroom observations. Interview data showed that students reported positive views of their mathematics experiences and that teachers reported being able to successfully meet their students' academic. Implications include considerations for how to prepare future teachers as well as practicing teachers to successfully implement these personalized differentiation approaches in their classrooms.

Keywords: Personalized learning, differentiation, elementary mathematics

In the past decade, the idea of personalizing learning experiences for learners from pre-kindergarten through Grade 12 (PK-12) has become more popular (Childress & Benson, 2014; Pane et al., 2017). Among this emphasis are recommendations for teachers and instructional leaders to consider how to ensure that learners have individualized activities aligned to state Standards that are based on data (McNeill & Polly, 2023).

Personalized learning and the concept of differentiating instruction to meet students' individual needs are not only popular concepts in elementary education, but they align with research on formative assessment with the use of data to drive instructional decisions (NCTM, 2014; Pane et al., 2017; Martin et al., 2022). Formative assessment includes the process of collecting data and using it to design, implement, and reflect on activities based on data (Martin et al., 2022). Despite the emphasis on personalized learning and differentiated instruction, little is known about what this looks like.

LITERATURE REVIEW

Personalized Learning

"The heart of personalized learning is *personal* - it is about *knowing the person in front of you and expecting the best of them."* (Zmuda & Thompson, 2018). Personalized learning is a differentiated approach to learning, differentiating for each student rather than for a group of students or the class. According to Zmuda and Thompson, the focus of personalized learning is that instruction be student driven, deep engagement, and desired outcomes. Personalized learning is similar to blended learning. Blended learning is defined by Christensen, Horn, and Staker (2003) as students learning partially through online learning, which is not required for personalized learning but is often a resource that teachers implementing personalized learning will use.

Bearne (1996) states that in order for all students to gain knowledge, we must differentiate. This differentiation should focus on the individual to provide them with the curriculum that they need. Through interviewing teachers, Bearne found that there are different definitions and understandings of what differentiation is within the field. This study is situated in Dr. Carol Tomlinson's definition of differentiated instruction (2017), "… students have multiple options for taking in information." Carol Tomlinson is known for her work in differentiation. Tomlinson (2000) states the key elements of differentiated curriculum as content, process, and products. From here, she shares that this can be done based on the students' readiness, interests, and/or learning profile.

Content. Tomlinson (2000) defines content and the skills you want students to learn, and how you present that information, including the materials you use to do so. Content is about what your students are ready to learn, some students may need more time to master a skill, or may be at a higher level than their grade level. In mathematics, this could be using manipulatives to teach a new concept or reteaching the concept.

Process. Another way Tomlinson (2000) describes process is the activity the students do to understand the information presented to them. These activities should be focused on a goal that has been set for student learning. This is where options should be provided to students for how they would like to show what they are learning. Process can also reflect the students' interests and learning preferences.

Products. Products are what Tomlinson (2000) considers to be a demonstration of the student's understanding of a longer period of study. This is how you would assess the unit. A teacher could have this be a project, test, portfolio, or a mix of assignments. These assessments should show a variety of difficulties. Part of the product portion of differentiation is also to develop your rubrics with the help of students that reflect their own personal learning goals and whole-class goals.

Benefits of Personalized Learning

Ensign (2012) discusses differentiation implementation in the Seattle, Washington public school district. The district had math coaches that taught teachers about using differentiation and how to use differentiation in their mathematics instruction. By providing teachers with the information about why differentiation would be helpful in their classroom and how to implement differentiated instruction teachers become more likely to want to learn more about differentiation and more likely

to implement it in their own classroom. The Seattle, Washington public school district did this through professional development workshops focusing on two teachers that became the model of differentiating for the area and started a wave of differentiation implementation in Seattle.

Kesteloot (2011) found that when instruction is differentiated, students have a more positive outlook and less anxiety when learning mathematics. Classroom learning environment is linked to a student's math disposition in the areas of personalization, participation, and independence. If a classroom has less personalization, there were more negative dispositions in mathematics amongst students (Mello, 2018).

