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Examining Elementary School Teachers' Perceptions of and Use of Formative Assessment in Mathematics

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Abstract

Formative assessment and related processes continue to prove to be a high-leverage instructional practice that has potential to support all learners, especially those who demonstrate misconceptions with significant mathematics concepts. Teachers use formative assessment practices in varied ways and share different perspectives of the value of these assessments for student learning. This article will share survey results of 65 teachers across grade levels. Findings indicate teachers find formative assessment beneficial for identifying gaps in learning, offers opportunity to increase student learning, and supports their teaching practices. These results support prior research; however, there were notable findings that offer insight into improving the use of formative assessment. The survey showed that formative assessment was used primarily to identify gaps, but not used to identify strengths of the learner. Formative assessment prompts focus on the learner but does not include reflection of the efficacy of the tool that was used or instruction. Commercially created materials, a large expense for schools, was not identified as useful. Teachers identified barriers to using formative assessment. Implications for improving formative assessment practices are shared and continued research.

Keywords:

Assessment, Differentiation, Digital Instruction, Elementary Education, Formative Assessment, Mathematics Education

Introduction

Learning Differences in Mathematics

In mathematics data from large-scale assessments continues to suggest that large gaps exist between students who are able to solve mathematical tasks and reason proficiently from those students who demonstrate opportunities to further develop and grow in their knowledge and understanding of mathematics topics (Institute for Educational Statistics, 2009; National Center for Educational Statistics, 2020; Organisation for Economic Cooperation and Development [OECD], 2019). On the large scale United States National Assessment of Educational

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Progress (NAEP) assessment, fourth grade data has improved in general over the last 20 years, the gap between students' scores as well as the percentage of students who do not perform at the Proficient Level. For inclusion in this special issue on atypical learning in elementary school mathematics we provide an overview and findings of an investigation on teachers' use of formative assessment practices since formative assessment has been empirically shown to be a high-leverage teaching practice to support the mathematical development of all learners regardless of their abilities and backgrounds (Hattie, 2009; NCTM, 2014; Polly et al., 2016). While atypical learning and learning differences often eludes to children who have been identified as those with special or exceptional learning needs, we posit that all mathematics teachers should be adept and familiar with practices related to formative assessment which includes the process of assessing students, analyzing data, and determining subsequent instructional steps based on the data (NCTM, 2014; Polly et al., 2016; Polly et al., 2018).

Formative assessment is designed with the intent to understand the learner and use this understanding to provide instruction that is specific, but without a focus on ranking or ability grouping (McNeill & Polly, in press). Black and Wiliam (1998) highlight that the appropriate use of formative assessment is when the design and use culminate around student learning. Effective formative assessment practices include opportunities to use feedback, extend thinking, reveal reasoning, create goals, and engage in peer assessment (Baroudi, 2007; Black, Harrison, Lee, Marshall, & Wiliam, 2004; Heritage, 2007; Huinker & Freckmann, 2009; Polly et al., 2017). Formative assessment serves as a tool to address learning needs of students; however, these needs are not limited to challenges or misconceptions but rather the needs of the students holistically.

Background of Formative Assessment

The use of formative assessment has become common in classrooms as educators seek ways to use assessment data to differentiate instruction (Johnson, Sondergeld, & Walton, 2019). In their seminal work, Black and Wiliam (1998) describe formative assessment as teaching and learning activities that are adapted to meet student needs based on feedback received from students. Formative assessment supports the recursive feedback loop of instruction, assessment, analysis, and goal setting (Conderman & Hedin, 2012). The goal of formative assessment is to allow teachers to obtain systematic evidence about student thinking during instruction and to use those data to adjust and adapt instruction to meet individual students' needs. (Confrey, Toutkoushian, & Shah, 2019; Johnson, Sondergeld, & Walton, 2019; Wilson, 2018).

Formative assessments are typically informal and are embedded within an instructional activity. Examples include observations of students, student interviews or informal question-answer activities, admit slips or exit slips, journals, classroom discussions, and short written assignments (Bahr & Garcia, 2010). Technology tools, such as interactive white boards, mobile device apps, and educational software can support the use of formative assessment while providing students with immediate feedback (Pilli & Aksu, 2013).

