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Teachers' Approaches to Inquiry-focused Mathematics Teaching During the COVID-19 Pandemic in Hybrid and Online Settings

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Study purpose

There is some question about the effectiveness of online or blended approaches to formal education at the elementary level (Anthony, 2019). While the COVID-19 pandemic has posed an immense challenge to elementary school teachers, the context has provided a rich setting to unearth what these best practices might be. To understand the convergence of the online setting and inquiry teaching in mathematics, we have undertaken a study to understand how elementary school teachers have sought to teach online using inquiry-focused approaches.

Theoretical Framework

Inquiry teaching in mathematics classrooms includes approaches such as discovery learning (Tuovinen & Sweller, 1999), problem-based learning (Savery, 2006) and constructivist approaches to sense-making (von Glasersfeld, 1983). Staples (2007) suggests that there are aspects of both inquiry *into* and inquiry *with* mathematics in inquiry-focused classrooms. Thus, inquiry in mathematics classrooms encompasses, "delving into mathematical ideas and concepts and trying to understand the structure, power, and limitations of mathematics" (p. 163) and applying mathematics as a tool to make sense of world. Inquiry approaches provide students with the tools necessary to confront new mathematical challenges and do mathematics as mathematicians do.

Key to most of these approaches is that students should work to make sense of mathematical ideas and draw their own conclusions based on their collective understandings, which assumes social construction of knowledge where students learn in community with each other influenced by the local culture (Albert, 2012). Within these student collaborations, issues of status, power, and identity emerge, just as they do elsewhere in the world (Ball et al., 2005).

With the COVID-19 pandemic and ensuing emergency closing in US elementary schools, teachers have faced an even larger challenge. There is a dearth of research on best practices for elementary level synchronous classrooms (Schwirzke et al., 2018). Thus, to continue inquiry practices, teachers were tasked with designing an online classroom with little guidance from previous research. We have undertaken this study in order to address some of these questions, leaning on the teachers who have been in the field to guide our conclusions.

Methodology

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To address the research question, "What practical approaches have teachers taken to design for inquiry-based mathematics learning in an online or hybrid setting?", we embarked on a case study (Creswell, 2013) of elementary school teachers who have been teaching mathematics during the pandemic. Table 1 summarizes the context for the four participants. For this paper, we have used the date from 60–90-minute semi-structured individual interviews. An inductive content analysis (Elo & Kyngäs, 2008) was undertaken using the several definitions of inquiry learning previously provided and based on a shared understanding between the participants and researchers.

Table 1

Summary of participants and their contexts

Interviewee Number	Description of District	Years of Experience	Grade Level	Online Setting during 2020-2021
1	Large, Urban, Northeastern	0	K-2	Fully online
2	Large, Suburban, Northeastern	3	4	Hybrid: students asynchronous 2 days, in person 2 days, all synchronous 1 day
3	Small, Suburban, Northeastern	1	4	Hybrid: All students synchronous 3 days, in person 2 days
4	Medium, Suburban, Northeastern	15	4	Hybrid: Students both asynchronous and synchronous 2 days, in person 2 days, all students synchronous 1 day

Results

The following section represent some of the classroom practices teachers found useful, divided into two domains: "planning and preparation" and "instruction" as suggested by Anthony (2019). Quotations that support these conclusions can be found in Table 2.

Planning and preparation

The planning and preparation domain includes practices primarily incorporated by the teacher prior to a synchronous virtual class meeting. These include use of breakout rooms, provision of physical manipulatives, and use of editing software.

Breakout rooms gave teachers the opportunity to work with smaller groups. In the quotation, the teacher highlighted how the breakout rooms could support students who were challenged by the current topic.

While virtual manipulatives fall into the instruction category, one participant teacher designed and laminated physical manipulatives for students to use during synchronous virtual instruction.

These manipulatives both supported students to make sense of the mathematics and express the solution in the online environment.

Teachers found editing software useful for creating mathematics problem sets and designing student experiences. Teachers used this software to edit problems to meet student needs. Further, teachers used the editing software to design experiences for students to be able to manipulate problems or complete experiences like card sorts.

Instruction

Instruction practices are those that the teacher employed during the class time that centered the students' approaches to mathematics. Outlined below, these include employing online math games, virtual manipulatives, online whiteboard, and document cameras.

Though physical math games were no longer an option, teachers made use of online math games and puzzles. In the provided quotation, the teacher described how the students could have conversations about their shared experiences, even though they were playing the games individually.

We have placed the use of virtual manipulatives in this section because teachers referred to these in terms of their ease of access for students. While physical manipulative required teachers to send them to students' homes, virtual manipulatives could be accessed on the spot by students. In the provided quotation, the teacher highlighted how students could choose to use their manipulatives without needing to search for the physical equivalent.

The online whiteboard was comparable to a classroom whiteboard according to one of the teachers. A document camera was used in some instances to enable physical distancing, participation, and to allow for online/hybrid viewing.

