Innovative Professional Development Methods and Strategies for STEM Education

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Chapter 3
Primary Grades Teachers' Fidelity of Teaching Practices during Mathematics Professional Development

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ABSTRACT

This chapter shares the findings from a study that examined primary grades teachers' fidelity of implementation during a year-long professional development program on formative assessment in mathematics. The project provided over 80 hours of professional development to elementary school teachers regarding their use of an internet-based formative assessment system for their students' mathematics achievement. This study examined teachers' online reflections and data in the internet-based assessment system to identify themes that lead to either a high fidelity or low fidelity of implementation. High fidelity teachers expressed beliefs that formative assessment supported their mathematics teaching, improved their students' learning, and was feasible to carry out in their classrooms. Low fidelity teachers' reflections were associated with numerous barriers to implementation as well as a lack of buy-in that the formative assessment system could benefit their teaching.

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EXPLORING PRIMARY GRADES TEACHERS' FIDELITY OF FORMATIVE ASSESSMENT PRACTICES DURING MATHEMATICS PROFESSIONAL DEVELOPMENT

Introduction

Research continues to document the struggles that United States elementary school teachers face related to teaching mathematics effectively (National Mathematics Advisory Panel, 2008). Barriers to effective mathematics teaching include teachers' beliefs in more traditional approaches (Clark et al., 2014; Stipek, Givvin, Salmon, & MacGyvers, 2001), a lack of knowledge related to the mathematics that they teach (Thames & Ball, 2010), insufficient curricula materials or a lack of knowledge on how to use them (Sherin & Drake, 2009), and pressure to teach a certain way in an effort to increase test scores (McGee, Wang, & Polly, 2013). In light of the research on mathematics teaching, it can clearly be stated as a complex process that requires specific skills and knowledge related to both pedagogy and content (Thames & Ball, 2010).

In an effort to support teachers' mathematics instruction, professional development programs are commonly viewed as a mechanism to positively support teachers and also improve student achievement. Mathematics professional development projects are most effective when they simultaneously can support teachers' development of knowledge related to content and pedagogy as well as how students develop an understanding of fundamental mathematics concepts. One, of the pedagogy-related processes, that has gained attention in the literature is formative assessment, specifically examining students' mathematical thinking, analyzing data, and then making sound instructional decisions based on that information (Wiliam, 2007a; Wiliam, 2007b). Teachers who are able to effectively carry out a formative assessment process have been empirically linked to gains in their students' mathematics achievement (Polly et al.., 2014; Wiliam & Thompson, 2007).

This chapter presents a study in which we analyzed participants who completed a professional development project designed to support primary school teachers' use of an internet-based mathematics formative assessment system to support their mathematics teaching. Teachers participated in an 80-hour learning experience and data was collected on their use of the assessment system, their responses to reflection prompts, and their students' scores in the formative assessment system.

BACKGROUND

Formative Assessment in Mathematics

The purpose of formative assessment is to elicit and collect data that directly impacts instruction for individual learners (Koellner, Colsman, & Risley, 2009). Further, when working on activities related to formative assessment, teachers must connect evidence with instruction, which in turn requires them to understand and apply their expertise of learning progressions and how students best learn (Wiliam, 2007a, 2010). To that end, research on formative assessment has noted that the process is only valuable to the teaching and learning when the data is closely examined to modify instructional goals, instructional activities, and instructional pedagogies (Black, Harrison, Lee, Marshall, & Wiliam, 2004; Heritage, 2007).

Formative assessment processes can positively impact student learning. Formative assessment has been empirically associated with gains in student learning, teachers' increased knowledge of their students' understanding, and an increase in the alignment of instructional activities to students' abilities (Polly et al., 2014; Black & Wiliam, 1998; Wiliam, 2007b). With students who are at-risk and performing below grade level expectations, formative assessment and data-based instructional decisions can improve students' learning in struggling areas (Fuchs & Fuchs, 1986).

While there is potential for formative assessment processes to transform teaching and learning, teachers report difficulty consistently and frequently using formative assessment in their classrooms (Polly et al., 2014, Wiliam, 2010). In Abrams' (2007) study, several teachers admitted that the time demands of simply teaching the standards prevented them from doing any types of formative assessment with their students. Cizek (2010) noted that while teachers may espouse the value of formative assessment, summative assessments at the end of units is the only types of assessments that teachers use. There is a need to examine ways to best support teachers' efforts to formatively assess their students' learning, analyze data, and use the data to make appropriate instructional decisions.