By contrast, summative assessments are typically administered after instruction has occurred, with the goal of evaluating how well students have mastered the content or achieved the learning objectives (Bahr & Garcia, 2010). Summative assessments may take the form of a final exam, report card grades, or a large cumulative project. They may be used to evaluate school-wide goals or program effectiveness (Conderman & Hedin, 2012). Because they are administered at the end of a term or unit of study, summative assessments do not provide data that teachers can use during the learning process to adjust instruction (Garrison & Ehringhaus, 2007). Summative assessments are sometimes referred to as assessments of learning, while formative assessments are assessments for learning (Johnson, Sondergeld, & Walton, 2019).

Frameworks for Formative Assessment

Wiliam and Thompson (2007) suggest a formative assessment framework in which teachers implement the following practices:

- Explain to the students the learning objectives and the criteria for meeting those objectives.
- Facilitate effective discussions that provide students with opportunities to demonstrate their understanding of concepts and to ask questions about concepts that need further clarification.
- Provide ongoing feedback to students to advance their learning.
- Encourage students to serve as instructional resources for one another.
- Encourage students to take ownership of their learning.

Andersson and Palm (2017) expanded Wiliam and Thompson's framework to include three dimensions of the formative assessment process:

Dimension 1: Identify students' current understanding of the topic to be studied; identify the learning objective; develop a plan for moving students toward that objective.

Dimension 2: Establish the role of the teacher, peers, and learners in the formative assessment process. Keep in mind that all students are both learners and peers. The teacher may, for example, encourage students to serve as resources for one another and to monitor their own learning.

Dimension 3: Differentiate ways of implementing formative assessment in terms of the length and frequency of the formative assessment cycle. Teachers may consider how often instructional practices will be adjusted based on formative assessment data, as well as the amount of time taken to adjust instruction based on the formative assessment data (Anderson & Palm, 2017).

For example, short formative assessment cycles can occur within and between lessons, daily or weekly; medium formative assessment cycles can occur within or between instructional units (NCTM, 2007).

The Impact of Formative Assessment on Student Learning

Formative assessment correlates positively with student achievement (Andersson & Palm, 2017; Black & Wiliam, 1998; Furtak, et. Al., 2016; Hattie, 2009; Kingston & Bash, 2011). Klute, Apthorp, Harlacher, & Reale (2017) note that an analysis of 23 studies, all of which applied systematic, rigorous, scientific procedures, showed that students who participated in formative assessment performed better on measures of academic achievement than those who did not. Formative assessment used during mathematics instruction was found to have larger effects than formative assessment used during reading and writing instruction. In mathematics, both student-directed formative assessment and teacher-directed formative assessment were found to be effective.

Similarly, Yeh (2009) found a strong relationship between teachers' instructional adjustments based on formative assessment data and increased student achievement. Specific formative assessment strategies have been found to support student learning. Those strategies include peer-assisted learning (Rohrbeck et al., 2003), self-assessment using rubrics (Panadero & Jonsson, 2013), and self-regulated learning (Dignath & Buttner, 2008). Formative assessment was found to be more effective when teachers provided students with immediate feedback and made instructional adjustments early in the learning process based on formative assessment feedback. Early recognition of and response to learner needs through formative assessment analysis has been found to be important in preventing struggling elementary students from falling further behind their peers (Baumert et al., 2012; Conderman & Hedin, 2012).

While researchers broadly agree that formative assessment can promote student learning, more research is needed on specific formative assessments that are most effective (McMillian et al., 2013; Yan & Cheng, 2015). Dunn & Mulvenon (2009) note the difficulty in identifying best practices related to formative assessment, given the wide range of assessments available. This is particularly true for the application of formative assessments in mathematics education (van den Berg et al., 2018). Currently, there is much pressure on teachers to prepare students for high-stakes, summative assessment (Yan & Cheng, 2015). Formative assessment, then, tends to be viewed as an extraneous task, rather than as an integral part of teaching and learning (Coffey et al., 2011). Research is needed on how best to prepare teachers to implement effective formative assessment.

Research Questions

This study was guided by the following research questions:

RQ 1: What are elementary school teachers' descriptions of formative assessment in mathematics?

