ELEMENTARY MATHEMATICS SPECIALISTS: ENSURING THE INTERSECTION OF RESEARCH AND PRACTICE[i]

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This paper provides a historical overview of the role and impact of elementary mathematics specialists as well as current implications and opportunities for the field. Furthermore, suggestions are offered for the mathematics education field for ensuring the intersection of practice and research.

Keywords: Teacher Education-Inservice/Professional Development, Teacher Knowledge, Elementary School Education

Historical Background

Over the years, many groups and leaders have seen the need for supporting teachers of elementary mathematics. In 1981, the National Council of Teachers of Mathematics (NCTM) Board of Directors recommended that state certification agencies offer teaching credentials for elementary school teachers that included mathematics specialist endorsements. The intent of this recommendation was to prepare elementary teachers to assume the primary responsibility of teaching mathematics, typically in the intermediate grades. At that time, certification boards across the country did not positively respond to this suggestion by creating mathematics specialist endorsements (Dossey, 1984). Since that time, a number of recommendations for the use of elementary mathematics specialists (EMSs) have emerged (see Figure 1).

Year	Recommendation
1981	The National Council of Teachers of Mathematics (NCTM) Board of Directors recommends that state certification agencies offer teaching credentials for elementary school teachers that include mathematics specialist endorsements.
1983	The National Science Board Commission on Precollege Education in Mathematics, Science and Technology recommends mathematics specialists in grades 4-6 in *Educating Americans for the 21st Century.*
1984	An article in *The Arithmetic Teacher* by John Dossey, entitled *Elementary School Mathematics Specialists: Where Are They?* discusses the importance of mathematics specialists in the elementary school.
1989	The National Research Council in *Everybody Counts* recommends that states alter certification requirements to encourage the use of mathematics specialists in elementary schools.
2000	*The Principles and Standards for School Mathematics* (NCTM) discusses the importance for mathematics teacher-leaders and specialists especially in grades 3-5.
2001	The National Research Council in *Adding It Up* recommends that mathematics specialists should be available in every elementary school.
2001	*The Mathematical Education of Teachers* (CBMS) calls for mathematics specialists starting at the fifth grade.

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2003	Johnny Lott's Presidential Message entitled *The Time Has Come for Pre-K-5 Mathematics Specialists* advocates for mathematics specialists at the elementary level.
2003	An article in *Teaching Children Mathematics* by Reys and Fennel, entitled *Who Should Lead Mathematics Instruction at the Elementary Level? A Case for Mathematics Specialists* makes the case for mathematics specialists using both models.
2003	NCTM and the National Council for Accreditation of Teacher Education (NCATE) release standards for Elementary Mathematics Specialists programs.
2006	Francis (Skip) Fennell's Presidential Message entitled *We Need Elementary Mathematics Specialists NOW* outlines the need for mathematics specialists/leaders.
2008	The National Mathematics Advisory Panel (NMAP) releases their report in which they call for research to be conducted on the use of mathematics specialists in elementary schools.
2009	NCTM Research Brief describes 9 research studies focused on mathematics specialists and coaches and calls for additional research.
2010	Association of Mathematics Teachers Educators (AMTE) releases *Standards for Elementary Mathematics Specialists* which outlines program standards for teacher credentialing and degree programs. Revised in 2013.
2010	AMTE, Association of State Supervisors of Mathematics (ASSM), National Council of Supervisors of Mathematics (NCSM), NCTM joint position statement recommends that every elementary school should have access to an EMS.
2012	Conference Board of Mathematical Sciences (CBMS) *The Mathematical Education of Teachers II* outlines the increased use of EMSs.
2012	NCTM/CAEP *Standards for Elementary Mathematics Specialists* (Advanced Preparation) are released.
2013	Linda Gojak's Presidential Message entitled, *It's Elementary: Rethinking the Role of the Elementary Classroom Teacher,* advocates for mathematics coaches and specialists at the elementary level.
2015	Updated NCTM Research Brief describes 24 research studies focused on mathematics coaches and calls for additional research.
2017	AMTE releases the 2nd book in their Professional Development Series, *Elementary Mathematics Specialists: Developing, Refining, and Examining Programs that Support Mathematics Teaching and Learning*

Figure 1. Recommendations for Mathematics Specialists and Coaches. Adapted from Fennell, F. S. (2017). We need elementary mathematics specialists now: A historical perspective and next steps. In M. B. McGatha & N. R. Rigelman, (Eds.). *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning.* Charlotte, NC: Information Age Publishing. Reprinted with permission. Copyright IAP. All rights reserved.