Learner-Centered Professional Development

Professional development continues to be highly regarded as a mechanism to provide teachers with support in terms of their adoption of new pedagogies and advance teachers' knowledge about the content related to what they teach (Borko, 2004; Loucks-Horsley et al., 2010). While teacher learning is important, many stakeholders posit that the primary reason for teacher professional development is to increase teaching effectiveness, therefore increasing student achievement (Polly & Hannafin, 2010; Borko, 2004). This study was grounded in the construct of learner-centered professional development ([LCPD]; National Partnership for Educational Accountability in Teaching, 2000; Polly & Hannafin, 2010), which aligns to the American Psychological Association's *Learner-centered Principles* (APA Work Group, 1997), as well as constructivist and socio-cultural views of teaching and learning (Alexander & Murphy, 1998). LCPD addresses student learning deficiencies, actively engages teachers in experiences that develop their knowledge of both content and pedagogy, gives teachers ownership and choice of some professional learning activities, provides collaborative opportunities, includes job-embedded activities, and promotes teachers' reflection of their experiences (Polly & Hannafin, 2010).

In specific relation to mathematics professional development, teachers need experiences to simultaneously deepen their understanding of mathematics content and pedagogies by exploring complex mathematical tasks (Polly, McGee, & Martin, 2010), analyzing concepts that are difficult for students to learn (Hawley & Valli, 1999), learning ways to address student learning deficiencies (Loucks-Horsley et al., 2010), as well as analyzing, modifying, and creating curricular resources to meet the needs of their students (Martin & Polly, 2015; Polly, 2010). Professional development should be ongoing and closely connected to classroom activities (Heck, Banilower, Weiss, & Rosenberg, 2008).

Purpose and Research Questions

The goal of the APLUS professional development program that was examined in this study was to support primary teachers (Grades Kindergarten through Grade 2) and their use a web-based formative assessment system focused on number sense. Based on prior research, teachers who effectively use formative assessment data to gather information about their students and make instructional data-based decisions

have greatly improved their students' mathematical achievement (Polly, Martin, Wang, Lambert, & Pugalee, under review; Wiliam, 2007). Professional development focused on formative assessment can greatly influence teaching and learning (Polly et al., 2014; Wiliam & Black, 2007). This study intended to identify and examine the differences between teachers that were considered high fidelity and low fidelity. Fidelity was measured by the amount of participation in the professional development and how much the teachers used the internet-based formative assessment in their classroom.

To that end, this study was framed by the following research question:

1. What were the differences between high and low fidelity teachers in their use of the internet-based formative assessment system?
2. What were the differences between high and low fidelity teachers on a professional development survey?
3. What were the differences between high and low fidelity teachers in their professional development reflections?

METHOD

This inductive study included purposeful sampling in order to explicitly compare data for high fidelity and low fidelity teacher-participants in the professional development project. Moodle was the online platform used to deliver professional development. This site produces activity reports for each of the participants. AMC Anywhere allows those with administrator status to access reports of activities for each participant. Activity reports from Moodle and AMC Anywhere for all participants were analyzed simultaneously to identify a purposeful sample. The purposeful sample was selected based on high engagement and fidelity. Once the purposeful sample was generated the researchers analyzed the data to extract themes to further explain the experience of each participant.

Context and Setting

The professional development project, *Assessment Practices to Support Mathematics Learning and Understanding for Students (APLUS)*, was funded by the North Carolina Mathematics Science Partnership program in the United States. This grant program supports intensive professional development projects focused on developing teachers' knowledge of content and pedagogy. The APLUS project provided teachers with professional learning experiences focused on the use of the internet-based assessment system *Assessing Mathematics Concepts* (*AMC Anywhere* hereafter) (Richardson, 2012), and the related instructional materials *Development Number Concepts* (Richardson, 1998). Richardson developed *AMC Anywhere* and the instructional materials abased on her experience teaching mathematics to children.

The APLUS grant was written in conjunction with faculty at two universities and five school districts around North Carolina. The grant provided funding for three cohorts of teachers who participated in the project for 11 months and each cohort included between 200-250 teachers. At the time of writing this manuscript, the third cohort is in progress. This study focuses on the second cohort of teachers since the professional development activities had been refined after year one, and teachers in the second cohort provide the most current data from the project.

Each cohort began the project with an intensive 5 day, 40-hour summer experience. During this time, teachers learned about the formative assessment system, the underlying mathematics concepts, and related mathematics activities that align to the concepts that are assessed. Teachers also are given time to practice using the assessments and analyzing data from actual students, in order to provide an authentic experience that mirrors actual classroom praxis as much as possible. The intensive summer professional development began on the first day with a teacher practices survey and on the last day ended with the same survey. Teaching practices were measured with 25 items on a 5-point Likert scale with higher scores on teaching practices suggesting more teacher-centered approach. Thirteen items (Items 1, 2, 3, 4, 8, 9, 10, 13, 14, 18, 19, 22, and 23) were indicators of teacher-centered practices whereas 12 (Items 5, 6, 7, 11, 12, 15, 16, 17, 20, 21, 24, and 25) were indicators of student-centered practices.

During the school year, teachers completed a series of classroom-embedded professional development activities that were facilitated through an online learning management system. These activities were organized into three large modules, which are described in Table 1. Each module required that teachers use the formative assessment system, analyze data, and then answer a series of reflection questions based on their experiences teaching mathematics and using the assessment system.