RQ 2: What benefit do elementary school teachers report about formative assessment in mathematics?

RQ 3: What barriers do elementary school teachers report related to formative assessment in mathematics?

RQ 4: What resources do teachers find useful for conducting formative assessment?

RQ 5: How does formative assessment help teachers differentiate mathematics instruction?

Methods

Participants and Procedures

To answer the research questions, we created an online survey using SurveyShare that included both Likert scale and open-ended items. Once the survey was created, we had the survey read by two elementary school teachers to make sure that the questions were clear and understandable.

Participants in this convenience sample were recruited to complete an online survey based on e-mail messages to the authors' current and former students as well as social media postings on Twitter and Facebook. Sixty-two participants completed the survey, 53 of whom identified themselves as elementary school teachers. Table 1 describes the grade level taught by the participants at the time that they completed the survey.

Table 1

Grade Level of Participants

Grade	Number of Participants
Kindergarten	3
Grade 1	6
Grade 2	9
Grade 3	6
Grade 4	9
Grade 5	20

Data Analysis

In order to answer the various research questions multiple processes were used in this mixed methods study (Johnson & Onwuegbuzie, 2004). Research question 1 was analyzed by a thematic open-coding process of participants' responses to the survey question, "Describe in a sentence what formative assessment means to you related to teaching mathematics." Responses were coded based on participants' response and then responses were sorted and organized by code.

Research question 2 was analyzed by calculating the percentage of participants that strongly agreed, agreed, disagreed, and strongly disagree to four statements on the survey. Percentages were also calculated for research question 4 to find what resources teachers found very useful, useful, somewhat useful, not useful, or not applicable. For research question 2, 3, and 5 open ended survey questions were also analyzed using a thematic open-coding process of participants' responses (Miles et al., 2019). Once the data was coded themes were generated. Those themes were then confirmed by revisiting the original open-ended survey responses.

Findings

RQ 1: What are elementary school teachers' descriptions of formative assessment in mathematics?

Table 2 provides the codes and frequencies of each of the codes related to the survey question, "Describe in a sentence what formative assessment means to you related to teaching mathematics." The most frequent codes from participants were that formative assessment was used to assess learning (35, 66.04%) and that it can provide an informal check for understanding (35, 66.04%). The assess learning code was primarily found in older grades and was mentioned by 77.14% of participants who teach in Grades 3-5 compared to only 44.44% of participants who teach in Grades K-2. The code that formative assessment provides an informal check for understanding was mentioned by 83.33% of the participants who teach in Grades K-2.

The analysis of participants' responses showed that teachers believe formative assessment is embedded throughout classroom instruction to gauge student learning and used to drive instruction. Responses included "helps me better understand what students know prior to teaching a new concept", "means giving a 1 question exit ticket to see who understands and who is still struggling", "On-going, daily observations" and "Formative assessment gives me feedback on the instruction that has taken place in my classroom."

These responses indicate teachers employ formative assessment prior, during, and at the end of instruction to assess students' understanding. Their responses also show formative assessment is used to improve instruction with examples such as "help to guide me in the instruction", "Reteach immediately for misconceptions", and "any data used to drive instruction." These responses represent the non-linear relationship between gathering formative assessment and teaching. There were however, two responses "End of Unit test" and "Observations, quizzes, tests, assessment activities" that were considered outliers as one refers to a summative assessment and the other response blends summative and formative assessments.

RQ2: What benefit do elementary school teachers report about formative assessment in mathematics?

The survey includes questions where teachers indicated their level of agreement or disagreement. Table 3 shows teachers' perceptions of the benefits of formative assessment.

