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Teacher Beliefs and Perspectives of Practice: Impacts of Online Professional Learning

Jessica Hunt [1,*], Alejandra Duarte [1], Brittany Miller [2], Brianna Bentley [1], Laura Albrecht [2] and Lance Kruse [2]

[1] Department of Teacher Education and Learning Sciences, North Carolina State University, Raleigh, NC 27695, USA
[2] Friday Institute for Educational Innovation, Raleigh, NC 27606, USA
* Correspondence: jhunt5@ncsu.edu

Abstract: Efforts to improve teachers' knowledge of tools and strategies are often intertwined with their beliefs regarding mathematics teaching and learning. Yet, few studies have examined the impact of professional development designed to bolster teachers' knowledge of and beliefs about young children's mathematical development. In this study, we evaluated whether participants' beliefs changed significantly after engaging in online professional learning on teaching math to young children, overall orientations of participants' teaching practices and shifts over time, and how changed beliefs might coincide with changed orientations to practice. We employed a multilevel mixed methods design, with quantitative results showing changes in participants' overall beliefs based on survey data. We discuss how trends in perceived instructional practices coincide with beliefs found to be statistically significant in the quantitative analysis and the potential for online professional development to influence beliefs. Considerations for design of online professional learning and implications for future research are shared.

Keywords: early childhood; mathematics; professional development; teacher beliefs; MOOC

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1. Introduction

Young children bring a wealth of informal mathematical knowledge to school [1]. Yet, differences in mathematics achievement often become evident before kindergarten [2] and are often linked to limited educational opportunities that exist for children from lower resource communities when compared to peers with increased educational means [3]. If these differences in mathematics achievement persist over time, a student's access to higher-level mathematics experiences can be impacted [4]. The teacher is the single most important school-based variable positioned to positively impact student achievement, especially in the formative years [5]. Clearly, there is a need to bolster teacher knowledge of effective ways to teach mathematics to all young children.

It is recommended that mathematics instruction should be incorporated into early childhood classrooms to support young children's mathematical development [6], and research has shown that this focus can improve young children's opportunity gaps [7,8]. Furthermore, research supports that time spent engaging children in specific mathematics activities based upon developmental progressions bolsters their understanding [8–10]. A critical step in improving learning is ensuring that teachers are afforded tools and strategies to engage young children with rich, developmentally appropriate mathematics experiences everyday [9].

Beliefs regarding the importance of mathematics learning in the early years, comfort in supporting children's mathematical development, and who holds the locus of mathematics knowledge can impact mathematics instruction in important ways [11]. Measuring how teachers' beliefs and orientations shift as a result of professional learning experiences can inform researchers about the impact of professional development programs on practice.

In this paper, we report the extent to which an online professional learning experience designed to enhance knowledge and beliefs about young children's mathematical thinking changed teacher beliefs. We also sought to understand participants' orientations in terms of their teaching practices and the extent to which orientations shifted as teachers participated in the course. In the following paragraphs, we present the theoretical framework that impacted course design and development. Next, we discuss the course content and activities, focusing on the structural components of the course as well as how recommended instructional practices were explored, implemented, and reflected upon by course participants. Finally, we present the study aims and research questions.

2. Interrelating Teachers' Beliefs, Practice, and Orientations

Beliefs act as a filter for experience and practice and directly impact attitudes of educators toward specific educational issues and topics 4012. Understanding teachers' beliefs holds implications for whether recommended or learned programs or practices are effectively taken up in the classroom and is an important aspect of educational research to inform policies and educator support resources [12]. For example, when curriculum requirements or desired classroom practices differ significantly from a teacher's beliefs, the effectiveness of the practice is diminished [13]. Achieving congruence between teachers' beliefs and recommended practice is fundamental to changing what happens in early childhood classrooms [14].

Professional development should not only include math content and curriculum, but also address teacher beliefs towards mathematics and effective mathematics practice [15]. In other words, professional development that targets both teachers' beliefs and their practices is more likely to create lasting impact as beliefs and practices are interdependent [14]. If beliefs of teachers differ significantly from perspectives of a program or recommended practice, efforts should be made to provide opportunities for teachers to reflect upon, challenge, and shape their beliefs over time. In this way, positively affecting teacher changes in pedagogy is intricately intertwined with the propensity of professional development to align teacher beliefs with recommended pedagogy. Unfortunately, teachers' existing beliefs when engaging in professional development are often resistant to change and difficult to measure [16].

Beliefs are interconnected with teacher orientations [17]. Schoenfeld's [18] theory of goal-oriented decision making supports that teachers' orientations—their "dispositions, beliefs, values, tastes, and preferences" (p. 29)—intertwine with instruction. That is, orientations can influence the practices that teachers employ in the early mathematics classroom, the way that they perceive or respond to students' thinking, or the way that they interpret and use assessment. Thus, studying changes in teachers' beliefs to understand potential changes in practice necessitates also understanding (shifts in) orientation. Researchers can measure changes in teachers' beliefs within professional development activities. Specifically, teachers can use activities provided within professional development to reconcile new understandings with prior beliefs and test out new beliefs in a learning community [19]. As a result, researchers might measure changes in beliefs through survey statements that measure beliefs before and after a development experience [20,21].

Yet, because teachers are often unaware of their orientations, it is difficult to inquire about and receive an accurate depiction of teachers' orientations directly [17]. Instead, alternate methods, such as interviewing teachers about their classroom actions or analyzing their spoken or written statements about their teaching, are often used to determine or infer orientation (e.g., see [22]). Other disciplines, such as science, used teachers' responses to promoted questions along with their "free style reflections" on course content to determine teachers' orientations (and changes therein) over the course of time [23]. Both methods suggest that analyzing teachers' spoken or written words can be used to infer their orientations, either at a point in time or over several points in time. Such a method may prove valuable in determining how orientations may shift in response to learning experiences, or in tandem with their beliefs about what it means to teach math to young children.

2.1. Teachers' Beliefs: Young Children, Mathematics, and Teaching and Learning

In this study, we focus on three out of four (Plates found four constructs on a validated questionnaire that measure teacher beliefs [11]. These constructs were found to be independent as well as interrelated. Accordingly, we use three in the research reported here.) specific types of beliefs teachers may hold about teaching math to young children (see [11]). First, teachers' ideas about the age appropriateness of mathematics instruction can impact teaching and learning of young children. Some teachers believe that mathematics instruction is an appropriate school experience in the early years, while others do not. If teachers believe, for example, that mathematics is not an age-appropriate use of instructional time, then they are less likely to engage their young students in mathematics during the school day [24]. This is important because fewer opportunities to develop mathematics early on can impede later learning—as early as PreK, children's success in mathematics is considered a strong predictor of their later academic success [2,25,26].

Second, the classroom locus of the generation of mathematics knowledge can affect the kinds of practices teachers take up in their classrooms. Research suggests that some teachers believe that children are responsible for the construction of mathematics knowledge, with the teacher taking more of a facilitative role [27]. For example, some teachers who take on this perspective may believe their job is to facilitate an overall environment that stimulates curiosity with no active teaching of mathematics. Conversely, other teachers believe that a more direct form of teaching is required to stimulate children's mathematical development, and as a result, deliberately plan ways for young students to interact with mathematics in the preschool classroom [28]. Either perspective holds implications for the mathematics experiences young children receive in school.