Issues with the traditional approach to learning. The effectiveness of the transitioning between a traditional learning approach to a blended approach of learning was studied in high school students. The study quickly found issues in the traditional learning approach. These problems were, time being a learning variable, teachers teaching to the students at grade level, and generally sorting students rather than educating all students as they needed. With the transition to a blended learning approach, behavior problems decreased, and students said the instruction fit their needs. In the study, grade point average and suspension rates were not found to be impacted from moving to a blended learning approach (Barrett, 2017).

Implementation of Personalized Learning

Teachers that are high implementers of differentiated instruction were found to be those with more experience and be determined. These high implantation teachers were also found to command the classroom and focused their energy on their instruction. The study had four main implications. First, that personal factors play a key role in the likelihood of a teacher to implement differentiated instruction in their classroom. Second, that the typical teacher would find complexities of planning differentiated lessons since they do not have as much experience with this teaching method. Third, you cannot learn differentiated instruction right away, it takes time. Lastly, the professional development given to the teachers was found to be an ineffective use of time (Abbati, 2012).

There are various degrees of a teacher's possible implementation of personalized learning. Allison (2016) found that a teacher's degree of implementation of personalized learning was connected to student achievement gains, with higher degrees of differentiation leading to higher student learning outcomes. The higher degrees of personalized learning implementation, the more student achievement gains. McNeill and Polly (2023a, 2023b) found that primary grade teachers desired to meet students' individual needs and differentiate instruction but often had limited access to professional learning and support about how to set up differentiated and personalized activities in mathematics classrooms.

Based on the existing literature, the purpose of the study was to examine how teachers reported using a personalized learning approach in elementary school classrooms. While differentiated instruction is commonplace in elementary settings with teacher-facilitated small groups and centers, personalized learning approaches where students are given choices and have different sets of small group, partner, and individual activities based on data has not been studied extensively in the literature. This study is intended to be an exploratory, initial examination of what teachers were doing in their classrooms. The following research questions guided the study.

1. What are the aspects of personalized learning in primary grades' mathematics classrooms?

2. What do teachers report about their use of personalized learning in mathematics?
3. What are students' feelings about their personalized learning mathematics instruction?

METHODS

Setting and Participants

The study occurred at 1 elementary school located 10 miles from a downtown, large urban area in the southeastern United States. The teachers and the school were purposefully chosen because each teacher had over 3 years of experience designing and implementing personalized learning activities in their mathematics teaching. The school includes a diverse student body (40.1% White, 28.6% Hispanic/Latinx, 25% Black), and their data typically is close to the state average in mathematics achievement.

The participants included a purposeful sample of 3 Kindergarten and 2 First Grade teachers. The study also included three students from each classroom. The three students from each classroom reflected at least one student whose suggested that they needed more rigorous activities, 1 student who was performing at grade level, and 1 student who is need of more foundational experiences. One First Grade teacher requested three additional students to be interviewed, 1 from each category described above which resulted in 18 students participating in interviews.

Data Sources and Data Analysis

Research Question One: Teachers' Use of Personalized Learning in Mathematics

In order to examine how teachers used personalized learning, there was a need to conduct observations in teachers' classrooms. Research Question One was examined using classroom observations made by the first author. Observations were conducted during what teacher-participants called a "typical lesson." The first author observed each participant once for the entire 60-minute math block. However, since the focus of this study is on personalized learning, the whole class activities, such as calendar time, number talks, and whole class opening activities were not included. The second author conducted all of the observations and collected field notes about activities. The categories that helped to focus the observations were: materials, teacher's role, student choice, technology, and checking for understanding.

In order to examine this research question field notes were analyzed inductively (Miles et al., 2019) based on the categories that were described above. Data was organized by category by the first author. The second author then read the data and they discussed the interpretation of the data. The first author then created descriptions of the data for each of the five pre-determined categories, which the second author provided feedback on.