Table 2
Codes for Participants' Description of What Formative Assessment Means

Code	Frequency in Grades K-2 (18 participants)	Frequency in Grades 3-5 (35 participants)	Total Frequency (53 participants)
Assess learning	8 (44.44%)	27 (77.14%)	35 (66.04%)
Differentiate instruction	10 (55.56%)	9 (25.71%)	19 (35.85%)
Inform or drive instruction	8 (44.44%)	13 (37.14%)	21 (39.62%)
Informal check for understanding	15 (83.33%)	20 (57.14%)	35 (66.04%)
Supports summative assessment (high-stakes tests)	0 (0%)	2 (5.71%)	2 (3.77%)

Table 3
Formative assessment survey statements

Survey Statements	Strongly Agree	Agree	Disagree	Strongly Disagree
Formative assessment in mathematics benefits my teaching.	44	8	1	
Formative assessment in mathematics increases my students' learning.	36	15	2	
Formative assessment in mathematics provides me with more opportunities to increase my students' learning.	42	10		1

Almost all elementary school teacher-participants reported that they found formative assessment to be beneficial and that it increases opportunity and learning for students. One fifth grade teacher responded that they disagree that formative assessment is beneficial and that it increases student learning. The same participant strongly disagreed that it provides more opportunities for the teacher to increase students' learning. One fourth grade teacher disagreed that formative assessment increases students' learning but agreed that it was beneficial and created more opportunities.

The open-ended response revealed more specific details about the benefits perceived by participants. The responses showed that teachers find that formative assessment allows them to be responsive to students' needs in the moment and plan accordingly. Responses included "pinpointing specifically what tools a student needs to master a standard", "teachers can meet students where they are and help them grow", "what to teach next", and "knowing the next steps." Responses like this example "guide to formulate small groups and what gaps students are missing" were consistent, teachers' noted formative assessment helped identify gaps, misunderstandings, and misconceptions. The idea of identifying students' strengths through formative assessment was not stated.

RQ 3: What barriers do elementary school teachers report related to formative assessment in mathematics?

One of the survey questions asked the teachers what disadvantages/barriers are there to formative assessment in mathematics? There were several responses related to lack of time: "Time to analyze/grade", "Time to create", "Time away from other activities", "Adds to already packed testing", and "Disadvantages - there's already a lot of testing so even though the formative assessments can be quick... It's still another thing to get done and squeeze in." Although teachers perceive formative assessment as beneficial as shown in responses to research question one, there remains concerns about time used in the classroom. In the data there were a few responses such as "There are no disadvantages" and "none" showing consistency between finding formative assessment beneficial and without barriers. There are several responses that provide insight into this difference.

Teachers shared their descriptions of formative assessment and there were differences in their responses that provided more context in the responses for barriers.

- I think the only drawback is analysis of the task. A teacher must ask is this what I just taught or is it a prerequisite skill or is this asking something beyond the standard. You have to be very strategic in picking the right formative assessment.
- Most need to be created to meet the needs of that teacher. I question if it's rigorous to get an accurate measure of what the students can do.
- Creating formatives when they aren't readily available.
- Level of questioning Rigor of questions
- All math work should be seen as a formative assessment that you use to determine student learning.....there are not any barriers.
- I don't think there are any disadvantages to formative assessment. Good teachers are doing this instinctively.

The first three responses show teachers that are considering the efficacy of what they are using for formative assessment, if it is accurately assessing students' knowledge, if it is covering too much content and how rigorous it is. These responses indicate that teachers search for and create material to assess their students. The last two responses show a perception of formative assessment that is less formal and already built into the classroom. The last responses indicate that formatively assessing students is instinctive. These responses provide insight into why a portion of participants find time for creating and analyzing formative assessment to be more of a barrier than others.

A few responses discussed barriers/disadvantages from the vantage point of how formative assessments are used.

- Teachers might dwell on student deficits -teachers might engage students in more low level tasks if specific areas are identified -teachers might spend more time isolating skills and less time helping students seeing connections between concepts -grouping students by perceived ability can be an equity issue -grouping students by perceived ability can lead many students to disassociate themselves from mathematics
- Time - to both effectively implement assessments AND analyze, brainstorm, and plan for instructional activities. Easy to fall into pairing/grouping of students with similar misunderstandings and strengths which limits student potential for growth.

These responses discuss the possible pitfalls of readily using formative assessments. As noted in research question two the idea of formative assessment being used to identify strengths was not mentioned and in the first two responses the idea of becoming overly focused on students' deficits may result in restrictive instruction and groupings that limit growth.

RQ 4: What resources do teachers find useful for conducting formative assessment?