Third, development as a primary goal of mathematics instruction can shift how (and if) math is taught in pre-school settings. For example, some teachers do not view mathematics learning as a primary goal in the early years, focusing instead on children's social and emotional development [29]. These individuals believe that academics, including mathematics, are best saved for K-12 settings as opposed to preschool environments [30]. On the other hand, there is extensive research that reveals that young children can benefit and thrive in preschool environments that provide rich opportunities for mathematics learning [31]. Other research suggests that both social-emotional *and* academic goals are appropriate for preschool settings [32]. Given that academic disparities among young children in mathematics has long-term effects on overall development, teachers' views of the importance of developing mathematical thinking in the early years hold lasting implications [25].

Finally, teachers' own confidence in math and mathematics instruction impacts the extent to which certain practices are used and how much math is taught. In this paper, we use 'confidence' and 'self-efficacy' interchangeably. Self-efficacy refers to beliefs about one's own capacity [33–35]; high self-efficacy implies confidence, which is the term adopted by the author of the survey instrument used in this study. Research suggests that teachers with a higher degree of confidence in their mathematical ability take up contemporary teaching practices more readily than those with lower confidence. Teachers' own confidence in math and mathematics teaching can quickly become an equity issue for their young students because students identified as low achieving have been shown to experience the greatest disparities when working with a teacher believed to have lower levels of confidence or self-efficacy [36].

As mentioned above, researchers might measure changes in beliefs alongside shifts in dispositions, such as through an examination of discourse teachers have about their teaching practices as they participate in development opportunities over time. Using multiple ways to determine how changed beliefs and dispositions align, or not, with the goals and big ideas of professional development can yield important insight into whether recommended practices may become utilized in the classroom [37].

2.2. Teaching Math to Young Children: Online Professional Learning

Teaching Math to Young Children (TMYC) is an asynchronous, self-paced course organized around the Institute of Education Sciences (IES) "Teaching Math to Young Children" Practice Guide (2013) by the U.S. Department of Education's *What Works Clearinghouse*. The course is free to participants worldwide and offers the opportunity for participants to earn five additional certificate hours per micro credential, up to five micro credentials. The course begins with an opportunity to get acclimated to the learning management system, online course structure, and a forum where introductions can be made with other colleagues. Next, participants interact with five research-based recommendations from the guide presented in five course units. Each unit is structured around one recommendation and includes a common structure: *Connect* (i.e., consider mathematics activities and sample student thinking in connection with current practices and beliefs), *Engage* (i.e., explore the featured recommendation through video and written artifacts of children's thinking), *Notice and Reflect* (i.e., observe the recommendation in action and reflect on implementation of the ideas presented), *Extend* (i.e., put the recommendation into practice, or simulate how this might be done) and *Dive Deeper* (i.e., access additional information and resources). The aims, concepts covered, and sample activities for each unit are included in Table 1.

Throughout all of the units, the discussion forum was an important venue for collaboration and conversation about practice. In addition to posting their own reflections, participants responded to each other's ideas as they thought through connections between the resources they were exploring and the recommended practices in the IES guide. In the culminating activity for the course, participants used what they learned across the units to plan, implement, and reflect upon a task-based interview, a whole group lesson, and a connected small group activity. Participants provided and received peer feedback on their plans, reflected upon their beliefs about the mathematical thinking of young children, and connected it to their evolving practice.

Table 1. *Description of Course Concepts, Aims, and Sample Activities Organized by Unit.*

Unit	Focus & Concepts	Aims	Sample Activities
1	Teaching Number and Operations Using a Developmental Progression • *Subitize* • *One-to-one correspondence* • *Compare number words & quantities* • *Label collections* • *Solve basic problems*	• Engage participants in young children's mathematical thinking • Augment understanding of development • Challenge beliefs that mathematics is not age appropriate for early childhood	• Discuss instructional practice and beliefs about early math in a forum • Use a progression to analyze student thinking in videos of young children engaged in gameplay • Implement an exemplar activity with young students based on IES-guide recommendations • Reflect on student thinking observed with other participants
2	Teaching Geometry, Patterns, Measurement, and Data Analysis Using a Developmental Progression • *Recognize, name, compare, combine, and separate shapes* • *Identify, extend, correct, and create patterns* • *Make direct comparisons and use non-standard and standard measurement tools* • *Organize and represent information graphically*	• Engage participants in how young children develop these often-ignored concepts • Illustrate the power of young children's thinking • Position development (as opposed to direct teaching) as a core pedagogical mechanism.	• Observe young children as they interact with parents and teachers in videotaped exemplary activities • Discuss how development of these concepts can be interconnected • Design a game that connects with one or more concepts from the unit; implement it with young students • Reflect upon their own evolving ideas about early math instruction • Connect with other participants through discussion
3	Using Progress Monitoring and Building on Student Thinking • *Use observations to determine existing math knowledge* • *Tailor instruction* • *Assess, record, and monitor progress*	• Bolster confidence in teachers' knowledge of the progressions of concepts and the process of monitoring children's thinking	• Use data to gauge young children's present knowledge of specific content • Generate next steps for instruction • Collaboratively identify potential roadblocks to progress monitoring • Pose critical questions for discussion and reflection.

Table 1. *Cont.*

Unit	Focus & Concepts	Aims	Sample Activities
4	Teach Children to View and Describe their World Mathematically • *Support children's use of informal representations* • *Link formal math vocabulary, symbols, and procedures to informal knowledge and experiences* • *Encourage children to recognize and talk about math in everyday situations*	• Challenge participants to view children as the originators of their own knowledge • Support a vision of teaching as an explicit developmental tool to support concept learning and connections to informal and formal math ideas	• Reflect on how to help children see mathematics in a video scenario • Explore and unpack the recommendation • Observe teachers at work and reflect on how they implement the recommended practices through one of three lenses
5	Dedicate Time to Teaching Math and Integrating Math Instruction Throughout the School Day • *Plan daily instruction targeting specific math concepts and skills* • *Embed math in routines and activities in the classroom* • *Create a math-rich environment* • *Use games to teach and practice math*	• Encourage participants to find ways that math can be an integrated part of the school day • Support dedicated and purposeful instructional spaces for mathematics	• Investigate several sample classroom spaces and scenarios of practice • Make observations of how math is or is not embedded in the classroom environment • Discuss ideas for adjusting the sample educator's practice. • Explore and critique varied resources for teaching mathematics • Reflect upon how each resource makes use of opportunities to connect informal ideas to mathematical tools

3. The Current Study

Resources to augment pedagogy connected to knowledge of young children's mathematical development in the early years are widely available. Yet, few studies have examined if participation in professional development designed specifically from these resources changes participant beliefs, and how shifts in perceived instructional practices may coincide with changed beliefs. Accordingly, the aim of this study was to evaluate the beliefs of 97 participants before and after engaging in an online professional learning experience designed to bolster knowledge of children's mathematical development and developmental teaching practices. We were interested in evaluating whether participants' beliefs changed significantly after engaging in online professional learning, overall orientations of participants' teaching practices and if these orientations shift over time, and how changed beliefs might coincide with changed orientations to practice. We addressed the following research questions:

Research Question 1: How did participant beliefs, as measured by the Mathematical Development Beliefs Survey, significantly change after engaging in Early Math Online Professional Learning?

