ENGAGING PROSPECTIVE ELEMENTARY TEACHERS IN STANDARDS FOR MATHEMATICAL PRACTICE WITHIN CONTENT COURSES FOR TEACHERS

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Since prospective elementary teachers (PTs) in the US will be expected to engage students in mathematics via the Common Core Standards for Mathematical Practice (SMPs), national teacher preparation standards are calling for PTs to have opportunities to engage in these practices during their development of mathematical knowledge for teaching (e.g., AMTE's Standards for Preparing Teachers of Mathematics, 2018). This report investigates the intended curriculum of 82 mathematics content courses for teachers for such opportunities. Findings suggest that most instructors of these courses intend to engage PTs in several of the SMPs, mostly by offering them opportunities to experience learning through lessons planned with the SMPs in mind. However, substantial variance was noticed in the frequency and depth of which the individual SMPs were reported or found evidenced in sample tasks. Implications to follow.

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Common Core State Standards of Mathematics (CCSS-M, National Governors Association Center for Best Practices and the Council of Chief State School Officers [NGA & CCSSO], 2010) offer standards for K-12 students in terms of mathematical content and practices. The Standards for Mathematical Practice (SMPs) bring attention to the processes and practices that have been recommended by US national organizations for K-12 students (e.g., National Council of Teachers of Mathematics (NCTM) *Process Standards*, 2000; National Research Council *Strands of Mathematical Proficiency*, 2001). The CCSS-M, including the SMPs, are currently adopted by 41 states (NGA & CCSSO, 2019) and included in national recommendations for the preparation of prospective elementary teachers (PTs) (e.g., Association of Mathematics Teacher Educators *Standards for Preparing Teachers of Mathematics*, 2018; Conference Board of Mathematical Sciences (CBMS) *Mathematical Education of Teachers II*, 2012). Because of the increased attention being given to the SMPs in terms of teacher preparation, we investigated the intended curriculum of mathematical content courses for opportunities they afford prospective elementary teachers (PTs) to engage with the SMPs during their development of mathematical knowledge. By gaining insight into the ways in which Mathematics Teacher Educators (MTEs) are affording PTs such opportunities, our community can consider ways of replicating and enhancing this work.

Methods

Data Collection

A subset of data from a larger study on the mathematical content preparation of elementary teachers was analyzed to address the question, "In what ways are PTs being afforded opportunities to engage with CCSS-M SMPs in content courses for PTs?" The data for the larger study (see Max, 2018) was collected through an online survey that was sent to MTEs across the US through the use of various large-scale listservs and social media outlets (e.g., the AMTE email and affiliate list, the STaR listserv, the AERA SIG-RME Facebook page). The survey

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asked MTEs who are involved in the mathematical preparation of elementary teachers about their educational and professional backgrounds, the teacher preparation programs in which they are involved, and any content courses they teach that are specifically designed for PTs.

For each content course, participants were asked to select all of the SMPs they intentionally address in their courses and to provide general information about the ways in which the SMPs are addressed (by selecting from a list of potential options, including an option to select "other" and explain). They were also asked to identify the SMP that receives the *most* attention in each course and to describe an example of a way in which PTs are engaged in that particular practice. Open-ended responses to this prompt will be referred to as *SMP descriptions* and considered to be *explicit* ways in which MTEs are engaging PTs with SMPs.

Participants were also asked to upload or describe an activity, assessment, or reading related to the content domain (CBMS, 2012) that receives the most attention in each class. While respondents were not asked to consider the SMPs in regard to their content examples, their responses to this prompt were analyzed through the lens of the SMPs to identify ways in which MTEs might be engaging PTs in SMPs throughout tasks focused on content development. This collection of written responses and uploaded materials will be referred to as *content examples* and considered to be *implicit* ways in which MTEs are engaging PTs in SMPs. For more detailed information on survey construction and data collection, please see Max (2018).