Module 1 focused on reminding teachers about the *AMC Anywhere* assessment system from the summer by watching a video and having them assess their students. Teachers also had to share about how they have organized their classroom to allow for differentiated, small group instruction. Module 2 allowed teachers to work more with the *AMC Anywhere* system with a focus on analyzing the data and making an instructional plan for their students. Module 3 focused on Number Talks as an instructional activity to promote discourse and conversations about number sense. Module 3 also allowed teachers to assess their students and analyze the data with a focus on struggling students in their class.

Participants

Teacher-participants in this study all taught in a large urban school district. In order to contrast the characteristics between high fidelity and low fidelity teachers, we purposefully selected (Patton, 2015) five teachers who had demonstrated a high fidelity of implementation of formative assessment pedagogies

Table 1. Overview of online professional development modules

	Time of Year	Activities
Module 1	First two months of the school year	Teachers assess their students using the *AMC Anywhere* system. Teachers design and share their plan for organizing their mathematics instruction to differentiate activities based on data. Teachers collaborate via online discussion boards sharing ideas about instructional activities to use.
Module 2	Middle of the school year	Teachers assess their students using the *AMC Anywhere* system. Teachers design and share their plan for intensive targeted support for a group of their students who require specific differentiation. Teachers collaborate via online discussion boards their successes, barriers to implementation, questions, and progress of their students.
Module 3	Last two months of the school year	Teachers assess their students using the *AMC Anywhere* system. Teachers provide results and updates about their students' growth, the use of the *AMC Anywhere* system and associated instructional materials. Teachers learn about Number Talks, a process for facilitating conversation about number sense, and implement at least one Number Talk in their classroom.

and five teachers who had demonstrated a low fidelity of implementation. All teachers were classroom teachers and licensed by the state to teach Grades Kindergarten through Grade 6. Lastly, each participant attended and completed all of the summer professional development workshops.

Data Collection

The data used for this study was collected from the academic year 2013-2014 which was year two of the MSP grant. The AMC Anywhere site provides spreadsheets for each of the nine assessments available that show students' performance on those tasks. A student will have several lines in the spreadsheet that show each instance that their teacher assessed them in that particular assessment. Reports for the four most used assessments (Counting, Hiding, Number Arrangements and Combination Trains) were generated, combined, and sorted to show how many assessments were administered for each student. These reports clearly showed the usage pattern for the teacher participants. From these reports a list of teachers that were using the assessments several times with each student was created along with a list of teachers that were assessing their students less than twice.

The online professional development (PD) was set up in three Modules that included activities, discussion boards, videos, and a requirement to respond to other teachers. These modules were examined to connect the teachers that were using AMC assessments regularly and had high participation in the online PD and those teachers that were using AMC assessments minimally and were either not engaged in the required PD or did not complete all modules.

The participants participation in both pre and post survey is also included. The online participation was scaled as 0 –did not participate, 1- participated less than the required amount, 2- exceeded requirements. Fidelity was measured by the use of the formative assessment technology. Again, a scale of as 0 –did not participate, 1- participated less than the required amount, 2- exceeded requirements. This project included 6 districts of teacher participants; the largest district was used for purposeful sampling. The rationale behind using the largest district for purposeful sampling was to have teachers experiencing similar demands and schedules for the mathematics instruction.

Data Analysis

The module data were analyzed using inductive, thematic analysis (Coffey & Atkinson, 1996) and researchers organized the data into categories by themes (Ezzy, 2002). The themes found in each of the modules focused on depth of response, intentionality of teaching practices, evidence of data driven instructional practices, level of interaction with their professional community. The data from the internet-based assessment system was examined to determine the amount of assessments that were administered per student and per teacher. The survey on teacher practices was administered at the beginning of the summer week long professional development and again at the end of the PD that week. The survey included open ended responses that were analyzed along with the pre/post paired sample t-test. The mean scores and significance are reported.

FINDINGS

The teachers were selected based on their participation in the online modules and their activity within the AMC system. The high fidelity group consists of teachers that were active in all three modules of the online professional development and used AMC anywhere assessments with their students regularly. Regularly was defined as students being assessed from 2 to 4 times throughout the year. The low fidelity group of teachers was identified as those that had minimal to no participation in the online modules and had minimally assessed their students with the AMC Anywhere system. The high and low group consisted of 5 teachers. There were several themes that were identified in the comparison of their participation in the online modules.

Learning Environments

Professional development focused on using AMC Anywhere web-based formative assessments and creating a learning environment that promotes hands-on learning and mathematical talk. Module one of the online professional development centered on teachers' classroom learning environment and routines for mathematics instruction.

High fidelity teachers: The teachers identified as high fidelity showed a level of thought and reflection in the module responses that was noticeably than other participants. The responses below are representative of the high fidelity group. The response is taken from Module one where teachers are asked to describe their classroom environment and mathematics routines.

My classroom environment facilitates a safe environment by providing students the opportunity to take ownership of their learning and growth. I have students grouped according to their abilities but each group has students with varying strengths and weaknesses. This is to have helps and support when I can't get to them right away. Each group has a student who is strong in all areas and then the other members of the learning team have different degrees of strength in mathematical ability. My space is set up so that manipulatives are readily available and students can access them on their own. Independence is the word for the year!!