Although these recommendations use the term *mathematics specialist*, they describe models that include working with students, teachers, or both. Some of the recommendations distinguish between the models by using different titles and others do not. In fact, the title of these teacher leaders varies from state to state and even from district to district. In an effort to provide some clarity on these titles, my colleague and I (McGatha & Rigelman, 2017) offered a general overview of the work in

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which these teacher leaders engage and suggested some common language that could be used in referring to these positions (see Figure 2).

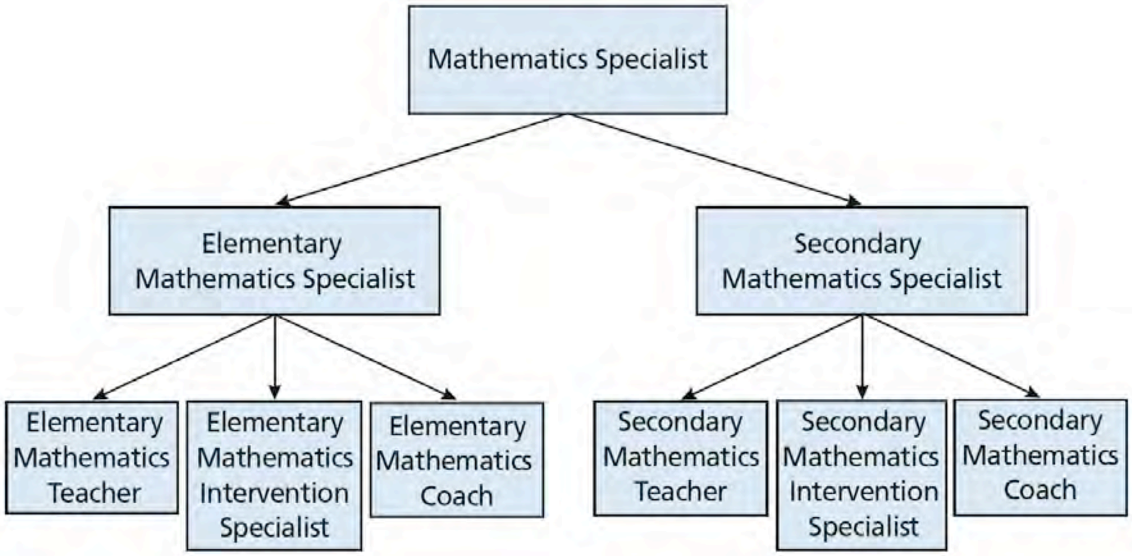

Figure 2. Mathematics Specialists' Titles. Source: McGatha, M. B. & Rigelman, N. R. (2017). Introduction. In M. B. McGatha & N. R. Rigelman (Eds.). Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning. Charlotte, NC: Information Age Publishing. Reprinted with permission. Copyright IAP. All rights reserved.

The titles under EMS and Secondary Mathematics Specialist (SMS) describe the major roles in which these teacher leaders engage: (a) mathematics teacher, a professional who teaches mathematics to students; (b) mathematics intervention specialist, a professional who works with students in "pull out" or "push in" intervention programs; and (c) mathematics coach, a professional who works primarily with teachers (McGatha & Rigelman, 2017).

Regardless of the title used to describe these teacher leaders as indicated in Figures 1 and 2, the mathematics education community has recognized a need for mathematics specialists at the elementary level for over 35 years. These recommendations stimulated several initiatives in schools and districts across the country.

Practice: What is Happening in the Field?

In 1988, ExxonMobil launched the *K-5 Mathematics Specialist Program* in which grants were given to 120 districts across the country to train and place mathematics specialists in elementary schools. However, the model in this program was actually the mathematics coach model since teachers were trained to be "proactive resources for other teachers, administrators, and parents" (ExxonMobile, n.d.). This corporate-based program was one of the first large-scale mathematics coaching initiatives in the United States. The state of Virginia took advantage of the ExxonMobile grants and became an early leader in supporting the work of EMSs. Various stakeholders and organizations in that state began work as early as 1992 and that work still continues today (http://www.vacms.org). More recently, the Elementary Mathematics Specialists & Teacher Leaders project (ems&tl), supported by the Brookhill Institute of Mathematics, was created in 2009 to support a core group of EMSs in Maryland. The project studies the impact of mathematics specialists and also hosts a nationally recognized clearinghouse (www.mathspecialists.org). Other large scale projects (e.g., Mathematics Coaching Project, Examining Mathematics Coaching Project) have, and continue to, support EMSs. This is in addition to the many district-based programs that exist across the US.

Another important aspect of work in the field, focuses on the ongoing support of the three national mathematics education professional organizations (AMTE, NCSM, NCTM). Arbaugh, Mills, and Briars (2017) outlined this important work and presented a representative list of activities from each organization (see Figure 3).