The survey asked teachers to describe their experiences using the following materials to support

January 2022, Volume 14, Issue 3, 417-425

formative assessment in mathematics: teacher created resources, resources created by a district or school leader, commercially made resources, online resources, digital tools used only to assess students, digital tools used to instruct and assess students. The survey also asked teachers to describe the use and usefulness of the following: commercially made resources (textbook, curriculum), digital instruction on a computer or iPad, teacher-led small groups on current grade content, teacher-led small groups on previous grade content, online resources, and 1 on 1 teaching or tutoring. Table 4 show the breakdown of responses by percentage.

Teacher-led small groups in current content, 1 to 1 teaching or tutoring, and teacher created resources are highly valued and considered useful across the participants. Less than half of the participants view commercially made resources useful. These responses align with participant responses to previous questions that suggest teachers take time to create formative assessments that match their specific needs.

RQ 5: How does formative assessment help teachers differentiate mathematics instruction?

This research question examined participants use of formative assessment data to differentiate their mathematics instruction The previously discussed research questions revealed differences in what teachers consider formative assessment, their benefits, and the barriers. The responses here also showed differences in how the data from formative assessments impacts the learning environment.

Responses were coded as grouped based on level or misconceptions, no grouping, and flexible grouping. The responses were mostly split between grouping by level and flexible grouping with only a few noting that they do not group their students stating "We do not group students using assessment data" or "I typically do not group my students in mathematics. I feel that all students can benefit from the discussion we have at all levels. "The teachers that grouped by level or misconceptions responded with statements such as:

- Students receive instruction in the strategies they are lacking during small group.
- We use group rotations within my group.... each group meets with me.... my lower-level students get a reteach, whereas my higher-level students are taught higher levels of math materials.
- Students are re-taught the lesson, or they are assessed to see what mathematical skill they have not mastered. We try to find what student is missing in his/her math skills so those gaps can be filled.
- Grouping with FA allows students to go above and beyond their learning because they aren't "held back" from the slower learners who need more practice. I can water it down or juice it up depending on the level of knowledge for each group.
- It normally means that those who "get it" - can work solo or in a group on a math group project (still related to what we are doing) - while the others work on something a little.

These responses indicate support for the perception of formative assessment as a tool to find areas of challenge and remediate based on those targeted needs. The responses show students are identified as higher or lower and are grouped accordingly. The last response alludes to a watered-down curriculum based on formative assessments.

There were distinctions made in the responses coded as flexible grouping. Some examples of those responses are:

- My groups are fluid - so if they quickly master the skill, they are moved into a different group. The groups are always changing and the children LOVE it!
- When using data to group students, we may do it in a variety of ways. Sometimes we may group students based on the strategies that they

Table 4

Participants Perceived Usefulness of Resources for Formative Assessment

	Teacher-created resource	Resources created by a district or school leader	Commercially-made resources	Online resources	Digital tools used only to assess students	Digital tools used to instruct and assess students	Commercially made resources (textbook, curriculum)	Digital instruction on a computer or iPad	Teacher-led small groups on current grade content	Teacher-led small groups on previous grade content	Online resources	1 on 1 teaching or tutoring
Very Useful/ Useful	91%	63%	49%	72%	58%	62%	48%	60%	92%	76%	79%	89%
Somewhat Useful	6%	19%	37%	19%	22%	18%	26%	26%	2%	6%	15%	3%
Not Useful	0%	6%	9%	3%	9%	8%	9%	6%	0%	9%	3%	2%
N/A	3%	12%	5%	6%	11%	12%	17%	8%	6%	9%	3%	6%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

are using. Sometimes we may group students based on a common need. Sometimes we may group students together heterogeneously, so that the thinking of students can nudge the thinking of the whole group or help students to see connections.

- My groups are super flexible, I always work in small group so they see it like something j We typically employ differentiation strategies that allow students to use their strengths, not assume competence and group based on trailing data. A focus on equity means WE need to see all students as capable and provide opportunities that have multiple entry points. We monitor student efficacy and have professional discussions about student identities towards mathematics. Just normal.
- So this differentiation doesn't always result in student grouping of students with like misconceptions or strengths. FAs (formative assessment) allows me to see where some students are struggling, and others are progressing. It pushes me to examine at how I am delivering the content and how it is being received by my students. Sometimes it means reteaching... sometimes it means pairing students with different strengths and misconceptions to help them progress through the problem-solving aspects of these math skills. It's very easy to fall into the trap of "below grade level, on grade level, above grade level" when grouping students by formative assessment data. The challenge lies in using the data to differentiate the approach and instructional activities after the assessment.