The teacher's response to the question on environment and mathematics instruction reveals a level of intentionality in the construction of her classroom that is more focused on the learners. She purposefully creates groups that have ability differences, but seems to move beyond high and low ability and looks to have students working together that have different strengths to offer. She has an overall goal of creating independent learners and thinkers.

Another participant wrote:

Our math routine changes depending on the need of the students…We also do an estimate of magnetic chips as well as number talks that include "how did you see it?" Students are shown a dot card and then they have to tell me the amount, then I call on several students to tell me how they saw it. The students love this!!!!

This teacher's response conveys a sense of enthusiasm for facilitating an environment that her students can thrive. That same sense of enthusiasm along with flexibility and responsiveness appears in the response about classroom routines. The learners are at the center of the planning and therefore there is constant change in the routine based on those needs.

Low fidelity teachers: The teachers identified as low fidelity responded to the questions on environment and routines in a way that provides the details prompted by the question; however, the responses are limited in the planning and reasoning behind these decisions. One teacher wrote:

We have math from 1:30-3:00 Monday-Wednesday, and 2:15-3:00 on Thursday and Friday. Each math session begins with a math word problem. Then, students share their strategies for solving the problem. Then, we move into a math talk, often using tens frames or place value rods. On some days, the class then divides into groups and I am able teach small group lessons to target specific skills. The independent groups will play a Kathy Richardson or Investigations game, complete independent work, or practice a math skill on the computer. On other days I introduce or review a Kathy Richardson or Investigations game. The math time ends by coming back together to share strategies that we used that day during math.

The same teacher briefly summarized her mathematics instructional time by writing:

We have math from 1:30-3:00 Monday-Wednesday, and 2:15-3:00 on Thursday and Friday. Each math session begins with a math word problem. Then, students share their strategies for solving the problem. Then, we move into a math talk, often using tens frames or place value rods.

The second response provides the answer to the module question in a list-like fashion. The details of why mathematics instruction is structured in that way are not provided and there is little elaboration of the overall objectives and goals. The response fails to show the level of enthusiasm offered in the first response. She includes math problems, math talk, grouping, games, and sharing in the response; however, the intentionality and purpose of using these strategies are not shared. The routine question is met with what appears to be copy and paste from the previous response. This question may have been a place to elaborate on the reasoning behind the environment and agenda choices, but it is merely a reiteration of the first response.

Use of Student Data

The next topic in module one asked about the ways in which the teachers collected and used data. This particular district, as in many school districts, employs many different types of both formative and summative assessments. The example response from high fidelity teachers exhibits more reflection on those assessments.

High fidelity teachers: Participants' use of data was not a completely new idea to teachers. Many teachers, regardless of their fidelity of implementation, commented about the use of data from curriculum-based assessments, quarterly assessments, and end of unit tests. One high fidelity teacher discussed her transition from only using curriculum-based assessments to also using the data from *AMC Anywhere*.

Last year data came from Math Investigation Pre and Post-testing. We also gave students timed tests to determine as well as build fluency with addition and subtraction within a certain number (I did 5, 10,

15, 20, 30). Data in the form of Pre and Post-testing allowed me to know what they could do and what they need to work on. However, it wasn't giving me the skills that my students had difficulty in acquiring. I knew they couldn't subtract, but I didn't know why? If that makes sense. So, if my students did well on the Pre-test for addition, subtraction, word problems, measuring, etc. then we worked on the next "lesson skill" coming up…Data is used to not only plan the next steps for students, but it is also used to have an understanding of where they are and then provide activities that students can do (workshop) that will build upon what they already know. Now, differentiation in workshop and even homework has changed this year in order to meet students where they are mathematically. Data is used for groupings and for informing parents as it has been in the past. The difference now is that we know where they need to go because of what they need to work on in hopes of getting them where they need to be by the years end. Growth is now more evident from the things we have been doing with AMC. High Fidelity Teacher

This response describes the data that the teacher was and still is using, the strengths of that data, the ways in which that data was not providing the full picture, and details on how that data was used in instruction, with parents, and for grouping. She evaluates AMC Anywhere data and notes that while the data provides evidence on students' learning like the curriculum-based assessments did, the AMC Anywhere reports are offering more insight into the specific ways students are struggling and their growth.

Low fidelity teachers: Low fidelity teachers focused their comments primarily on district-mandated and end-of-use data. Further, low-fidelity teachers provided scant information about how the data is used to inform future instruction. The teacher response below provides a list of assessments that have been used in the past and present.

In previous years, our team used common assessments (10 questions every 10 days). We also created assessments based on standards for mid and end of quarter assessments. The data was used at conferences to share student progress. It was also used in intervention team meetings to determine what steps to take with struggling students. Now, we share Kathy Richardson data at grade level meetings. We also look at MAP scores across the grade level. These assessments help us to create small groups for specific skills in math.