Research Question 2: What were participants' orientations toward early mathematics teaching practices as evidenced within Early Math Online Professional Learning?

Research Question 3: How do teachers' orientations toward practice shift over time? How might these shifts coincide with changed beliefs?

4. Materials and Methods

4.1. Course Context

This paper reports on one iteration of the TMYC Online Professional Learning course. Data reported on are from the pilot iteration of the course, which occurred with 847 participants using a Moodle course builder. Our aim was to make essential professional development opportunities widely available, as professional development focused on student learning and adult collaboration is indispensable to meeting the goals of effective math instruction in the early grades. The course was offered in the Fall of 2020, opening September of that year and remaining open through December 2020. As described in the review of literature, the course contained an introductory unit and five core content units. Each unit was released in the course one at a time for the first seven weeks (i.e., the introductory unit, five core content units, and a concluding unit). Within each unit, participants had opportunities for multiple means of engagement (e.g., video, audio, and text-based resources) and expression of gained knowledge (e.g., creation of materials; discussion and critique of ideas) throughout the course. Announcements were released weekly to discuss course activity and to remind participants about course activities.

The course was open to new enrollments throughout the time it was open. Participants could begin the course at any point, whether that be during the seven weeks units were actively being released or afterwards. They could also decide which units to complete and whether they would engage in or complete all or only some of the course materials. However, participants could only gain certificates of completion if they completed initial surveys upon registration (one of which measured beliefs, described below), contributed to at least one forum per unit (which provided the opportunity to apply learning by asking questions, responding to others' questions, and sharing ideas, as well as by agreeing with or expanding on peer comments) and completed final surveys at the end of the course, reporting their beliefs and providing suggestions for improving it in the future. After the course closed, discussions and other activities became 'read only.' That is, materials continued to be accessible to participants, but they could not post new entries to discussion forums, complete a microcredential, or submit artifacts for peer feedback and comment.

4.2. Participants

Ninety-seven participants who were enrolled in the TMYC online professional learning course were included in the current study. Participants were identified purposively for inclusion in the study according to the following criteria: (a) enrolled in the course (i.e., one of the 847 total enrollment), (b) completed both the pre and post survey of beliefs (described below), and (c) engaged in at least three of the five course units (although units were not conceptually similar, they had the same structure, allowing for similar opportunities for course engagement). Engagement was defined broadly and included activities such as clicking on course pages, writing posts in forums, and replying to other participants' posts.

Of those who enrolled in the course, 90.55% were female and 55.84% had master's or doctoral degrees. At course registration, participants were asked to report their primary reason for enrolling in the course. The two most common reasons, accounting for 81% of responses, were "Deepen my knowledge of course topics" and "Collect resources and tools for my practice." Several participants reported they planned to collaborate with peers while enrolled in a Massive Open Online Course (MOOC). Table 2 provides information about the course participants' educational background and work experiences.

Table 2. *Course Participants' Demographics.*

Identified Role		**Experience Level in Early Mathematics Education**		**Grade Level Specification**	
Classroom Teachers	62	No Experience	9	Pre-K	7
Curriculum & Instruction	7	Less Than 2 Years	11	Kindergarten	1
Special Education	12	2–5 Years	19	Elementary	5
School Admin & Support Staff	3	6–15 Years	41	Middle and/or High School	5
Teacher Prep	3	16+ Years	17	Post-Secondary	0
Other (e.g., parent, non-education profession)	10			Not Provided	19

Note. Percentages in this table indicate how many course participants identified themselves within each role, experience level, and grade level. Some people did not identify a grade level. The *data is based on 97 participants.*

4.3. Data Sources

Using the aforementioned theoretical framing as a guide, we examined how beliefs changed before and after engagement in TMYC, participants' orientations with respect to early mathematics practice, and orientations of their teaching practices as they engaged in the course. To gauge participants' beliefs, we administered the *Mathematical Development* Beliefs Survey (MDBS; [11]) before and after completion of the TMYC course as a quantitative measure of change. Participants provided answers to 32 items ranging from Strongly Agree (5) to Strongly Disagree (1). Of the 32 items, seven items required reverse coding such that Strongly Agree = 1 and Strongly Disagree = 5. We utilized three subscales without adaptations from the survey [11]: (a) Classroom locus of generation of mathematical knowledge (12 items), (b) Age appropriateness of mathematics as a preschool subject (10 items), and (c) Teacher confidence with classroom support of mathematical development (10 items). Table 3 highlights two sample statements from each subscale of the survey. Survey results were computed by identifying the sum of all rating scale items (range 0–160), the average rating scale score (range 1–5), and the percentage of raw score out of total possible points (range 0–100).

Table 3. *Mathematical Beliefs Survey Sample Items.*

Subscale	Sample Statements
Classroom locus of generation of mathematics knowledge	*In preschool children construct mathematical knowledge* *Teachers should show preschoolers the correct way*
Age appropriateness of mathematics as a school subject	*Math is a worthwhile and necessary subject for preschoolers* *Very few preschoolers are ready for math*
Teacher confidence with classroom support of mathematical development	*I am unsure how to support math development for young children* *Math would be easy for me to incorporate into preschool curricula*

The construct validity of the MDBS was explored through a literature review, conversations with experts, and two pilot studies which included cognitive interviews and calculations of Cronbach's alpha [11]. Following these two pilot studies, a final version of the MDBS was created from the original 71 items. Then, a validation study was conducted with 346 respondents and this final version of the survey. A one-way ANOVA compared mean scores for each dimension across three cohorts. Within each dimension, the cohort means were significantly different, indicating that respondents with varying demographics and experience in early childhood education answered the survey differently. The age appropriateness of mathematics instruction and mathematical development as a primary goal subscales were correlated, $r = 0.87$, but only one of these subscales was used in our study. Correlational analyses of the other dimensions ranged from 0.001 to 0.386. Therefore, these dimensions measure independent as well as interrelated constructs and can be used as such in scientific research. Reliability of the instrument was assessed through calculations of Cronbach's alpha, which ranged from 0.84 to 0.93 for the four belief dimensions. Overall, the MDBS has been found to be a valid and reliable measure of early childhood teachers' beliefs about mathematics instruction in the early childhood classroom [11].

We also examined participants' orientations toward early mathematics teaching practices, and shifts in orientation during course participation. Specifically, we assessed participants' discussion posts in the *Connect*, *Notice* and *Reflect, and Extend* forums that were contained within each unit. We chose these specific discussion posts due to (a) opportunities participants had to discuss and reflect upon their practice in these spaces and (b) questions posed to participants that supported their discussion of perceived practices as they related to the content of each unit. These data were collected across the five units of the course, which were organized such that participants started with unit one and continued to the other units sequentially.