With the increased attention on EMSs and projects to support their work, AMTE felt it was important to address credentialing and degree programs for these mathematics professionals. In 2010, AMTE released *Standards for Elementary Mathematics Specialists: A Reference for Teacher Credentialing and Degree Programs.* When the standards were published, there were only nine states that had a credential for EMSs while nearly every state has a credential for reading specialists. Currently, 20 states have some sort of credential for EMSs. While this growth is impressive in just seven years, we need every state to support the credentialing of EMSs.

Unfortunately, the number of schools or districts that have implemented mathematics coaching or specialist programs is unknown because a comprehensive national survey of such programs does not exist (National Mathematics Advisory Panel, 2008). However, the number of large-scale projects and the work of professional organizations as described above clearly indicate a growing focus on EMSs. Since 2000 the number of sessions on mathematics coaching and specialists at the annual conferences for AMTE, NCSM, and NCTM has steadily increased. In addition, other anecdotal evidence provides insights into the growing popularity of mathematics coaches and specialists. For example, a search on the Internet for “mathematics coach” produced 21,900 hits in 2008 and 26,600,000 in 2017 and “mathematics specialist” produced 17,000 hits in 2008 and 615,000 in 2017. While the exact number of schools and districts using mathematics specialists or coaches is unknown, it is clear that these programs have become a preferred professional development strategy to improve the teaching and learning of mathematics. It is critically important that we research what is happening in the field to verify the impact of EMSs.

Research: What is Happening in the Field?

When the first NCTM research brief on mathematics specialists was published in 2009, there were only nine studies included in the report. Research in this area quickly gained prominence and there were 24 research studies included in the 2015 research brief. And, the research continues. The research included in this brief overview (2002-2017) has either been published in an educational journal, edited book, or presented at a research conference so it has undergone some sort of peer-review process. Additional research has been conducted and can be found in evaluation reports, program review documents, and dissertations.

	AMTE **AMTE.net**	**NCSM** **MathEdLeadership.org**	**NCTM** **NCTM.org**
Peer Reviewed Journals	• *Mathematics Teacher Educator* (*MTE*) (with NCTM)	• *NCSM Journal of Mathematical Leadership*	• *Mathematics Teacher Educator (MTE) (with AMTE)* • *Teaching Children Mathematics (TCM)* • *Coaches Corner* • *Reflect and Discuss* • *Journal for Research*

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			in Mathematics Education (JRME)
Facilitated Learning Opportunities	• *Annual Meeting* • *EMS State Certification Conferences* • *EMS Research Conference* • *Webinars*	• *Annual Meeting* • *Summer Academies* • *Fall Leadership Seminars* • *Webinars*	• *Annual Meeting and Exposition* • *Regional Conferences and Expositions* • *Research Conference* • *PreConference workshops* • *Institutes provide a deep-dive into grade and/or topic-specific content* • *Innov8 Conferences focus on a particular problem of practice* • *Webinars and webcasts*
***Sample* Print and Electronic Resources**	• *Standards for Elementary Mathematics Specialists: A reference for Teacher Credentialing and Degree Programs* • *AMTE Professional Book Series* • *Jump Start -Formative Assessment (w/NCSM)* • *Connections newsletter* • *Contemporary Issues in Technology and Teacher Education (CITE) journal*	• *The PRIME Leadership Framework: Principles and Indicators for Mathematics Education Leaders* • *It's TIME: Themes and Imperatives for Mathematics Education* • *Professional Learning Module Resources* • *Illustrating the Standards for Mathematical Practice* • *Jump Start -Formative Assessment (with AMTE)* • *NCSM PLC: The Digital Mathematics Education PLC* • *Coaches Corner* • *Curriculum Materials Evaluation Toolkit (with NCTM)*	• *Principles to Actions: Ensuring Mathematical Success for All* • *Principles to Actions Professional Development Toolkit* • *The Elementary Mathematics Specialist's Handbook* • *A Guide to Mathematics Coaching: Processes for Increasing Student Achievement* • *Professional Development Guides and More4U that provide suggestions for using NCTM publications in professional learning.* • *5 Practices for Orchestrating Productive Mathematics Discussions*

		• *Position/White Papers on teaching/learning topics* • *NCSM Newsletter and eNews*	• *Online classroom resources* • *Research Briefs summarize research on mathematics teaching and learning* • *Position Statements address policy issues relevant to mathematics education* • *Curriculum Materials Evaluation Toolkit (Joint with NCSM)*
Scholarships and Grants	• *EMS Scholarship Program*	• *Iris Carl Travel Grants*	• *Mathematics Education Trust (MET) grants*

Figure 3. Representative AMTE, NCSM, & NCTM Support for Elementary Mathematics Specialists. Source: Arbaugh, F., Mills, V. L., Briars, D. J. (2017). The role of professional organizations: Advocacy, development and research. In M. McGatha & N. Rigelman (Eds.). *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning.* Charlotte, NC: Information Age Publishing. Reprinted with permission. Copyright IAP. All rights reserved.