The ideas of small groups, intervention, and determining struggling students are listed in the use of certain assessments. The MAP scores are examined by grade level, but it is unclear how they are used for student learning. Similarly, AMC assessments are only mentioned as something discussed at grade level meetings and not directly connected to planning.

Implementation of AMC Anywhere

The professional development workshops in the summer provided video-based examples and allowed teachers to use AMC Anywhere with students in a summer camp. These engaging experiences were strategically part of the professional development to help teacher participants begin the school year ready to implement AMC Anywhere in their classrooms. The online professional development also included videos of teachers administering AMC Anywhere formative assessments and our participants needed to evaluate the student performance and share what level and what type of instruction they may need based

on the video. This allowed participants to share their evaluation with other participants and get ideas for instruction. Both the open-ended questions on the survey that was administered in the summer and the online participation showed a variance perception from the high fidelity and low fidelity teachers regarding ease of implementation.

High Fidelity Teachers: Participating teachers completed a pre/post survey during the summer professional development. The post survey included the question below that asked teachers about their plan for collecting data. The high fidelity teachers' responses to this question suggested they feel *AMC Anywhere* will be an effective and easy to use formative assessment.

How did the PD influence how you plan on collecting and using data this year?

I feel a lot more comfortable going in as a 1st year teacher. I think this data will give me exactly what I need for each student. It will be easier to adapt instruction based on data

This has given me such a better understanding of math concept progression. I feel like I will have assessments that I can use to direct my instruction. So awesome. I am really looking forward to using. Thanks very much

The responses to the survey show a level of enthusiasm and excitement for implementing this program in their classroom. Both responses suggest the teachers will be using the data to direct their instruction. The next responses were included in the online modules from high fidelity teachers and suggest they were using AMC without difficulty and were using the data for instruction.

I think the AMC data is giving us so much more [data]! I found out where my kids were in math quickly. I like how it is easy to work with.

I love how the AMC Anywhere testing results help us determine groups for math.

The responses from the high fidelity teachers continue to exude a positive and enthusiastic outlook for using the AMC Anywhere program. The first response shows the data provided by AMC Anywhere was more comprehensive than other assessments, pinpointed students' understanding, and was easy to use. The second response focuses on the data report created by AMC Anywhere and the ease in using those reports for grouping students. Both responses reveal the teachers are not having difficulty implementing AMC Anywhere. The high fidelity teachers expressed their challenges in a way that suggested they were engaging with the professional development to work toward creating an environment that supported their learners.

Low fidelity teachers: The teachers that were identified as low fidelity teachers in this study have responses that demonstrate a level of struggle that may be limiting their successful implementation of the ideas and AMC assessment program that were part of this grant. The responses of the low fidelity teachers are limited to Module One; they did not participate in Module Two and Three. The lack of participation in these last two modules also displays a lack of implementation fidelity, reflection, and collaboration with regards to this particular project. Their responses to the post survey at the end of the summer professional development also reveal barriers to implementation.

How did the PD influence how you plan on collecting and using data this year?

We may need magnetic 2 color sided counters at our school (WSE). Suggestions: I would like to see a video/s of model classrooms set up/designed for Kathy Richardson. A video library would be helpful.

I will be able to get much more detailed information about my students learning. I will be able to tell how students got their answers rather than just the answer. I have specific activities to address student needs. I would love to go to a model class that uses Kathy Richardson to get an idea of how it will actually look in a classroom. It would be great of we could get magnetic red and yellow chips to use in number talks.

The first response presents ideas for more materials and support that would be helpful to get started, there are no details about how the summer professional development will impact their data collection for the coming school year. It appears that without more materials and video support the collection of data is hindered for this particular participant. The second response exhibits a more positive view toward using AMC Anywhere; however, the plans for the year are non-specific and the request for more materials and modeling indicates the actual implementation of AMC Anywhere may be impeded. The next responses were posted in the online modules.

Being new to this material, I am feeling a bit overwhelmed with trying to familiarize myself with the materials and prepare the materials. I often feel like there just isn't enough time.

This is where I would like to be more familiar with the Kathy Richardson activities so that I could easily access the necessary prerequisite activities for these children. Being new to this material, I am feeling a bit overwhelmed with trying to familiarize myself with the materials and prepare the materials. I am eager to hear how others have designed their math instruction because I am definitely in the market for suggestions. Low Fidelity Teachers

The responses illustrate the teachers' struggle with dedicating time to participating in this project and becoming familiar with the program, strategies, and professional development. These responses, as noted, are coming from Module One and show feelings of being overwhelmed from the beginning of the project. Even though the second response appears to be seeking collaboration with other participants the teachers does not continue with the modules and therefore limits the chance to exchange ideas. The low fidelity teachers shared a sense of being overwhelmed that prevented them from engaging or from continuing to engage in the professional development

Collaboration

The online professional development required participants to thoughtfully respond to the posts of their peers. The requirement was designed to encourage teachers to collaborate with one another and share ideas. The high fidelity teachers actively sought out collaboration and appeared to genuinely want feedback from their peers.