Table 2

Supporting quotations

Domain	**Classroom Practice**	**Quotation**	**Interviewee**
Planning and Preparation	Breakout rooms	And the other kids who were struggling had to stay on with me on the camera, and I would walk them through all the problems, just like we've done in the past. Sort of the equivalent of the small table until breakout rooms really became a thing. And then, once breakout rooms became a thing a little bit more I pulled some kids into the breakout room.	4
	Physical manipulatives	And the other kids who were struggling had to stay on with me on the camera, and I would walk them through all the problems, just like we've done in the past. Sort of the equivalent of the small table until	1

		breakout rooms really became a thing. And then, once breakout rooms became a thing a little bit more I pulled some kids into the breakout room.	
Instruction	Online Games	one of the things that will do occasionally when we have them all together as a group is we'll do they call it like a puzzle talk so we'll kind of look through and see which problems, um or which games have been difficult for kids or even if they're not challenging with where a lot of kids are working right now, where they happen to be in like their journey.	2
	Virtual Manipulatives	If I didn't want to pull out the fraction circles, I could just say okay for independent today you, you know do that page, but if you want to use fraction circles, open up your Chromebooks and […] use the fraction circles on the e-toolkit. So that was nice. I definitely didn't use it as much as other teachers did. Um, but I tried to remember it's there um, because I think it's better than the physical manipulatives.	3

Conclusions

The findings from this study mirror some of the best practices that exist in inquiry learning in the face-to-face classroom setting. For example, when using breakout rooms, teachers were promoting the use of small groups, as has been extensively described in constructivist approaches (Dean & Zimmerman, 2012; Yackel et al., 1991). The use of active practices such as the use of document camera and whiteboard for students to share work promotes ideas of mathematical discourse and connecting mathematical ideas as described in Smith and Stein's (2011) seminal *Five Practices for Orchestrating Productive Mathematics Discussions*. Finally, manipulatives, which are closely tied to promoting sense-making and have been found to promote student learning (Uribe-Flórez & Wilkins, 2017), were present in both the planning and preparation (e.g., physical manipulatives sent home) and instructional (e.g., virtual manipulatives) domains.

Educational implications

Inquiry-based mathematics education can be undertaken in online and hybrid settings at the elementary level. There are, however, some caveats; teachers did not like the experience as much, they felt there was less interaction, and students needed to have access to certain devices. Nevertheless, online and hybrid inquiry approaches used in the pandemic can be extended to students who need to be out of the classroom for extended periods of time for health or other reasons.

References

Albert, L. R. (2012). Vygotsky's Sociocultural Historic Theory, A Primer. In *Rhetorical Ways of Thinking* (pp. 5–30). Springer Netherlands. https://doi.org/10.1007/978-94-007-4065-5_2

Anthony, E. (2019). (Blended) Learning: How Traditional Best Teaching Practices Impact Blended Elementary Classrooms. *Journal of Online Learning Research*, *5*(1), 25–48.

Ball, D. L., Goffney, I. M., & Bass, H. (2005). The Role of Mathematics Instruction in Building a Socially Just and Diverse Democracy. *The Mathematics Educator*, *15*(1), 2–6.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Sage Publications.

Dean, S., & Zimmerman, M. (2012). Math Groups That Make Sense. *Educational Leadership*, *69*(4). http://www.ascd.org/publications/educational-leadership/feb12/vol69/num05/Math-Groups-That-Make-Sense.aspx

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Savery, J. R. (2006). Overview of Problem-based Learning: Definitions and Distinctions. *Interdisciplinary Journal of Problem-Based Learning*, *1*(1), 9–20. https://doi.org/10.7771/1541-5015.1002

Schwirzke, K., Vashaw, L., & Watson, J. (2018). A history of K-12 online and blended instruction in the United States. In K. Kennedy & R. E. Ferdig (Eds.), *Handbook of research on K-12 online and blended learning* (2nd ed., pp. 7–20). ETC Press.

Smith, M. S., & Stein, M. K. (2011). *Five practices for orchestrating productive mathematics discussions*. Corwin Press.

Staples, M. (2007). Supporting whole-class collaborative inquiry in a secondary mathematics classroom. *Cognition and Instruction*, *25*(2–3), 161–217. https://doi.org/10.1080/07370000701301125

Tuovinen, J. E., & Sweller, J. (1999). A comparison of Cognitive Load Associated With Discovery Learning and Worked Examples. *Journal of Educational Psychology*, *91*(2), 334–341. https://doi.org/10.1037/0022-0663.91.2.334

Uribe-Flórez, L. J., & Wilkins, J. L. M. (2017). Manipulative Use and Elementary School Students' Mathematics Learning. *International Journal of Science and Mathematics Education*, *15*(8), 1541–1557. https://doi.org/10.1007/s10763-016-9757-3

von Glasersfeld, E. (1983). Learning as Constructive Activity. In J. C. Bergeron & N. Herscovics (Eds.), *Proceedings of the 5th Annual Meeting of the North American Group of Psychology in Mathematics Education* (Vol. 1, pp. 41–101). PME-NA.

Yackel, E., Cobb, P., & Wood, T. (1991). Small-Group Interactions as a Source of Learning Opportunities in Second-Grade Mathematics. *Journal for Research in Mathematics Education*, *22*(5), 390–408.