4.4. Study Design and Analysis

We utilized a triangulation mixed methods design with a multilevel model approach [38] with a cross-sectional design. The multilevel model allows us to use different methods to address different levels within a system (Group—Quantitative and Qualitative; Individual—Qualitative), as shown in Figure 1. The findings from each level are merged together into one overall interpretation.

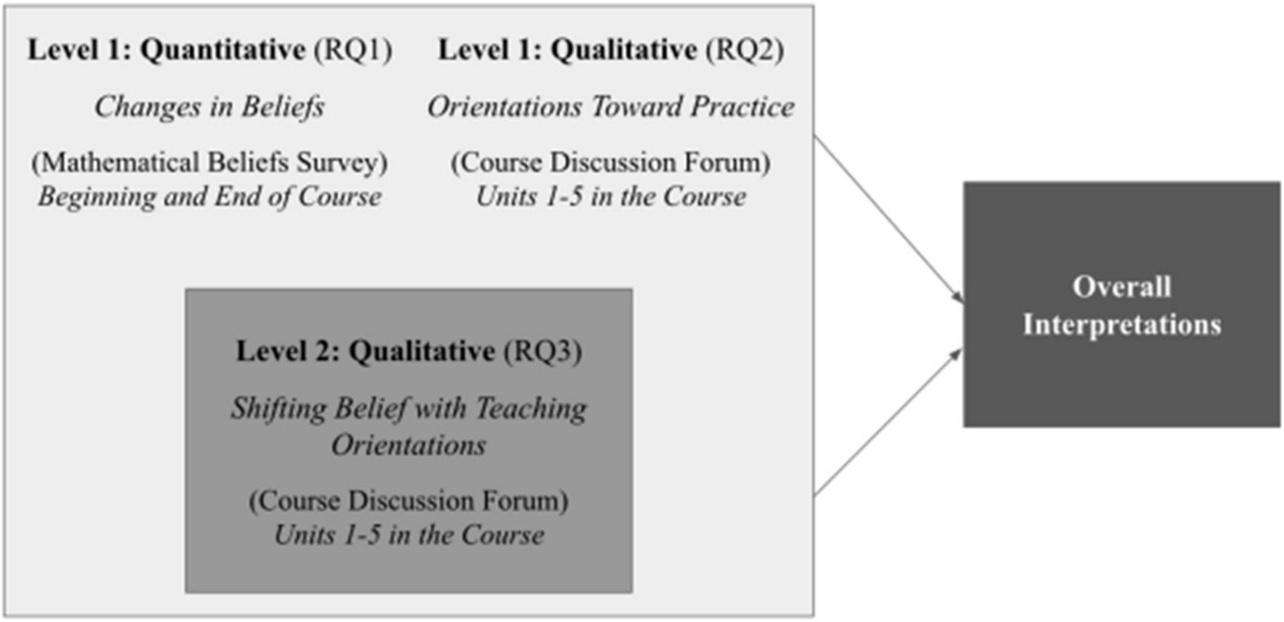

Figure 1. Multilevel Triangulation Design.

4.5. Level-One Quantitative Analysis

To evaluate whether there were changes in participants' beliefs before and after course engagement, a series of dependent sample t-tests were conducted. Specifically, changes were compared for the overall survey score as well as for each of the three subscales. Significance level was set at 0.025, corrected using the Bonferroni equation. Effect sizes were calculated using Cohen's *d* such that 0.2 is small, 0.5 is medium, and 0.80 is large [39].

4.6. Level-One Qualitative Analyses

Data from the forum posts were used to evaluate the second research question. That is, to uncover participants' orientation to early mathematics teaching practices across the course, we conducted a thematic analysis. To analyze the data, the first and second authors began by entering all forum posts into Microsoft Excel for organization and analysis. To prepare the data, forum posts were chunked into smaller, more meaningful parts (i.e., discussion strings within forums). Verification strategies for assuring reliability and validity of the findings were used. Namely, categories for analysis were generated and defined by the researchers who began by independently examining the data. For each question, the responses were reviewed for common ideas and themes related to the five effective practices in teaching math to young children [9]. These ideas and themes were used to develop an initial list of categories and analyzed using guidelines suggested by Miles, Huberman, and Saldana [40] for data analysis and reduction.

The researchers then met to negotiate a mutual set of categories, with examples for each, to assure content validity of generated themes and categories. After coding each participant using the defined categories, the researchers conferred to compare responses, further revise, and resolve differences in coding. The development of data summaries followed. Using matrices, the researchers summarized key findings for each of the categories (i.e., exposure orientation and development orientation; see results section). Conclusions from the data analyses were developed and verified. Conclusions were drawn over time and reported as they were found to be explicit and grounded [41].

Reliability, trustworthiness, and transferability of the data were established in several ways. First, reliability of the coding process was supported by the first and second author independently coding the data and then comparing findings. The data were constantly revisited until saturation was reached (i.e., until the material was not yielding any new information or patterns). Second, to ensure trustworthiness, the role of researchers in the process, the data gathering tools, and analysis procedures were explained in detail. Triangulation techniques were supported by direct quotations by the participants. Finally, to address potential bias and increase transferability, we employed detailed description, peer debriefing, and negative case analysis.

4.7. Level-Two Qualitative Analyses

For the level-two qualitative analysis, researchers focused on capturing how shifts in perceived instructional practices may coincide with beliefs found to be statistically significant in the quantitative analysis in relation to the overall themes. Researchers reorganized the data by each participant's posts across time and engaged in a second coding process, using the three beliefs that impact teacher practice in early childhood mathematics measured by the survey [11] as a deductive framework. Because the confidence subscale showed the largest effect size (and only statistically significant subscale to demonstrate pre post change), we focused these analyses here (see results section). From this coding, we identified a purposive subset of 12 participants who emerged as either 'confident' ($n = 5$) or 'not confident' ($n = 7$) (Teacher confidence with math and mathematics teaching was found to be statistically significant (see results). To be coded as 'not confident', participants had to explicitly mention a feeling or experience with teaching mathematics in which they lacked confidence in at least two of their forum posts.

Researchers next returned to the categories of *exposure orientation* and *development orientation* from the Level-One analysis. For each unit and forum response, we searched each of the 12 participants' response for clear evidence of a traditional or conceptual teaching orientation, with traditional language defined as mentions of skills, procedures, and vocabulary, and conceptual language defined as emphasizing understanding, concepts, and discourse. Depending on the language a participant used in a given post, it was possible for a post not to contain any evidence of either teaching orientation. It was also possible for a post to contain evidence from both categories.

Finally, researchers organized the data across each of the 12 participants to examine potential shifts across time. We employed classical content analysis to provide descriptive information concerning how many times participants were coded a particular way within and across the units of the online learning experience [42]. We calculated the percentages of exposure and developmental orientation instances for each participant across total instances of either orientation in all the units. In addition, we calculated those percentages for each participant in each unit. Visualizations of teacher change over time were prepared.