Research Question Two: Teachers' Perceptions of Personalized Learning in Mathematics

Research Question Two was examined using semi-structured interviews with the 5 primary grades teachers. Each interview lasted between 15-20 minutes. The first author audio recorded the interviews and transcribed them.

Qualitative data collected by interviews were analyzed via an inductive, thematic analysis (Miles et al., 2019). Initially, the first author read through the data collected multiple times and annotated/took notes of meanings and patterns seen. The researcher then began to organize the data into groups to code data for as many patterns as possible. After going through and getting all patterns together, the researcher sorted related codes into themes. The first author then went back over these themes after and defined distinctions for each theme to make sure each are their own. The second author revisited the data to confirm the themes and to ensure that themes aligned to the original data sources, and supported the writing of the findings.

Research Question Three: Students Perceptions of Personalized Learning in Mathematics

Data for Research Question Three came from student interviews. Three students were interviewed from each of the five teacher-participants' classes. Each interview lasted four to six minutes. Due to parent permissions, field notes were taken by the first author instead of audio recording the interviews. Data was analyzed thematically based on each interview question (Miles et al., 2019). After the first author wrote a description of the interview findings, the second author reviewed the data to check for agreement.

FINDINGS

Question 1: Enacted Personalized Learning in Mathematics

Classroom observation data provided information about Question 1, which focused on the activities being used in the implementation of personalized learning. In all five classrooms, there were multiple students using hands-on manipulatives throughout the classroom activities. The use of centers and task bins were a way that nearly all teachers differentiated based on student data and need. They formed groups to go through these centers. Centers were skill-based and included the use of technology in which students were on their own personalized learning path which was determined by the digital program Dreambox Learning, which the district provided. At the non-technology centers, students in each classroom had some degree of choice in the task they wanted to do at particular stations.

Materials

All five of the teacher-participants used center activities in their classroom and had bins with various mathematics activities and tasks in them. These activities included tasks with hands-on manipulatives (all 5 teachers), activity sheets or laminated task cards with problems (Teachers A, B, D, and E), hands-on mathematics games involving counting, addition, or subtraction (All three Kindergarten teachers- A, B, and C). All three Kindergarten teachers and one First Grade teacher (Teacher D) had students write their work on whiteboards and students erased their work after

each problem. Teacher E, a First Grade teacher had students do their work on paper instead of white boards, which was collected by the teacher at the end of the class.

Teacher Role

In terms of teacher's role during these activities each teacher provided their class with a brief introduction of what activities were available during mathematics time. In each case this introduction lasted no more than 5 minutes. The teacher circulated in two of the Kindergarten classrooms (Teachers A and B) the entire time providing support to individual students or a table of students who needed clarity. These two teachers provided clarity but were not observed doing any direct teaching of concepts. In Teacher C's classroom (Kindergarten) and the two First Grade classrooms the teacher worked for extended periods of time (12 to 15 minutes per group) with small groups of children. At these teacher-facilitated small groups, teachers gave their students manipulatives and worksheets and were observed doing guided teaching of specific mathematics skills to groups of students. The students had been organized by ability; specifically, teachers had students who needed more of a challenge were in a group, students who needed more foundational experiences were in a group, etc.

Student Choice

In two of the three Kindergarten classrooms (Teacher A and Teacher B) students were observed having a choice between two activities that were at the same location. Specifically, when students rotated to a specific table, they had two different math games to work on, and they had to choose one. In Teacher C's Kindergarten classroom teachers had a choice about where to sit but not about what activities to do. More student choice was evident in Teacher D and Teacher E's First Grade classrooms. Students were given the choice of which activities to work on from a pre-determined list. Students indicated that this was the "list for the week" and they could do any activity on the list. Teacher E's students also had a choice on where they could do partner activities, while Teacher D had students in specific places in the classroom.