Participants

The online survey was completed by 44 MTEs who have experience teaching content courses for PTs and will serve as the sample for this study. This sample represents MTEs from 41 different US universities across 19 states. Thirty-nine (89%) of the MTEs reported having some affiliation within a department of mathematics: 28 (72%) of these MTEs belong solely to a mathematics department, while 11 (28%) have joint affiliations with a department of education. The remaining five MTEs (11%) work solely in departments of education. The participants reported a mean of 10.7 years of experience teaching at the post-secondary level. Thirty-three (75%) MTEs reported prior experience as a K-12 teacher, with a mean of 4.5 years of teaching experience. Ten (30%) MTEs had taught at the elementary level, nineteen (58%) at the middle level, and twenty-five (76%) at the secondary level, with twenty-two (66%) having taught at more than one of these levels.

The respondents reported a mean university program requirement of 2.1 content courses for PTs, worth a mean of 6.7 total credit hours, with 84% of these courses being housed in departments of mathematics. These courses are reportedly being taught by faculty 91% of the time, with staff (17%), graduate students (16%), and adjunct faculty (7%) teaching these courses much less frequently. MTEs also reported over 50% of these courses tending to be taken by first-year college students, with only 22% likely to be enrolled by juniors or seniors. Lastly, all but one of the respondents reported research as being a component of their current position, with 38 (88%) of MTEs conducting research in the area of mathematics education, 3 (7%) in mathematics, and 2 (5%) in a non-math related field.

Analysis

Descriptive statistics and content analysis were used to investigate the collected data looking for evidence of opportunities for PTs to engage in the SMPs in content courses. Using protocol coding (Saldaña, 2016), all SMP descriptions and content examples were coded according to each of the SMPs considered to be addressed. This was done by identifying opportunities that aligned with the actions explicated in the detailed SMP descriptors offered in the CCSS-M standards document (NGA & CCSSO, 2010). For example, for SMP3: Argumentation, the

coders looked for opportunities for PTs to "construct viable arguments and critique the reasoning of others…make conjectures… use counterexamples… justify their conclusions, communicate them to others…explain what it [a flaw in an argument] is" (pp. 6-7). Although the participants were asked to discuss activities pertaining to the SMP and content domain that receive the *most* attention in each course, the coding served to identify any and all SMPs that PTs were invited to engage in throughout the activities described. This coding scheme was used because SMPs are interconnected and at times unable to be separated from one another. For example, one respondent described how they address SMP1: Problem-Solving in a task related to finding the volume and surface area of three-dimensional objects. Since this task involved PTs using Geo-Solids, it was also coded as addressing SMP5: Tools. Each of the SMP descriptions and content examples were independently coded by two researchers. The coders cross-checked their work to find an initial 75% agreement; all disagreements were discussed until consensus was achieved.

Results

The 44 participating MTEs provided information for a total of 82 content courses for PTs that they were either teaching or have previously taught. Below, we report findings on our analysis of the ways in which PTs are being provided opportunities to engage in SMPs in these 82 courses. First, we will discuss *explicit* attention given to SMPs found in the intended curriculum of content courses through analyzing SMP selection data and coded SMP descriptions. Afterwards, we will discuss *implicit* attention identified through analyzing coded content examples).

MTEs selected one or more SMPs as being intentionally addressed in 74 (90%) of the reported 82 content courses (n = 74). See Table 1 for the number of courses for which each SMP was selected. For 55 (74%) of the 74 courses that address at least one SMP, MTEs selected a most-addressed SMP (n = 55). Table 1 also shows the number of times each SMP was selected as being the most-addressed SMP for a course. However, we acknowledge that asking participants to choose a single most-addressed SMP may have presented a challenge. For example, one respondent indicated, "Each of them [SMPs] is addressed regularly. It is difficult to say which is addressed the most." In fact, MTEs stated that all SMPs received regular and/or equal attention in 4 of the 55 courses. In these cases, we recorded all 8 SMPs as having been selected (thus the total in the "Most Addressed" column is greater than 55).