5. Results

In this study, we sought to evaluate if 97 participants' beliefs about mathematics learning in the early years, confidence in supporting children's mathematical development, and perspectives about who holds the locus of mathematics knowledge changed significantly after engaging in online professional learning. We also conducted an overall thematic analysis of participants' orientations of their teaching practices as well as a close analysis of 12 participants' shifts in teaching orientations and changed beliefs over time. We present the results of this leveled mixed methods study below, beginning with the level-one quantitative results on change in teacher beliefs. We then shift to level-one qualitative findings to illuminate overall teaching orientations found across the online professional learning. Finally, we discuss the level-two qualitative results, which describe how shifts in perceived instructional practices coincide with beliefs found to be statistically significant in relation to changes in beliefs in the quantitative analysis.

6. Level-One Quantitative Differences in Participant Beliefs after Online Professional Learning

We ran individual t-tests to detect whether beliefs changed significantly after participation in online professional learning. The results from the dependent samples *t*-tests are reported in Table 4. There was a statistically significant difference in overall TMYC beliefs from before to after engagement in the TMYC course; t(96) = 7.714, $p < 0.001$, with a moderate effect size (Cohen's d = 0.78).

Table 4. *Descriptive and inferential dependent samples t-test results for differences in beliefs survey scores and its subscales from pre- to post-course completion (n = 97).*

Survey Subscale	Mean Raw Score	SD	*df*	*t*	*p*	Cohen's *d* [1]
Pre Overall Post Overall	101.67 107.73	10.64 7.70	96	7.714	<0.001	0.78
Pre Locus Post Locus	34.07 34.87	6.74 5.99	96	1.590	0.115	0.16
Pre Age Post Age	29.64 30.26	2.98 2.36	96	1.906	0.060	0.19
Pre Confidence Post Confidence	37.96 42.61	7.29 5.57	96	7.600	<0.001	0.77

[1] Cohen's *d* interpretation: small = 0.2, medium = 0.5, and large = 0.80.

Given the overall significant result, we conducted further analysis to understand significant changes relevant to particular beliefs. The analysis revealed a significant change from before to after completion of the course for the confidence subscale; t(96) = 7.600, $p < 0.001$, with a moderate to large effect size (Cohen's d = 0.77). The locus and age subscales were not significantly different ($p > 0.05$). The significant differences in participants' own confidence in math and mathematics instruction led to further analysis on the individual level of how changes in confidence may have coincided with teachers' orientation to early mathematics teaching, which we describe at the group level below.

7. Level-One Qualitative Results

Overall Themes

We found two broad themes of participants' orientation to early mathematics teaching practices across their experiences in the course: (a) exposure orientation and (b) development orientation. Table 5 summarizes the indicators of each theme and its associated codes.

Table 5. *Thematic analysis of participants' early math teaching orientation.*

Theme	**Description**	**Corresponding codes**
Orientation to Teaching-*Exposure*	A clear focus in a discussion string on children's exposure to math skills, vocabulary, or interaction with skills with cognitive features, such as attention or behavior.	**Behavior; *attention; *ability to remember; * ability; *ability with vocabulary; *cognition.*
Orientation to Teaching-*Development*	A clear focus in a discussion string on children's development of mathematical ideas or understandings, or interaction with prior knowledge or stages of knowledge.	**Access;*Prior knowledge; *Concepts; *Stages; *Grow; *Connect,*Progressions*

Exposure orientation. An exposure orientation to the teaching of mathematics to young children was evident by a clear focus in a discussion string on children's exposure to or practice of mathematics, and was often also present in conversation about children's need for behavioral or cognitive components, such as paying attention. Exposure-oriented responses in discussion strings reflected a surface-level engagement with the content or unit prompt, or short, one sentence responses that did not engage deeply with the question posed or the recommendations of the practice guide.

A group of participants evidenced an *exposure orientation* during a discussion string in a Unit One "Connect" forum that asked participants to report on what concepts they noticed when engaging in a *Shell Game*, which is an online game supported via a Java applet and is designed to support young children's counting development. However, as opposed to discussing concepts, most discussion strings revealed a focus on skills or difficulties children would experience based on behavioral aspects of the game:

Participant post: "Counting was practiced in the Five Frame game. Addition and Subtraction are practiced in the other game."

Reply: "Another thing they need to be able to do is to pay attention—especially in the shell game."

Reply: "With the first game students would definitely need to listen to the directions."

Reply: "Some students may not have paid enough attention so that may be hard for them to answer the questions correctly."

Reply: "I also thought about how students had to listen carefully to what was being asked in the five-frame game, or they would get the wrong answer."

Another discussion string within the same forum and topic evidenced a deficit perspective of young students within the exposure orientation of teaching:

Participant post: "I could see younger students having trouble with the shell game. Not having the actual bubbles to count may frustrate some of them."

Reply: "It would be very confusing for primary kids to do without some help."

Reply: "I don't think the average PK or K student would be able to play these games without a lot of support and pre-teaching of vocabulary."

Reply: "I agree with you that students need to understand the vocabulary to solve the problems. If they had good memory skills they could also solve the problems without computing."

This deficit perspective was often focused on a behavioral connotation of learning as uptake. Instead of commenting on the concepts the game might support, participants instead discussed a need for young children to pay attention, behave in a certain way, remember, or recite mathematics skills they were exposed to during teaching.

Another group of participants evidenced an *exposure orientation* in Unit One during a "Notice and Reflect" discussion forum. The discussion prompt asked teachers to notice young children's concepts related to a developmental progression of subitizing and counting during an exemplar teaching video. Although participants initially responded in ways that were in line with the discussion prompt, the discussion string shifted to emphasize students' potential deficits and teachers' need to promote children to practice skills:

Participant post: "I noticed the students were able to recognize the number of items without having time to count the items. I was surprised that when the numbers got bigger, they still were able to recognize the number. I can have moments like [this] when I take time to review the skills every day. I struggled when I didn't review it for a while and the students had forgotten. My biggest obstacle would be teaching the lesson and then expecting the students to know it without additional review and practice."

Reply: "I can definitely relate to the struggle of teaching it, moving on, and expecting that the children have all just retained the information previously taught. I want to find ways to incorporate earlier lessons and learning into daily activities that can keep it fresh in students' minds."

Reply: "I completely agree we all need to review. So many students need that daily review or they won't ever transfer the info to long term memory."

In Unit three, another teacher evidenced an exposure orientation when responding to a video of a small group of children engaged in a measurement activity in a "Notice and Reflect" forum. Participants were asked to use progressions from the first two units to notice young students' concepts and suggest teaching moves to support their development. In this discussion string, participants do make linkages to the developmental progressions while also evidencing a skills and vocabulary orientation to teaching:

Participant post: "For Child 1, because she is making direct comparisons, I would model measurement vocabulary for her as she makes these comparisons. For Child 2, I would work on developing his measurement vocabulary, moving from using "littler" and "bigger" to using long, short, the same or equal. Child 3 demonstrates many of the skills in the measurement progression. He is making direct comparisons and using appropriate measurement vocabulary. He may need to acquire the vocabulary equal for the same length. Before moving to standard measurement I would work on his understanding that number words further along in the counting sequence represent larger quantities. Child 4 is beginning to make direct comparisons but needs practice and exposure to measurement vocabulary. I would continue to practice direct comparisons and using measurement vocabulary."