Technology

Students in both First Grade classrooms and two of the three Kindergarten classrooms used iPads as part of the personalized learning mathematics time. Both Kindergarten classrooms included students on Dreambox Learning, and students were working on different activities that the program assigned based on students' data. Students in one First Grade classroom were on Dreambox, while students in the other classroom were using iPads to work on a program that included a combination of digital-based instruction and practice with the quick recall of addition and subtraction facts.

Checking for Understanding

Only one First Grade teacher (Teacher E) had students write down work and collected it. The two First Grade teachers (Teacher D and E) and one Kindergarten teacher (Teacher C) informally checked for understanding by asking questions and observing students at their small group table. The other two Kindergarten teachers (Teacher A and B), as stated earlier, walked around and

clarified instructions for students but they were not observed asking questions to check students' understanding of the mathematics.

Summary of Classroom Observations

The observations of the five teacher-participants indicated the use of centers and small groups in all of the mathematics classrooms. In three classrooms (1 Kindergarten, 2 First Grade), teachers spent extensive time with small groups of students, while in the other 2 Kindergarten classrooms, teachers floated and helped students as needed. Additionally, students had a choice of activities in four of the five classrooms, and in the other classroom, students had choice of where to sit to do centers but not choice of activities. Lastly, checking for understanding seemed informal in four classrooms, as only 1 First Grade teacher collected student work during the day.

Research Question Two: Teachers' Perceptions of Personalized Learning in Mathematics

Research Question 2 was examined using data from interviews with the five teacher-participants. The findings below have been organized by the interview questions.

What Does your Math Class Typically Look Like?

All teacher-participants reported using small groups and/or centers daily. All five teachers reported starting their mathematics block using whole group mini lessons before moving students to small groups/centers. The structure of their small groups and centers differed by teacher. Teachers A and B, who both teach Kindergarten, shared that their small groups are organized by ability level with students in groups with students who are around the same ability. Teacher A talked about both how data formed small groups and her purpose of teaching with small groups: "Small groups are formed using data from formal and informal assessments and are structures to provide additional support with skills taught in whole group lessons." Meanwhile, Teacher C, who teaches Kindergarten, mentioned that she intentionally plans centers to include the current concept that her class is working on as well as at least one review concept. Additionally, Teacher D, who teaches First Grade, mentioned that the activities that she allows her students to choose from focus more on the review of concepts that her students needed more practice with compared to current concepts.

What Types of Materials Do You Use in Your Classroom?

respect All five teachers talked about the daily use of hands-on manipulatives in centers, the use of technology with the Dreambox Learning program. The hands-on manipulatives that they referenced included the use of counters and cubes in Kindergarten, while the two First Grade teachers referenced the use of base ten blocks, which are commonly used for place value concepts. When asked follow-up questions teachers referenced the daily use of iPads in their classroom. All three Kindergarten teachers mentioned that the frequency of iPad use was required by their school's administration and their school district.

In addition to technology use, all five teacher-participants referenced selecting activities from multiple sets of resources provided by either the district, their school, or other resources that they had obtained themselves. When asked why they use multiple resources and not just the district-provided resource, Teacher B, a Kindergarten teacher, mentioned "There are not a lot of good center activities in the resource that we have. If we want to do centers well we need to use multiple resources and pick the best ones." Both First Grade teachers mentioned the use of the current mathematics curriculum as well as one that the district had purchased a decade earlier. Teacher E, a First Grade teacher, said, "Even though it is older, that resource has really engaging games and activities for centers. I have seen how playing those games helps my students make sense of our grade level concepts."