Specialists as Mathematics Teachers

There are currently very few studies on EMSs working as MTs. McGrath and Rust (2002) studied the effectiveness of departmentalized mathematics at the elementary level. The study compared gain scores in achievement test data from students in self-contained classrooms and departmentalized classrooms in grades 5 and 6. For the mathematics subtest of the achievement data, there were no significant differences in student achievement data gain scores between departmentalized and self-contained classes. However, Gerretson, Bosnick, and Schofield (2008) found that using MTs at the elementary school level allowed teachers more time to effectively plan lessons and focus their professional development (PD). In addition, teachers in this study reported gains in student achievement as a result of using MTs. Nickerson (2010) also noted that achievement gains were greater in treatment schools with MTs as compared to control schools without MTs. The MTs in this study noted significant changes to students' persistence in solving mathematics tasks and increased interest in mathematics. Nickerson noted changes in MTs' instructional practice towards an inquiry-based approach, but pointed out that this took time.

More recently, Markworth (2017), examined the various content specialization models of MTs involved in team teaching within seven school districts. Similar to the Gerretson, Bosnick, and Schofield study (2008), the MTs acknowledged affordances to the content specialization models such as having more time to focus on fewer content areas, which allowed for more in-depth study and focused PD. The MTs believed this supported them in providing higher quality instruction. MTs also pointed out that sharing the responsibility for teaching was beneficial to students. Constraints to the model are also described including (a) scheduling issues not present when teaching in a self-contained class and (b) isolation can occur if there is only one content area teacher per grade level.

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Specialists as Mathematics Coaches

The majority of the research on EMSs focuses on MCs. These studies answer three main questions: (*a*) How do coaches interact with teachers? (*b*) What knowledge do coaches need? and (*c*) What is the impact of mathematics coaching?

How Do Coaches Interact with Teachers? The answer to this question varies greatly because districts and schools are still trying to figure this out. Several studies have focused on this question in order to support schools in understanding the most beneficial coaching practices. The research focuses on coaching practice in one-on-one settings (one coach and one teacher) and group settings (one coach and multiple teachers).

Studies that reported on coaching in one-on-one settings, in general, have identified similar ways of interacting with teachers that fell along a continuum from *more-directive* to *less-directive.* While each study used different language to describe the ways of interacting, they all focused on similar ideas. On the *more-directive* end of the continuum, the coach shared knowledge by (*a*) modeling lessons, (*b*) telling teachers what to do, or (*c*) providing resources for teachers (Becker, 2001; Chavl et al. 2010; Polly, 2012). Toward the middle of the continuum, coaching interactions focused on collaborative activities such as co-teaching, co-planning, and providing support during teaching (Becker, 2001; Chavl et al. 2010; Gibbons & Cobb, 2017; McGatha, 2008; Polly, 2012; Race, Ho, & Bower, 2002). At the *less-directive* end of the continuum, the coach supported teachers in becoming reflective practitioners. Activities on this end of the continuum included collecting data from observed lessons, providing feedback, and engaging teachers in thoughtful reflections (Becker, 2001; Bruce & Ross, 2008; Chavl et al., 2010; Gibbons & Cobb, 2017; Harrison, Higgins, Zollinger, Brosnan, & Erchick, 2011; McGatha, 2008; Olson & Barrett, 2004; Olson, 2005; Polly, 2012; Race, Ho, & Bower, 2002). While all of these coaching interactions serve useful purposes, activities on the *less-directive* end of the continuum seem to be more powerful in supporting teachers in changing their instructional practice.

A second aspect of coaching practice is coaching in group settings, such as a coach working with grade-level teams or professional learning communities. Gibbons and Cobb (2017) identified potential group coaching practices from the research on professional development and teacher learning that included (*a*) doing mathematics, (*b*) analyzing student work, (*c*) analyzing classroom video, and (*d*) rehearsing high-leverage practices. They point out that these practices can serve as a beginning framework, but additional research is needed to understand the usefulness of these practices in group settings. Baker, Bailey, Larsen and Galanti (2017) used the potential coaching activities identified by Gibbons and Cobb (2017) as a framework to identify high-leverage coaching practices across other coaching studies. Baker et al. (2017) suggested that even though the practices were not identified in many of the coaching studies, it did not invalidate the list. They agreed with Gibbons and Cobb (2017) that more research is needed in this area.