Reply: "I agree with you and I believe that the proposed activities provide the necessary support."

Reply: "I like the idea of helping child 2 to use the words long, short, and equal rather than little and bigger."

A final example of an exposure orientation to teaching can be seen in a Unit 3 "Connect" discussion forum post. The prompt instructed participants to watch a video of a group of children engaging in a developmental activity centered on subitizing, counting, and combining/addition. Participants were asked to notice aspects of children's thinking and connect it to developmental progressions from the previous two units. The discussion string, however, related development to exposure to next skills and seemed to focus on the child's ability to focus and answer questions correctly:

Participant post: "I tried to pay close attention to child #2 in the video. He seemed very energetic and ready to participate but I could see focus issues. After the beginning of the lesson he seemed to gain understanding or confidence in his answers, although some of his answers were off track. I would like to see if he could recognize numbers and relationships without the use of manipulatives to be able to help understand what his next skills would be."

Reply: "I totally agree that he appears to have issues with focus and attention. He was able to complete the task which actually surprised me. I think his abilities are there, he may actually be on the young side. I would suggest some one on one with him to further decide if attention was a concern for future learning."

Reply: "I agree to add to that I thought the student was intimidated by the other students' understanding compared to his."

Development orientation. In contrast, a development orientation to the teaching of mathematics to young children was evident by a clear focus in a discussion string on children's development of mathematical ideas or understandings, or interaction with prior knowledge or stages of knowledge. Development-focused discussion strings also evidenced a deeper engagement with the content/unit prompt, often portrayed through a multi-sentence or multi-round exchange of ideas that directly engaged with the question posed or the recommendations of the practice guide.

A group of participants evidenced a development orientation during a discussion string in a Unit one "Connect" forum that asked what concepts participants noticed when engaging in a game designed to support young children's counting development. In this string, participants directly attended to aspects of development promoted by the games:

Participant post: "In Game 1, the game builds children's understanding of numbers. The game brings children from enumerating the numbers they see in the frames. The first activity ensures that children are all starting on equal standing with regards to their ability to produce the appropriate numbers of counters in the frame per request. They also model different ways of asking questions to determine the cardinal quantity. This first activity builds the basis for the next activity that requires the child to fill in the frame with the correct numbers of chips. The first builds the number knowledge so that the child is able to "test" his/her own understanding with the second activity where he/she has to build the number. Building on the first two activities, the third looks at the empty spaces. The child has to determine how many more chips are needed to build a five. This activity is the introduction to addition by asking "how many more to make 5." Finally, the last of the "teaching" activities brings the child to a comfortable place of combining two sets of chips to determine how many there are "altogether" when both groups are combined."

Reply: "5 Frames is a neat short activity for later-preschoolers as they are about to transition to Kindergarten. Preschoolers still need to touch actual items and are busy learning math concepts. I think these are great ideas to use with hands on manipulatives, though!"

Reply: "I love combining to introduce addition. I think changing the colors to create two sets is a fun easy visual aid for our students to grasp the concept early on. Subitizing certainly does not allow for memorization. It is quick and fast is the key to really understanding the quantity they see."

Another example of a development orientation to teaching becomes evident in a discussion string in a "Notice and Reflect" forum in Unit one. Here, a teacher was reflecting on her practice of using progressions to better understand student thinking and how to support its growth over time:

Participant post: "One of the things I noticed was the discussion that the teacher would have to get a better understanding of the child's thought process. In one of the videos, the teacher asked the student how she remembered how many objects there were. She said,'Did it help to put two down and then add three more from there?' Having a discussion with the children as they progress through the stages really helps to identify their reasoning. I really appreciated the instruction to use everyday situations to promote math discussions, like at lunch or snack. I have struggled to promote number understanding when I look at teaching moment by moment or standard by standard rather than a progression that builds upon itself. Seeing math in an overall framework to understand where I'm going and what I need to get there is how I can efficiently put the foundation in place."

Reply: "I agree the discussions throughout the activity kept the child engaged so she didn't lose interest. I as well show number recognition throughout the day in various scenarios. Where I've struggled is to remember to ask how many instead of telling them to count."

Reply: "I remember many years ago (about 14) giving an assignment that students were to think of ways they used math at home. Everyone did so, except for a little girl named Patsy (pseudonym). I kept trying to urge her to think of a way she used math at home, without totally giving it away. What about helping bake? In games? Attending softball games? Patsy insisted they NEVER used math at home, and began to get angry about it. It took me a long time to realize that to Patsy, math was strictly the math worksheets we then used at school. Wow! What a great lesson for me. I thought I'd been doing so much to show that math was all around us and we used it all the time, but to her, it was worksheets. So, talking, as in the video, to understand children's thinking, is so important."

Another way that a development orientation came forward in the same unit and forum post was when two teachers commented on the power of the mathematical thinking of young children, how noticing thinking informed her teaching, and how traditional assessments often fell short of capturing young children's reasoning along a developmental progression:

Participant post: "I find subitizing amazing. I love to watch young children use it and I feel it is foundational [to other areas of math development]. I am particularly strong when I do feel like I am racing against a clock to teach students everything. I need to realize that if is far better for my students to truly understand math. I need to allow assessments to inform my instruction so that I can better serve my students."

Reply: "We are all guilty of rushing through concepts because we are short on time. It is sometimes hard for us to slow down to ensure success for all. Math is made of so many building blocks, we have to take a step back to make sure we are building a foundation. I know our administrations focus on us all being on the same pace, but we need to make sure we are using our data to guide instruction."

Participant post: "As I watched the videos, I was reminded of the importance of having children explain their thinking. It is so important for us to ask our students 'How do you know?' When I taught PreK, numbers and counting were everywhere. Throughout the day we counted things and talked about how many we counted. I can have more moments like this by looking for opportunities to count within everyday routines. As a second grade teacher, I often assumed that my students had a foundational understanding of number and operations and would often go to the abstract without investing time in learning more about what my students actually knew and understood about numbers and counting. The biggest obstacle is assessing students' understanding of numbers and operations. I have learned about several game-like activities that will provide the information I need in a more engaging way for students."

Reply: "I agree with you, children should be able to explain their thought process when solving a problem. Sometimes I assume my students should know this when they come to be in first grade."

Reply: "I agreed with a lot of what you wrote but the assessment piece is critical. I think we focus on reading assessments and math assessments get left behind to the point where we aren't really sure what to assess to meet a student right where they are like we do in reading. [With reading], we assess immediately what they know and plan a way forward; however, I don't see that and also don't see tools to assist with that as a classroom teacher."

Another example of a development orientation to teaching can be viewed in a "Connect" discussion forum in Unit two. This discussion string highlighted connections one participant made between developmental progressions of patterning and data analysis as well as number, along with linkages to classroom and home activities:

Participant post: "After watching the Sorting it Out videos, the mathematical concepts I observed were sorting, counting, patterns, graphing, data analysis, and algebra. The concepts relate to the patterns, sorting and data analysis. In the at home video, the little girl sorted the different objects, then counted the objects and then progressed to making patterns. In the classroom, the class sorted the shoes, then put them in columns which created a graph, then progressed to counting the shoes in each column and then progressed to data analysis by determining the group of shoes with the most and least. In both videos sorting was used to identify different objects and place them in groups. In the at home video, progression was made from sorting objects to counting the objects and then placing them in patterns. It clearly shows how the child thinks about objects differently and how to group them into common characteristics. It also reinforces the thinking concepts of how to count and develop patterns out of objects from around the house."