High fidelity teachers: High fidelity teachers participated in the online professional development in a way that supported collaboration among their peers through the discussion board posts. Their posts revealed they valued and wanted the input of the other participating teachers.

I agree with you on what works for one may not work for all. I find that very difficult to work around. Again, differentiation I find that there are times when I need to work with just one student and I can't devote the time that I need as I have about six students who have different needs. I am working to find a solution. Any ideas?

My "to do" list going forward is to keep math talks, number of the day, and the dot cards for "how did you see it?" My students have grown just from seeing how others process the dot cards and what number combinations they are seeing to get a particular number. Any suggestions for a better way to do place value will be greatly appreciated!!

(Responding to a teacher's concern about balancing time constraints and small group instruction) I totally agree with the challenge you are facing. That is where I struggle as well. Any thoughts on how to combat this from the group would be greatly appreciated!! High Fidelity Teachers

The responses above show the teachers have read the responses of other colleagues, they affirm those concerns, share their own challenges, and open the conversation for ideas from their peers. There is also a sense of diligence conveyed in these concerns that suggests the teachers are challenged, but persistent in working through those challenges.

Low fidelity teachers: The low fidelity teachers included limited posts about collaborative experiences that they had with their colleagues during the school year. All teacher-participants are required to collaborate weekly with their grade level teams during mathematics planning. During this planning time, teachers are supported by an administrator or instructional facilitator/coach to guide this process. Despite the fact that collaboration was not mentioned by the low fidelity teachers, they did collaborate weekly with their teachers regarding mathematics instruction.

Reflection about Implementation and Experiences

The questions included in the professional development modules were designed to encourage teachers to reflect on their practice, share their challenges and successes, and to provide new ideas from peers.

High fidelity teachers: High fidelity teachers posted reflective responses that evaluated their practices, highlighted challenges, and shared ideas with others on the discussion board for helping their students.

That is an area I need to work on too. I tend to like things a little too quiet sometimes! I have definitely seen the kids learning a lot for each other this year. For this to really be successful they need to be able to talk to each other.

I agree with this reflection. One of the challenges of having the students work in small groups is that when I look over and see that the work is not going as I had planned, my initial reaction is to run over to the students and "help" them fix it. I need to learn to give them time to work through issues on their own.

When reading this post it really helped me realize that if I conducted number talks on a regular basis, I would reinforce and practice these key skills constantly.

All three responses begin with the acknowledgement of having read another teachers' post, thoughtfully considered the ideas presented, followed by describing their challenges and a plan to adjust instruction. The plans include allowing more discussion between students even if the volume tests the teachers comfort level, allowing more time for students to think through problems, and implementing math talk more consistently. These ideas are reinforced in the professional development and seem to be becoming part of the mathematics routines of high fidelity teachers.

Low fidelity teachers: The low fidelity teachers did not include any posts that included reflective thoughts or ideas regarding the professional development or the use of the *AMC Anywhere* system. While these teachers may have had successes or struggles they did not include them. Discussion posts were simply just a presentation of factual information.

Focus on Student Learning

Teachers varied in their comments about their focus on student learning. The goal of the APLUS project was to improve student learning by supporting teachers' use of formative assessment processes. High fidelity teachers wrote in-depth responses about student learning, while low fidelity teachers did not mention student learning in detail.

High fidelity teachers: High fidelity teachers continued to complete all three online professional development modules and included many posts that emphasize the benefit of using the assessments and noticeable student growth. The observation of student growth may be one of the factors that contributed to the teachers' fidelity to the program.

I completely agree. My students are much more fluent within 10 and 20. AMC really proves to work!

Kathy has changed math workshop for my students as well. I feel more informed and am challenged to meet the needs of my students who still aren't performing at grade level. The tools from Kathy Richardson that I have implemented have strengthened math work time for my students and I can see a difference from the growth they are making. Last year it was hard to see growth. Classroom observations are now spent seeing how students are growing and using the terminology and thinking about math more.

I have seen so much growth already, and I am excited to watch them learn and experience math through differentiated workshop.

My students have achieved so much more! They are fluent within 10. Most of my students are even fluent within 12. They have grown so much since the beginning.

I have found that some of my higher level thinkers sometimes try to out think each other! They hear somebody else's strategy that was the same one they actually used too. Then they try to come up with another strategy that becomes more complicated than the original strategy.

I am seeing improvement all around. My struggling students have been able to master fluency within five and are almost there within ten.

As noted earlier the responses of the high fidelity teachers show a level of enthusiasm for the project and especially the growth they are experiencing with their students. They are reflecting on the way students are developing and how they are interacting with one other. The responses include growth in the area of fluency, using mathematical terminology, and problem solving strategies. The first response indicates this particular teacher found identifying growth and progress with students' number sense to be a challenge the year before and AMC Anywhere has made a positive difference. The teacher continues to note that the data on student growth has allowed her classroom observations to take on a new focus. Their responses indicate they are invested in the professional development and following implementation with reflection

Low fidelity teachers: The low fidelity teachers' mentioned some information about their use of data and students' growth. However, their responses lacked the specificity and enthusiasm presented in high fidelity responses.