A few studies have focused on group coaching situations. In these settings, it is important to have regularly scheduled meetings in order to build continuity and maintain momentum (Gibbons, Garrison, & Cobb, 2011). In addition, it is critical to focus group meetings on issues of practice such as student learning and best teaching practices. (Alloway & Jilk, 2010; Obara & Sloan, 2009; Gibbons, Garrison, & Cobb, 2011). Beyond regularly scheduled meetings, Gibbons (2017) reported on the use of math labs (similar to lesson study) as a coaching structure to support the collective learning of a group of teachers.

What Knowledge Do Coaches Need? The *Standards for Elementary Mathematics Specialists* (AMTE, 2010, 2013) offer detailed descriptions of three broad areas of knowledge necessary for mathematics coaches and specialists: (*a*) content knowledge for teaching mathematics, (*b*) pedagogical content knowledge for teaching mathematics, and (*c*) leadership knowledge and skills

(p. 4). Researchers generally agree that these three areas of knowledge are important. However, the research focuses more explicitly on the third category of leadership knowledge and skills.

Sutton, Burroughs, and Yopp (2011) outlined eight domains of mathematics coaching knowledge: “Assessment, Communication, Leadership, Relationships, Student Learning, Teacher Development, Teacher Learning, and Teacher Practice” (p. 16). At first glance, many of these domains seem aligned with the AMTE categories; however, the detailed descriptions reveal more focused attention on supporting *teacher* learning, which falls into the AMTE category of leadership knowledge and skills. Several research studies help to further define specific ways coaches can support teachers. For example, it is important for coaches to understand trajectories of teachers’ development so they can offer differentiated experiences for teachers (Baldinger, 2014; Gibbons & Cobb, 2016; Sutton, Burroughs & Yopp, 2011) and create long-term goals for teachers’ development (Gibbons & Cobb, 2016). Coaches should have a deep knowledge of instructional practice and theory so they can support teachers in (*a*) assessing their own practice (Gibbons & Cobb, 2016) and (*b*) making connections between theory and practice (Alloway & Jilk, 2010; Sutton, Burroughs, & Yopp, 2011). Campbell and Malkus (2013) reiterated the importance of adequate preparation for coaches to make sure they possess the knowledge necessary to be effective coaches.

What Is the Impact of Mathematics Coaching? Two major areas are discussed in the research concerning the impact of mathematics coaching: improving teacher instructional practice and improving student achievement. Teacher instructional practice is defined broadly to focus on best practices in teaching as described in NCTM documents (1991, 2007). Of course, each study reports on particular aspects of teacher instructional practice.

Across all the instructional practice studies, researchers saw improvements (in varying degrees) in teacher instructional practice including increases in teacher questioning (Polly, 2012; Race, Ho, & Bower, 2002); student engagement (Balfanz, MacIver, & Byrnes, 2006; Race, Ho, & Bower, 2002); and teaching for understanding (Becker & Pence, 2003; Bruce & Ross, 2008; Burroughs, E., Yopp, D., Sutton, J., & Greenwood, M, 2017; Neuberger, 2012). Increases were also noted in particular instructional formats such as cooperative learning (Balfanz, MacIver, & Byrnes, 2006; Becker & Pence, 2003); classroom discourse (Balfanz, MacIver, & Byrnes, 2006; Neuberger, 2012; Race, Ho, & Bower, 2002); and technology (Becker & Pence, 2003). Two studies in this category differed from the others in that their findings did not fall into the categories described above but were more focused on specific instructional practices. Rudd, Lambert, Satterwhite, and Smith (2009) focused on one particular instructional practice, teacher’s use of math-mediated language in their lessons. After the professional development and coaching sessions, researchers saw an increase in teacher’s use of math-mediated language. Krupa and Confrey (2010) noted increases in (*a*) effective use of class time, (*b*) accurate delivery of content, and (*c*) frequent use of formative assessment as a result of teachers working with coaches.

Seven studies looked at the impact of mathematics coaching on student achievement. In varying degrees and with a variety of methods, all the studies reported increases in student achievement. At the elementary and middle school levels, studies show that coaching positively impacted student achievement on state-level assessments during the first and second years of a coaching program (Conaim, 2010; Zolligner, Brosnan, Erchick, & Bao, 2010). Additional studies at the elementary and middle school levels focused on student achievement impact after four years of a coaching program and showed even stronger results (Balfanz, MacIver, & Byrnes, 2006; Brosnan & Erchick, 2010; Campbell, Griffin, & Malkus, 2017; Campbell & Malkus, 2011). Findings from these longer studies indicate that, in order to significantly impact student achievement, coaches needed both experience and sufficient time to interact with teachers. There is only one study conducted at the high school level (Alloway & Jilk, 2010) and it was not specifically designed to study student achievement; however, its authors noted that pass rates in algebra and geometry classes increased from 40% to

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70% after the implementation of coaching. As we move forward in the field, it is imperative to ensure the intersection of practice and research.