When asked about worksheets the three Kindergarten teachers all expressed negative mannerisms. Teacher B, a Kindergarten teacher, said, "We use worksheets during some centers but try not to focus too much on worksheets and busy work." Teacher A, also a Kindergarten teacher, reported, "We use recording sheets for games but we do not give our students worksheets with problems. That is not good for our kids." Teacher D, a First Grade teacher, said, "We do use worksheets as center activities sometimes. It is good for students to get some practice." Teacher E, the other First Grade teacher said, "The worksheets in centers give us some information about how students are doing on important concepts. That data is very helpful in planning." Teacher E was also the teacher observed who had collected students' written work from their centers as a way to check for understanding.

How does Personalized Learning Influence Achievement?

Teachers were also asked how they feel about their students' mathematics achievement based on their use of personalized learning and centers. Both First-Grade teachers were adamant that their approach led to student learning compared to past approaches that they had used. Teacher D, a First-Grade teacher said, "At the end of the year, I had 25 students. 21 of them exceeded expectations for all Standards. I feel that being able to meet with individuals/small groups to promote their learning is the key."

The three Kindergarten teachers were more hesitant about how personalized learning influenced achievement. Teacher A mentioned that student achievement varied based on the concept as well as her students' ability to stay on task. Teacher C said, "The struggle I find to be more difficult, is for students to retain that information taught and remember it on a quarterly assessment that is 2 months from the time I taught something."

How Did you Learn about Personalized Learning?

When asked about personalized learning four (2 Kindergarten teachers, 2 First Grade teachers) of the five teachers reported they learned themselves through reading things on the internet, working with other teachers, and doing their own learning. Teacher A, a Kindergarten teacher mentioned, "My grade level teaches each other. We work well together and share a lot of ideas and resources."

Teacher D, a First-Grade teacher, referenced reading about the research about how effective personalized learning is: "During my 26 years of teaching, I've tried to stay abreast of new studies and data on all teaching ideas."

Teacher B, a Kindergarten teacher, was not the one who did not reference learning about it herself, said, "I attended a workshop about personalized learning hosted by the school district.

It was not math specific, but a lot of the ideas work in my math classroom." Teacher B also commented, "I have been reading a lot about multiple intelligences so I am trying to include as many types of activities in my activities as I can."

Summary of Teachers' Interviews

In summary, teachers discussed their use of multiple curricula resources, their grouping of students by ability, and their use of various games and activities during personalized learning time in their classroom. Additionally, teachers shared that most of their learning about personalized learning has been on their own and with each other instead of formal workshops or courses.

Research Question Three: What are Students' Feelings about Personalized Learning in Mathematics Instruction?

Research Question 3 was examined with data from interviews with primary grades students, which included 9 students each from Kindergarten and First Grade. Each of the students made positive comments about their mathematics classroom. Words such as "fun" and phrases such as, "I like math."

When asked the follow up question, "What do you like about math?" students had varied responses. Multiple students talked about having student choice. One First Grade student commented, "We get to use different strategies to solve a lot of problems." Another First Grade student said, "In math we get to choose our activities and that is really cool." A Kindergarten student mentioned, "We do a lot of activities. It is always new."

When asked about what their favorite specific math activities are students mentioned a few different things. Five of the 18 students mentioned using technology; there were four mentioned of Dreambox, and one student mentioned using the "video games on the iPad" which referred to the math games on Dreambox. Other students mentioned the use of manipulatives such as cubes, counters, and blocks. One Kindergarten student said, "We get to build towers with blocks, count them, and then destroy them like Godzilla." Another Kindergarten student said, "I love math. We play a lot of games."

In summary, students positively talked about their time in their mathematics classrooms. They referenced student choice, the use of mathematics games, and hands-on materials.

DISCUSSION

This study contributes to the current literature by providing an examination about how primary grades teachers implemented and talked about the use of personalized learning in their classrooms. Additionally, while brief and non-detailed, students' responses also provided insight into their experiences in these types of classrooms. There are three findings that we would like to elaborate on: providing students with choice, the use of multiple resources, and the extent to which activities were (or were not) personalized.