The Kathy Richardson assessments allow me to ability group my students based on specific skills and with specific numbers to review. I've always had flexible grouping, but for many skills, the groups would stay the same. Now that I have more data to support my grouping decisions, I truly have had more movement between groups depending on the skill we are working on and those that a child needs more practice or has mastered and is ready for a higher number or greater challenge.

Kathy Richardson has allowed me to change the way that I use data in my classroom as it really organizes student performance based on specific skills.

The focus of both responses is primarily on grouping students. The first response alludes to groups having greater flexibility than prior years due to the data offering more insight into the student learning. It is assumed that movement of students to different groups is a movement of growth due to an increase in their understanding. The response lacks details to better understand how the groups are created, how the data influences the grouping, and how impactful the program has been on student growth. The second response also focuses on organization of students by their performance on specific skills, but does not include a description of student growth.

Examining Teachers' Responses to the Summer Survey

The paired t-test analysis of the pre and post survey indicated both the high and low fidelity teachers had mean scores that moved more towards student centered practices in the classroom; however, the difference in mean scores from pre ($M = 3.26$, $SD = .11$) ($M = 3.05$, $SD = .31$) to post ($M = 2.96$, $SD = .36$) ($M = 2.73$, $SD = .74$) for each group were not statistically significant ($t(4) = 2.10$, $p > .05$)($t(4) = .79$, $p > .05$). The survey included a small section on assessment goals, both the high and low fidelity groups mean scores went up from pre ($M = 3.26$, $SD = .11$) ($M = 3.16$, $SD = .55$) to post ($M = 3.76$, $SD = .79$) ($M = 3.84$, $SD = .74$)indicating they gained self-efficacy in their ability to use assessment with their students. The increase was not statistically significant for either group ($t(4) = -1.77$, $p > .05$) ($t(4) = -1.43$, $p > .05$). Hence, there was no empirical connection between teachers' implementation of the professional development with fidelity and their responses on the survey at the end of the 40-hour summer experience.

Summary of Differences between High Fidelity and Low Fidelity Teachers

The data analysis of discussion board posts indicated that teachers who used the AMC Anywhere system and related instructional activities with a high degree of fidelity resembled specific characteristics. High fidelity teachers organized their classroom in a flexible manner in which the learning environment had structure but could be modified to best meet the academic needs of their students. Further, high fidelity teachers espoused a belief that the data from the *AMC Anywhere* system was beneficial to them, and could be used with other data sources to help them make effective instructional decisions. High fidelity teachers also discussed the growth they were seeing in their students and the benefits of making data-based decisions in their classroom. Lastly, high fidelity teachers wrote more reflective comments about their experiences, and posted comments in which the reaffirmed and supported their peers on the discussion board posts.

DISCUSSION

The findings from this study highlight the differences that exist between a high fidelity teacher and a low fidelity teacher. Ideally, professional development is planned with the goal of creating high fidelity teachers that are effectively implementing the learning tool to address student learning in a meaningful way. The factors pertaining to in the classroom practices, out of the classroom practices, and student progress were where we found differences between high and low fidelity teachers. These findings warrant further discussion.

In Classroom Factors

Several objectives included in the professional development were centered on implementation of the AMC Anywhere web-based formative assessment and creating a learning environment that would allow the data to be used effectively.

Learning environment: The professional development provided participating teachers with instruction for using the AMC Anywhere program and materials were provided to help teachers connect the formative assessment data directly to the learning environment they would create for their students. Linking formative assessment data with instructional practices has been shown to produce gains in student learning (Polly et al., 2014; Black & Wiliam, 1998; Wiliam, 2007b).The first module of the professional development revealed high fidelity teachers had structure and routines that were fluid and adapted based on data. Their responses indicated they implemented the strategies discussed in professional development and were directed by student data.

Implementation: The AMC Anywhere program is designed for students to be regularly assessed. Formative assessment collected and analyzed at the individual level consistency produces significant gains in student learning (Fuchs &Fuchs, 1986). The APLUS teacher participants were required to assess students at least three times during the school year. The high fidelity participants adhered to and exceeded this requirement. Their discussion responses throughout the on-line modules showed they valued the data and it became instrumental in designing their classroom and instructional strategies. Low fidelity teachers struggled to meet the requirement and in most cases assessed their students only once. Formative assessment research affirms that consistent assessment that produces data that directly impacts practice is essential for increasing student growth (Black & Wiliam, 1998; Wiliam, 2007b).

Student growth: The professional development supported the implementation of AMC Anywhere formative assessment, provided teachers with additional learning materials, and illustrated ways to facilitate a learning environment that is flexible to student needs. These objectives were intended to increase students' growth in their mathematical thinking. The high fidelity teachers used the assessment consistently and used the data in their instruction. This was evident in the AMC Anywhere data and their online posts. Their posts indicated they were seeing their students grow in their number sense and with specific skills. Low fidelity teachers responded in less specific terms and in some cases failed to mention student growth. Formative assessment research suggests regular assessment produces growth (Black & Wiliam, 1998); therefore the inconsistency of low fidelity teachers may have impeded their ability to see growth with their students. Future research studies need to examine how professional development can further assist teachers in connecting data to a learning environment that promotes student growth. This may occur through mentorship between high fidelity teachers and low fidelity teachers to create a more specific network of support.