Ensuring the Intersection of Practice and Research

Probably the most important way to ensure the intersection of EMS practice and research is to collaborate, collaborate, collaborate! We must emphasize the importance of ongoing research to identify best practices in the field that are making a difference in teacher practice and student achievement. We really can't describe research-based practices in the field quite yet. We need more research!

I propose four suggestions to support the field in ensuring the intersection of EMS practice and research:

1. *Identify districts using EMSs.* As noted above, the number of districts using EMSs is unknown because a comprehensive national survey of such programs does not exist. Such a survey needs to happen! Once we know where programs exist, we can encourage districts to share their successes and challenges to support other EMSs through conference presentations and articles in practitioner journals. In addition, we can support districts in conducting research on their EMS programs to inform the field.
2. *Provide adequate preparation and ongoing support for EMSs*. As noted throughout this paper, there are many initiatives focused on supporting EMSs in the field. These efforts need to continue and new initiatives need to emerge. There is an abundance of anecdotal evidence of districts utilizing EMSs without providing them any professional development or ongoing support. Research has shown that adequate preparation and ongoing professional development can positively impact student achievement (Campbell & Malkus, 2013).
3. *Increase the number of states with EMS certifications/endorsements.* As noted previously, there are currently only 20 states that offer an EMS certification/endorsement. As the number of states offering an EMS credential increases, we will see more EMSs in the field supporting the teaching and learning of mathematics. Receiving a credential should require some level of preparation which aligns with suggestion #2. And, of course, more well-prepared EMSs in the field will increase the research possibilities.
4. *Establish working groups focused on EMS research.* There are relatively few researchers focused on EMSs. They need opportunities to collaborate with other like-minded researchers to reflect on their practice and explore future research opportunities. A few such groups have emerged but we need more attention on focusing the EMS research agenda. Relatedly, two EMS research conferences have occurred recently (AMTE in 2015 and the Virginia Mathematics Specialist Initiative in 2016). Such conferences are another opportunity for researchers to share their work and form collaborations. Because the audience is relatively small, these conferences are not that expensive and funding is available to support these efforts. The research that emerges from these collaborations will provide insights for EMSs in the field.

It is exciting to be involved in an area of practice and research that is still emerging and growing! We have opportunities to influence the field in multiple ways. We also still have many challenges facing us. As we continue to find ways to ensure the intersection of practice and research, we will move the field forward in positive ways.

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Endnotes

[i] Parts of this manuscript are adapted from *The Impact of Mathematics Coaching on Students and Teachers* published by NCTM (2015), http://www.nctm.org/Research-and-Advocacy/Research-Brief-and-Clips/Impact-of-Mathematics-Coaching-on-Teachers-and-Students/.

References

Alloway, M., & Jilk, L. M. (2010). Supporting students by supporting teachers: Coaching moves that impact learning. In P. Brosnan, D. B. Erchick, & L. Flevares (Eds.), *Proceedings of the 32nd annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. VI, pp. 1420–1427). Columbus, OH: The Ohio State University.

Arbaugh, F., Mills, V. L., Briars, D. J. (2017). The role of professional organizations: Advocacy, development and research. In M. McGatha & N. Rigelman (Eds.). *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning.* Charlotte, NC: Information Age Publishing, 141-149.

Association of Mathematics Teacher Educators (2010, 2013). *Standards for Elementary Mathematics Specialists: A Reference for Teacher Credentialing and Degree Programs.* San Diego, CA: AMTE. Available at https://amte.net/publications.

Association of Mathematics Teacher Educators, Association of State Supervisors of Mathematics, National Council of Supervisors of Mathematics, & National Council of Teachers of Mathematics, 2010. *The role of elementary mathematics specialists in the teaching and learning of mathematics: A position statement*. Retrieved from https://amte.net/group/resources/12-13/position-role-elementary-mathematics-specialists-teaching-and-learning-mathema

Baldinger, E. (2014). *Learning together: Looking for learning in coach-teacher interactions*. Paper presented at the Research Conference of the National Council of Teachers of Mathematics, New Orleans, LA.

Balfanz, R., MacIver, D. J., & Byrnes, V. (2006). The implementation and impact of evidence-based reforms in high-poverty middle schools: A multi-site, multi-year study. *Journal for Research in Mathematics Education, 37*(1), 33–64.

Baker, C., Bailey, P., Larsen, S. & Galanti, T. (2017) A critical analysis of emerging high-leverage practices for mathematics specialists. In M. McGatha & N. Rigelman (Eds.). *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning.* Charlotte, NC: Information Age Publishing, 183-191.