Providing Students with Choice

This study examined five primary grades teachers and their use of personalized learning in mathematics, where the teachers were purposefully selected for claiming that they use personalized learning. The classroom observations indicated that students in four classrooms used the notion that leaning was personalized by giving students options or choices of which mathematics activities they could do during part of their mathematics class. This notion of allowing students to choose is an approach that has been advanced in recent years with programs such as The Daily Five model, the use of lists that include "Must Do and May Do" activities, as well as more broad approaches to giving students agency and autonomy in classrooms.

Teachers constrained students' choice by limiting their options to 2 different activities at specific centers. Students had the choice to do only one of two activities in a few different locations in the four classrooms where this had taken place. Based on teachers' interviews (Research Question 2) and students' interviews (Research Question 3), there were multiple positive comments about this approach. Future work is needed to make more explicit connections between this idea of student choice and Tomlinson's framework for differentiation; more specifically, how does giving students choice of activities contribute to different content, processes, or products. Additionally, how does giving students choice influence various student learning outcomes such as self-efficacy in mathematics, dispositions and motivation towards learning mathematics, and student learning outcomes.

The Use of Multiple Curricula Resources

One surprising aspect of the classroom observations and the teacher interviews was the number of different curricula resources that was included and integrated into the mathematics classrooms. Teachers were using materials from the current and past district-provided curricula as well as other resources that teachers had selected. During the interviews all five teachers mentioned the value of hands-on manipulatives and math games, which they stated were not in the district-provided curricula. This study contributes to the literature as it provides more evidence about teachers' selection of curricula resources in order to meet their students' needs. This aligns to the framework advanced by Stein, Remillard, and Smith (2007) that teachers' use of curricula resources is heavily influenced by teachers' beliefs, their school context, and their knowledge of mathematics. Similar to previous studies (e.g., Polly, 2016, 2017) teachers believed that their district-provided resource did not meet the needs of their students, so they decided to use other resources in their classrooms.

In terms of implications, teachers need support in the selection and compilation of resources to ensure that their work meets the specific required standards and students' needs (Sawyer et al., 2020). District and school-based leaders must examine how to best support teachers' personalized mathematics activities through professional learning and other supports (Gilson et al., 2022; Martin et al., 2022).

The Extent to Which Activities Were (or Were Not) Personalized

All five teacher-participants were selected based on their claim that they used personalized learning in their mathematics classrooms. Meyer (2017) describes personalized learning with four characteristics for all learners from Kindergarten through Grade 12. They include: 1) student ownership of the learning process; 2) focus on the learning process rather than assessments; 3) competency-based student progression; and 4) anytime, anywhere learning. In the observations

students had some ownership of their learning process by being able to select the activities that they participated in. There also were emphases on center activities and hands-on learning instead of more formal assessments. There was not much evidence related to characteristics 3 and 4 above.

One argument made by Teacher B, a Kindergarten teacher, was that "Dreambox personalizes instruction since it bases the activities off students' past work." Teacher D, a First-Grade teacher also mentioned that "students get personalized activities in Dreambox." These comments indicate that teachers may have thought that their mathematics classroom was personalized simply by using Dreambox not by the various centers and small group activities that were being used.

In terms of implications, there is a need for more research studies to examine professional learning experiences on personalized learning and how teachers apply what they learn from their professional learning into their classroom. In this present study an extension would be to have teachers describe how their math centers is personalized and specifically hone in on how those experiences influence student learning. With most educational concepts there is a need for future studies that examine links between personalized learning and student achievement using both curriculum-based and large-scale, high-stakes assessments (see Polly, 2016; McNeill & Polly, 2023a).

All in all, this study provided insight into primary grades teachers' use of centers and aspects of personalized learning as well as both teachers' and their students' perceptions of personalized learning. While these ideas of personalizing learning experiences in mathematics have promise, future studies are needed to more closely examining to what extent and how personalized learning approaches compare to more typical approaches in light of student achievement.

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