In these responses there is attention given to students' misconceptions and providing instruction that supports student growth; however, the responses indicate that the groupings are also based on strengths, use of strategies, equity, differentiation, and change often.

Another survey question asked teachers, what types of instructional activities/resources do you use for differentiated mathematics instruction. Within the responses several digital platforms were identified as a resource for differentiation. The most noted digital resources were IReady, Khan Academy, Moby Max, and Prodigy. Teachers identified country, district and state provided resources such as NC tools for Teachers and NCDPI Tasks as useful for differentiation. The three most noted instructional strategies were the use of math games, small group instruction and manipulatives for reteaching.

Discussion and Implications

This study contributes to the current literature as it provides insight into the use of formative assessment in mathematics for elementary students. There was notable variability in teachers' responses to survey questions. Research suggests formative assessment is a practice that supports mathematics learning for students of all abilities (Gezer et al., 2021; Hattie, 2009; NCTM, 2014); however, it is important to consider how formative assessment is perceived, implemented, and used by teachers. Black and Wiliam (1998) emphasize that using formative assessment correctly would be focused on student learning. With this focus as a lens there would be expected variability in the responses as teachers would be discussing implementation of formative assessment that is centered on their students and their environment. There is variability in responses that remain aligned with research on effective use of formative assessment and some that may be somewhat misaligned.

Participants responded to questions related to how they use formative assessment to differentiate instruction. Small groups were discussed by most participants. Small groups designed to reteach material based on misconceptions revealed in formative assessment data aligns with the goals of using data to support students learning and adapt instruction (Confrey, Toutkoushian, & Shah, 2019; Johnson, Sondergeld, & Walton, 2019; Wilson, 2018). It was the participant responses that conveyed a rigidness toward ability grouping that seems to veer from the recursive relationship of instruction, analysis, and goal setting described by Conderman and Hedin (2012). Flexible groups that change often allow for students to bring different strengths and discourse to their peer interactions. It also prevents students from internalizing negative perceptions of their own ability. Andersson and Palm (2017) added dimensions to Wiliam and Thompson's (2007) framework that emphasize that students are learners and peers. Students should be involved in monitoring their progress and supporting their peers.

Most participants responded that formative assessment was beneficial for student learning, teaching, and providing opportunities for students' learning. When asked to describe what formative assessment means to their teaching and to consider if there are barriers to formative assessment the responses revealed differences in implementation that may contribute to barriers. Bahr and Garcia (2010) describe formative assessments as informal activities that reside within instruction; they provide examples such as exit slips, journals, and discussion. Several participants gave these examples when describing how they implement formative assessment. One of the participants that noted observations, progress monitoring, and not using formal assessments when describing what formative assessment means to their teaching of mathematics also responded none to barriers. It appears that participants that were creating rigorous formative assessments that were more formal were also finding design, implementation, and grading to be a burden.

Over half of the participants highlighted digital instruction as very useful and specifically named IReady, Khan Academy, Moby Max, and Prodigy as platforms that were used for differentiation. Pilli and

Aksu (2013) suggest that technology tools like these offer immediate feedback. These platforms have the potential to foster formative strategies that have been shown to support student learning such as self-regulated learning (Dignath & Buttner, 2008) and self-assessment (Panadero & Jonsson, 2013). They also may address some of the barriers to implementing formative assessment that were shared by participants.

Formative assessment is focused on student learning, provides ongoing feedback, and provides teachers with insight into student thinking that should guide their instructions. It is a responsive practice rather than standardized, therefore, differences in implementation and use were to be expected. It is important to examine where formative practices deviate from the research-based framework that has shown to improve learning outcomes for all students. Responses to the question of barriers indicate there are areas teachers need support. If barriers to formative assessment are perceived as outweighing the benefit to students, teachers may choose not to engage and grow in the practice. Technology and specific platforms may be an effective part of offering support; however, they must be examined in the same way practices within the classroom are to ensure alignment with formative assessment research.

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