Becker, J. R. (2001). Classroom coaching: An emerging method of professional development. In R. Speiser, C. Maher, & C. Walter (Eds.), *Proceedings of the Twenty-third Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 751–760). Snowbird, UT.

Becker, J. R., & Pence, B. J. (2003). Classroom coaching as a collaborative activity in professional development. In A. Peter-Koop, V. Santos-Wagner, C. Breen, & A. Begg (Eds.). *Collaboration in teacher education.* The Netherlands: Kluwer, 71–84.

Brosnan, P., & Erchick, D. (2010). Mathematics coaching and its impact on student achievement. In P. Brosnan, D. B. Erchick, & L. Flevares (Eds.), *Proceedings of the 32nd annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. VI, pp. 1362–1370). Columbus, OH: The Ohio State University.

Bruce, C. D. & Ross, J. A. (2008). A model for increasing reform implementation and teacher efficacy: Teacher peer coaching in grades 3 and 6 mathematics. *Canadian Journal of Education 31*,(2), 346-370.

Burroughs, E. A., Yopp, D. A., Sutton, J. T., & Greenwood, M. (2017). Knowledge for coaching. In M. McGatha & N. Rigelman (Eds.). *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning.* Charlotte, NC: Information Age Publishing, 175-181.

Campbell, P. F., Griffin, M. J., & Malkus, N. N. (2017) Factors influencing elementary mathematics specialists' impact on student achievement. In M. McGatha & N. Rigelman (Eds.). *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning.* Charlotte, NC: Information Age Publishing, 193-201.

Campbell, P. F., & Malkus, N. N. (2011). The impact of elementary mathematics coaches on student achievement. *The Elementary School Journal, 111*(3), 430-454.

Galindo, E., & Newton, J., (Eds.). (2017). *Proceedings of the 39th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* Indianapolis, IN: Hoosier Association of Mathematics Teacher Educators.

Campbell, P. F., & Malkus, N. N. (2013). The mathematical knowledge and beliefs of elementary mathematics specialist-coaches. *ZDM The International Journal on Mathematics Education*. doi:10.1007/s11858-013-0559-6 or http://link.springer.com.echo.louisville.edu/article/10.1007/s11858-013-0559-6

Chval, K. B., Arbaugh, F., Lannin, J. K., van Garderen, D., Cummings, L., Estapa, A. T., & Huey, M. E. (2010). The transition from experienced teacher to mathematics coach: Establishing a new identity. *The Elementary Schools Journal, 111*(1), 191–216.

Coniam, S. (2010). Mathematics coaching and its impact on urban fourth grade students' mathematics proficiency on high stakes testing. In P. Brosnan, D. B. Erchick, & L. Flevares (Eds.), *Proceedings of the 32nd annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. VI, pp. 1379–1386). Columbus, OH: The Ohio State University.

Conference Board of the Mathematical Sciences. (2001). *The mathematical education of teachers*. Providence, RI and Washington, DC: American Mathematical Society & Mathematical Association of America.

Conference Board of the Mathematical Sciences. (2012). *The mathematical education of teachers II* (CBMS Issues in Mathematics Education, Vol. 17). Providence, RI and Washington, DC: American Mathematical Society and Mathematical Association of America. Available at http://cbmsweb.org/MET2/met2.pdf.

Dossey, J. (1984). Elementary school mathematics specialists: Where are they? *The Arithmetic Teacher, 32*(3), 3, 50.

Fennell, F. (2006). We need elementary school mathematics specialists now. *NCTM News Bulletin*, *43*(4).

Gerretson, H., Bosnick, J., & Schofield. K. (2008). Promising practice: A case for content specialists as the elementary classroom teacher." *The Teacher Educator Journal, 43*(4), 302–314.

Gibbons, L. K. (2017). Examining mathematics coaching practices that help develop schoolwide professional learning. In M. McGatha & N. Rigelman (Eds.). *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning.* Charlotte, NC: Information Age Publishing, 167-174.

Gibbons, L. K., Garrison, A. L., & Cobb, P. (2011, April). *Teacher networks and the role of the mathematics coach: How institutional factors influence coach centrality.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Gibbons, L. K. & Cobb, P. (December, 2016). Content-focused coaching: Five key practices. *Elementary School Journal.*

Gibbons, L. K. & Cobb, P. (2017). Focusing on teacher learning opportunities to identify potentially productive coaching activities. *Journal of Teacher Education.*

Gojak, L. M. (2013, May 8). It's elementary! Rethinking the role of the elementary classroom teacher. *NCTM Summing Up.*

Harrison R., Higgins, C., Zollinger, S., Brosnan, P., and Erchick, D. (2011). Mathematics Coaching Program fidelity and its impact on student achievement. Brief research report. In L. R. Wiest & T. Lamberg (Eds.), *Proceedings of the 33rd annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* (Vol. VII, pp. 1545–1553). Reno, NV: University of Nevada.