Reply: "The student in the videos you watched was able to connect progression three with progression four. Progression four is measurement. The student was able to sort items and arrange and classify them according to their common characteristics. The student also developed some counting skills as well."

A final example of a development orientation to teaching was evident in a Unit 3 "Connect" discussion forum post. The prompt instructed participants to watch a video of a group of children engaging in a developmental activity centered on subitizing, counting, and combining/addition. Participants were asked to notice aspects of children's thinking and connect it to developmental progressions from the previous two units:

Participant post: "Jackson can count one-to-one, subitize small numbers, and display the cardinality principle with numbers under five. After watching the video, I wonder if he is able to subitize larger numbers and if he has 'number after' knowledge. I would have liked to see more of the video to see if he was able to count on after four. To gather more information about Jackson's location in the numbers and operations progression, I would continue the game and see if he could subitize numbers other than two. I would also ask how many spaces he has left to fill and see if he counts one-to-one or subitizes. I would also ask him how many he currently has on his board, and if he answers correctly, ask how many more he needs to fill his board. This would give me a better idea of what stage he is on in the numbers and operations progression. After learning what he already knows, I could tailor his instruction to focus on stages in the progression he is still thinking about. For example, when asked how many spaces he has left to fill, if he counts one-to-one incorrectly, I can tell he needs more experience with counting one-to-one with numbers 5–10 and adjust my instruction accordingly. When asked how many more he needs to fill his board, if he can correctly answer six without counting one-to-one, I know he is ready to move onto the comparing stage of the progression."

Reply: "I also noticed that Jackson can subitize small numbers and can also count one to one well. I would have liked to see him to see if he could subitize numbers to 5 and count on to see how many boxes were needed to be filled on the board."

Reply: "With Jackson rolling 2 both times it's hard to know his understanding of numbers beyond 2 and whether he's able to subitize or compare larger groups of numbers. Knowing this information would be necessary in order to move on in the progression to counting entering the sequence at a number other than 1."

8. Level-Two Qualitative Results

Close Analysis of Participant Comfort and Interaction with Themes

The significant differences in participants' own confidence in math and mathematics instruction after participating in online learning, along with clear orientations to either an exposure or developmental view of teaching math to young children, led to further analysis on the individual level. Specifically, we were interested in examining trends related to teaching orientation over the time of course engagement and how those trends interacted with teachers' confidence in teaching mathematics.

Overall, the forum responses for the six 'confident' participants included overall evidence of a developmental mathematics teaching orientation rather than an exposure orientation, with all but two participants having over 50% of their forum posts coded as developmentally oriented. Trends in participants' teaching orientation over time are shown in Figure 2. The numbers in the visualization show the percentage of forum posts coded as developmentally oriented.

The visualization suggests that three confident participants (i.e., C3, C4, and C6) followed a trend of favoring more developmental orientations as the course progressed. However, three participants (i.e., C1, C2, and C5) showed negative or negligible change in their teaching orientation over time. Together, the data suggest that participants coded as 'Confident' in this purposive set of 12 had variable trends in their teaching orientation as the course progressed.

In contrast, the six participants labeled 'Not Confident' evidenced more variability in their teaching orientation overall, with nine forum posts coded as under 50% developmentally oriented. Most of these occurrences took place at the beginning of the course in Unit 1 and were spread evenly across the 'Not Confident' participants. The visualization suggests that, for three 'not confident' participants (i.e., U1, U3, U4), there were clear changes in their orientation to teaching as the course progressed, favoring more developmental orientations as the course progressed. The other three participants (i.e., U2, U5, and U6) showed change that was more variable yet still leaned toward increased developmental teaching orientations by the final unit. Together, the data suggest that participants coded as 'Not Confident' shifted their teaching orientation to developmental as the course progressed.

Percentage of Posts Per Unit that Reflect Developmental Orientation

% of each participant's forum posts coded as developmentally oriented

	Unit 1 *Number and operations*	**Unit 2** *Geometry, patterns, measurement, data analysis*	**Unit 3** *Progress monitoring & building on thinking*	**Unit 4** *View/describe world mathematically*
C1	56%	33%	54%	*no data*
C2	80%	75%	75%	*no data*
C3	37.50%	75%	100%	100%
C4	50%	67%	71%	78%
C5	100%	75%	50%	100%
C6	13%	50%	*no data*	100%

	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
U1	38%	33%	50%	100%
U2	71%	80%	40%	100%
U3	40%	100%	100%	100%
U4	63%	80%	100%	*no data*
U5	0%	75%	33%	71%
U6	44%	100%	*no data*	67%

*C = confident participant

**U = not confident participant

Figure 2. Data visualization of shifts in orientation over time for confident and not confident participants.

9. Overall Interpretation

Participation in online professional learning supported significant changes in participants' beliefs regarding their own confidence with mathematics and mathematics teaching of young children. Clear orientations toward an exposure or a developmental view of teaching mathematics to young children emerged across the participants and their engagement in the course material. A closer examination of 12 participants' confidence and changing orientation to teaching across the online professional learning suggests that many of the less confident teachers demonstrated trends toward a more developmental teaching orientation as their experience in the course progressed. On the other hand, participants who entered the course more confident in mathematics and mathematics teaching already possessed a developmental view of teaching. Yet, some of these teachers also strengthened their developmental teaching orientation as their experience in the course progressed. Taken together, the findings suggest that the course was effective in bolstering confidence in mathematics and mathematics teaching for a variety of teachers. They also suggest that the changed beliefs strengthened orientations to developmentally based practices in teaching math to young children.

10. Discussion

A teacher's beliefs impact the mathematics experiences young children have in preschool [43]. Beliefs about the importance of mathematics learning in the early years, confidence in supporting children's mathematical development, and who holds the locus of mathematics knowledge can affect if, and how, teachers provide quality mathematics experience in the preschool setting [11]. Resources, such as online professional learning, are becoming increasingly available to bolster teacher knowledge of young children's development and positively change beliefs about mathematics teaching in the early years. Yet, more research is needed to evaluate the effectiveness of these resources and to better understand the nature of shifting beliefs and teachers' orientations toward using developmentally based teaching [1,6,9,44].

Accordingly, we studied how an online professional learning experience impacted participants' beliefs about mathematics teaching and learning in the early years. Specifically, we investigated whether participants' beliefs (locus of knowledge, confidence in teaching math, and age appropriateness of early math instruction) changed significantly after engaging in online professional learning. We also documented overall orientations of participants' teaching practices (i.e., with *development orientation* referring to concepts and understanding, and *exposure orientation* referring to skills and procedures) and how changed beliefs may coincide with orientations toward developmentally based teaching over time. Below, we discuss the findings of this work with respect to the broader literature on teacher practice and beliefs about teaching mathematics and speak to considerations for further research.