Out of Classroom Practices and Factors

Several out of classroom practices and factors were identified during the data analysis process. They include teachers' use of data, collaboration with colleagues and their reflective practices.

Use of data: The goal of the APLUS project was to support teachers' use of the *AMC Anywhere* formative assessment system to collect data on their students' mathematics understanding and then use the data to make sound instructional decisions. High fidelity teachers used the *AMC Anywhere* consistently and reported specific details in their discussion board posts about how they were using their data to make instructional decisions. Low fidelity teachers did not talk specifically talk about the use of *AMC Anywhere* data. However, in some cases these teachers did mention other data sources, such as district-wide assessments or curriculum-based assessments.

Research indicates that teachers' use of data collected for formative assessment processes directly indicates student learning (Wiliam, 2007b; Black & Wiliam, 1998). Further, teachers who do not effectively use formative data to make instructional decisions are missing a potentially rich opportunity to modify and differentiate instruction based on students' academic performance (Wiliam, 2007b). It is imperative that future studies examine how exactly teachers are using their data sources to make instructional decisions, as well as what factors teachers possess in order to effectively conduct formative assessment processes (Martin & Polly, 2015; Polly et al., under review).

Collaboration: High fidelity teachers used the online discussion forum as a tool to collaborate and interact with their colleagues. The comments made by high fidelity teachers spoke consistently about their thoughts and experiences, and also affirmed or offered suggestions to their peers on the discussion forum. All teacher-participants in this project collaborated on mathematics instruction weekly with their grade level teams, but the high fidelity teachers extended their collaboration using the discussion posts. The low fidelity teachers, however, did not post in depth responses to each other and did not seek out collaboration.

One possibility for the low fidelity teachers' lack of evidence of collaboration was that they may be working in a school that lacks collaborative efforts around the use of the *AMC Anywhere* system. Research studies on programs that embody LCPD found that teachers are more likely to implement new knowledge and skills from professional development if they have school-based support and collaboration from their peers (Polly, 2006; Polly & Hannafin, 2011; Heck et al., 2008; Loucks-Horsley et al., 2010).

Individuals who design online asynchronous professional development programs need to intentionally think about ways to increase teachers' collaboration with others. Further, subsequent research studies should examine the design and influence of online professional development projects that seek to improve the amount of collaboration between teacher-participants.

Reflective practices: Low fidelity teachers simply stated facts and did not post reflective comments about their instruction, their use of the *AMC Anywhere* system, or students' learning. High fidelity teachers, on the other hand, shared reflections about their students' growth, their experiences using the formative assessment system, and their experiences making data-based instructional decisions. Additionally, high fidelity teachers demonstrated reflective practices as they shared how they reflected on their student data to differentiate instruction.

LCPD research supports professional learning activities in which teachers complete classroom-based work and then reflect on their experiences as well as the impact on student learning (Loucks-Horsley et al., 2010). Formative assessment processes require teachers to be reflective about their students' performance, their data sources, and how student learning has been impacted by previous instruction (Wiliam, 2007a, 2007b). Future online LCPD projects should continue to look for ways to support and scaffold teachers' use of reflective practices. This could occur through more structured activities that require teachers to collect data followed by a series of tasks that promote analysis and reflection about the data.

CONCLUSION

This chapter closely examined the teacher participants in a professional development project, Assessment Practices to Support Mathematics Learning and Understanding for Students *(APLUS).* The teachers participated in the summer professional development and completed a survey related to their teaching practices and goals for assessment. At that point in the project the differences between participants were difficult to discern and there were not statistically significant changes in the pre post means; however, as the project progressed the on-line modules and assessment data revealed teacher participants that were considered high fidelity and those that were low fidelity. The high fidelity teachers exhibited several characteristics that seemed to show they were fully engaged and actively using the AMC Anywhere program and instructional supports to the benefit of their students. Low fidelity teachers exhibited a sense of being overwhelmed and discontinued their engagement in the on-line professional development and limited their use of the AMC Anywhere formative assessment. Some implications of this study are to include more structured activities with tasks that increase analysis and reflection, identify high fidelity teachers and find ways to give them leadership and mentorship roles, and increase support for teachers that begin to show low fidelity characteristics. Future research that examines how teachers use data in their instructional decisions, the factors of teachers that are effectively using formative assessment, and how online professional development should be designed to foster collaboration and teacher support is essential.

This particular study used data produced from an internet based PD and formative assessment usage reports. This provided insight into the effect of PD on participant practices; however, it is difficult to discern between what teachers reported in reflections and their actual behavior. This limitation has been noted by the researchers and the third year of the grant includes observations that will be used as our research continues.

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