Table 1: Attention to SMPs

	Explicit Attention			Implicit Attention
SMP Name	Intentionally Addressed (n = 74)	Most Addressed (n = 55)	Indicated by a SMP Description (n = 39)	Indicated by a Content Example (n = 57)
1. Problem Solving SMP	64	17	21	40
2. Reasoning SMP	63	6	4	10
3. Argumentation SMP	62	30	20	13
4. Modeling SMP	56	9	1	9
5. Tools SMP	62	7	5	26
6. Precision SMP	59	5	4	8

7. Structure SMP	60	8	2	23
8. Regularity MP	54	6	0	6

Information regarding the ways in which SMPs are being explicitly addressed was provided for 69 (93%) of the 74 courses. When asked to select from a list of potential options, respondents reported that 88% (61) of their courses offer PTs the opportunity to experience learning through lessons planned with the SMPs in mind. The remaining provided options, having PTs read the SMPs, facilitating lessons using the SMPs, and creating lesson plans that reference SMPs, were selected for 32 (46%), 16 (23%), and 5 (7%) courses, respectively. Respondents described "other ways" they address the SMPs for 9 (13%) courses, with open-ended responses including "discussion of how these standards play out in class lessons," "reflecting on their use in lessons in class," and having a "poster of SMPs on [a] wall in [the] classroom." Additionally, written SMP descriptions were provided for 39 (53%) of the 74 courses (n = 39). Table 1 presents the results of our coding showing the number of times each SMP was identified as being evidenced within a SMP description.

Content examples were provided by MTEs for 68 (83%) of the 82 content courses on which they reported, including 48 written descriptions of content activities and 20 uploaded activities/tasks. However, only 57 (84%) of the content examples provided enough information for the coders to identify one or more SMPs (n = 57). Table 1 provides the number of times each SMP was coded as being implicitly evidenced within one of these 57 content examples.

Discussion and Conclusion

MTEs reported that all SMPs are being addressed in the vast majority of their content courses for PTs with little variance among the individual SMPs (each being addressed in 73%-86% of the courses). However, when opportunities for explicit and implicit attention were further analyzed, the attention being given to individual SMPs showed greater variation. SMP1: Problem Solving and SMP3: Argumentation were selected much more often as being the most addressed SMP, and consequently showed up the most in the SMP descriptions (for task samples and discussion on the ways in which SMP3 occurred within content examples, see Max & Welder, accepted). These findings are consistent with the national attention these practices have received (e.g., NCTM, 1980, 2000). However, they were only somewhat consistent with the SMPs identified in the content examples, as the use of SMP5: Tools and SMP 7: Structure were noted much more frequently than SMP3: Argumentation. In fact, these two SMPs organically emerged in nearly half of all content examples. On the other hand, our results suggest that it could be beneficial for MTEs to consider additional ways to engage PTs in SMP8: Regularity, SMP4: Modeling, and SMP6: Precision. MTEs identified these three SMPs as receiving attention in the fewest of their courses and they were found to occur the least in the content examples they provided. We encourage MTEs to reflect upon their practice and the ways in which they can afford PTs meaningful opportunities to develop these less-evident SMPs in content courses, as they may not be occurring as organically as others (such as SMP1: Problem Solving). We also encourage MTEs to identify ways in which they are attending to SMPs, perhaps in ways of which they are not aware, so they can connect such occurrences to the SMP language for PTs.

We note that the findings of this work are based on MTEs' intended curriculum and hypothesize that more (and perhaps more explicit) attention to SMPs could be identified through observing activities being enacted with PTs. Additional research in this direction could be useful in supporting MTEs in finding ways to foster PTs' working understanding of the SMPs. By

helping PTs become more aware of the valuable role each SMP can play in the development of mathematical content knowledge, we may be able to better prepare elementary teachers for engaging their future students in such practices.

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