11. Bolstering Teachers' Beliefs about Mathematics and Developmentally Based Mathematics Teaching

Young children bring a wealth of informal mathematical knowledge to school [1]. At the same time, many early childhood teachers report a lack of confidence in their ability to deliver high quality math instruction [45]. For these reasons, the findings from the pre- and post-course beliefs survey are encouraging. That is, teachers' experiences in the Online Professional Learning course positively impacted their beliefs about teaching math to young children to a moderate degree. Participants' confidence with mathematics and with teaching mathematics to young children, in particular, increased significantly and with a large effect size. Increases in teacher confidence, then, can potentially be attributed to the quality of the course design and a positive professional development experience.

The propensity of the course to bolster teacher confidence is notable, as teachers who are more confident in mathematics and mathematics teaching demonstrate increased levels of effort, persistence, and openness to new ideas when working with young students compared to teachers who are less confident [36]. Because differences in mathematics achievement often form prior to kindergarten [31], it is important to continue efforts to raise the confidence of teachers such that research-based, developmental approaches to mathematics instruction can be implemented. Further research on online professional learning should examine whether increases in teacher confidence translate to improvements in classroom practice or, more distally, student outcomes.

Teaching and assessing number and operations and geometry skills based upon children's development positively affects learning when employed as a regular part of the early elementary school curriculum [7]. Yet, qualitative findings of the course uncovered that teachers who engaged in online professional learning had different orientations toward teaching mathematics to young children when examining holistic engagement in the course. Specifically, some teachers held a coverage orientation, or a clear focus on young children's exposure to math skills or vocabulary, with clear attention on behavioral aspects of young children's mathematics experiences, such as attention. Other teachers held a developmental orientation, or a clear focus on children's development of mathematical ideas or understandings, or interaction with prior knowledge or stages of knowledge.

A closer examination of a subset of 12 participants' confidence and changing orientation to teaching across the online professional learning suggests that teachers who were less confident when the course began also held exposure orientations toward teaching mathematics to young children. However, these same teachers showed trends toward a more developmental teaching orientation as their experience in the course progressed. In this way, our findings align with prior research that suggests teachers with a higher degree of confidence could take up contemporary teaching practices more readily than those with lower confidence [14]. Further research should test this assertion by following teachers engaged in online professional learning in their classrooms to document potential changing trends in enacted (as opposed to reported) practice.

12. Expanding Positive Effects of Online Professional Learning to Bolster Other Beliefs

Despite the promising effects on teachers' confidence, differential growth was observed in other beliefs that impact young children's mathematics experiences in the classroom. That is, the effects of online professional learning on teachers' locus of mathematics knowledge or beliefs about mathematics as age appropriate were not statistically significant when examined individually. Such findings indicate the course particularly impacted participants' comfort level with teaching math to young children, with less of an impact on locus of generation of mathematics knowledge or age appropriateness mathematical development.

Why might this be the case? One reason may rest in the extent to which the course adequately challenged teachers' existing beliefs about the capacities of young children in terms of their mathematics learning potential. For example, we noticed a trend in deficit language regarding young math learners used by participants in the course forums regardless of orientation to teaching. Teachers with exposure orientations as well as teachers with developmental orientations were coded as referring to young students in terms of ability (*exposure orientation*) or readiness (*development orientation*). Our analysis does not shed light on how different orientations to teaching or deficit perspectives within might hinder changes in teachers' beliefs that mathematics is (or is not) age appropriate for young children or how orientation connects to teachers' views of the locus of mathematics knowledge in the classroom. For example, prior research suggests that some teachers do not believe that mathematics instruction is an appropriate school experience in the early years [46], which could explain the deficit language viewed in the qualitative analysis. Future research might investigate these connections.

Another possibility for the lack of change in teachers' beliefs about age appropriateness of math learning or locus of math knowledge may be connected to the course resources utilized to support teachers' specific reflection on their practice with regard to locus or age appropriateness. If beliefs of teachers differ significantly from the perspectives of a program or recommended practice, then efforts should be made to provide opportunities for teachers to reflect upon, challenge, and shape their beliefs over time [47]. It is possible that course activities were too far removed from current perspectives of teachers in these areas and were not sufficiently designed to promote change. A revision of the course content with activities more purposely planned to challenge deficit views of young children pertaining to mathematics learning could test this assertion.

For example, to push participants' thinking about both of these important concepts, we plan to reorder the unit content, moving Recommendation 4: Teaching Children to View and Describe their World Mathematically to Unit one so that it becomes participants' first experience. This change might support participants to think more broadly about math learning beyond just specific tasks during a designated time at the beginning of the course, so they can carry this through the content-specific units. Additionally, a new section is planned for placement within the existing units focused on deficit vs. strengths-based language, with specific examples for early mathematics educators to put directly into use in their classrooms. This change may encourage participants to think critically about the language they use about young math learners and the impact it has, particularly for the age of their students. Future iterations of the course are being planned to develop these design changes and test their effects on teachers' beliefs.

13. Limitations and Future Research

Several limitations of this work need to be acknowledged. First, we tested for within-subject differences in beliefs before and after participation in Online Professional Learning. More work is needed to evaluate if similar significant changes in beliefs may be found in subsequent iterations of the course, on its own or in comparison to a control group of teachers who did not participate in online learning. Since our current study did not include a control group of teachers, we are limited in the conclusions we can draw about the effect of the course on teachers' beliefs. In addition, there are limits to the generalizability of our results given our sample of teachers. The teachers included in our study were mostly female, majorly elementary classroom teachers who had been teaching for over six years, and over half of them have an advanced degree. These teachers also indicated that they enrolled in the course so they could deepen their knowledge and improve their teaching, which might have impacted their engagement in the course compared to those who enrolled for other reasons. Thus, these teachers might not be generalizable to a larger population of early childhood educators.

Another limitation may have been the length of time between survey implementations. That is, the time between participants' reporting of their beliefs on the pre and post surveys may not have been long enough to understand or evaluate changes in beliefs resulting from participation in the course. Different results may have been found had the period between pre and post implementation, or the course content itself, sustained a longer period of time. We did not collect data on teacher beliefs with respect to particular units. This is an area of future research.

A third limitation to the qualitative analysis was our view of course activities and participant–participant discussion as the primary drivers of the observed trend toward an increased number of forum posts with a developmental orientation. We inferred these elements of the course to be responsible for such trends, but cannot say for certain without data from further iterations of the course. Finally, more information is needed on differences in other course elements that may connect to participants' beliefs, such as different engagement profiles (e.g., time spent; use of different course resources) to bolster learning, practice, and changes in beliefs.

Online professional learning may help bolster positive beliefs toward teaching math to young children for teachers and help teachers shift their orientation and practice toward research-based practices based on children's development. The results of the current study reflect potential positive results of engaging teachers in online professional learning, based upon best practices and recommendations for teaching mathematics to young children. There is a need for more research to address the differential effects of how instructional elements and orientations to teaching might change beliefs and practice for teachers of young children.

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