Krupa, E. E., & Confrey, J. (2010). Teacher change facilitated by instructional coaches: A customized approach to professional development. In P. Brosnan, D. B. Erchick, & L. Flevares (Eds.), *Proceedings of the 32nd annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. VI, pp. 1465–1473). Columbus, OH: The Ohio State University.

Lott, J. (2003). The time has come for Pre-K-5 mathematics specialists. *NCTM News Bulletin*.

Markworth, K. A. (2017). Elementary mathematics specialists as mathematics teachers. In M. McGatha & N. Rigelman (Eds.). *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning.* Charlotte, NC: Information Age Publishing, 203-210.

McGatha, M. (2008). Levels of engagement in establishing coaching relationships. *Teacher Development, 12*(2), 139–150.

McGatha, M. (2009). Mathematics specialists and mathematics coaches: What does the research say? In J. R Quander (Ed.) *NCTM Research Briefs*. Reston, VA: NCTM.

McGatha, M., Davis, R., & Stokes, A. (2015). The impact of mathematics coaching on teachers and students. In M. Fish (Ed.) *NCTM Research Briefs.* Reston, VA: NCTM.

McGatha, M. B. & Rigelman, N. F. (Eds.). (2017) *Elementary mathematics specialists: Developing, refining, and examining programs that support mathematics teaching and learning.* Charlotte, NC: Information Age Publishing.

McGrath, C., & Rust, J. (2002). Academic achievement and between class transition time for self-contained and developmental upper-elementary classes. *Journal of Instructional Psychology, 29*(1), 40–43.
National Council of Teachers of Mathematics (NCTM). (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.
National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.
National Council of Teachers of Mathematics. (2003). *NCTM NCATE standards for elementary mathematics specialists*. Reston, VA: Author.
National Council of Teachers of Mathematics (NCTM). (2007). *Mathematics teaching today.* Reston, VA: Author.
National Council of Teachers of Mathematics. (2003). *NCTM CAEP standards for elementary mathematics specialists*. Reston, VA: Author.
National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel*. Washington, DC: United States Department of Education.
National Research Council. (1989). *Everybody counts: A report to the nation on the future of mathematics education*. Washington, D.C.: National Academy Press.
National Research Council. (2001). *Adding it up: Helping children learn mathematics*. Washington, D.C.: National Academy Press.
Neuberger, J. (2012). Benefits of a teacher and coach collaboration: A case study. *Journal of Mathematical Behavior*, *31*(2), 290–311.
Nickerson, S. D. (2010). Preparing experienced elementary teachers as mathematics specialists. *Investigations in Mathematics Learning, 2*(2)*,* 51-68.
Obara, S. & Sloan, M. (2009). The evolving role of a mathematics coach during the implementation of performance standards. *The Professional Educator*, *33*(2), 346-370.
Olson, J. C. (2005). Evoking pedagogical curiosity: A coaching approach to support teacher's professional growth. *The Mathematics Educator, 8*(2), 84–94.
Olson, J. C., & Barrett, J. E. (2004). Coaching teachers to implement mathematics reform recommendations. *Mathematics Teacher Education and Development, 6*, 63–78.
Polly, D. (2012). Supporting mathematics instruction with an expert coaching model. *Mathematics Teacher Education and Development, 14*(1), 78–93.
Race, K., Ho, E., & Bower, L. (2002, April 1–5). *Documenting in-classroom support and coaching activities of a professional development program directed toward school-wide change: An integral part of an organization's evaluation efforts.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.
Reys, B, & Fennell, F. (2003). Who should lead mathematics instruction at the elementary school level? A case for mathematics specialists. *Teaching Children Mathematics, 23*(4).
Rudd, L., Lambert, M., Satterwhite, M., & Smith, C. (2009). Professional development + coaching = enhanced teaching: Increasing usage of math mediated language in preschool classrooms. *Early Childhood Education Journal*, *37*(1), 63–69.
Sutton, J. T., Burroughs, E. A., & Yopp, D. A. (2011). Coaching knowledge: Domains and definitions. *Journal of Mathematics Education Leadership, 13*(2), 13–20.
Zollinger, S., Brosnan, P., Erchick, D. B., & Bao, L. (2010). Mathematics coaching: Impact on student proficiency levels after one year of participation. In P. Brosnan, D. B. Erchick & L. Flevares (Eds.), *Proceedings of the 32nd annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. VI, pp. 1379–1386). Columbus, OH: The Ohio State University

Galindo, E., & Newton, J., (Eds.). (2017). *Proceedings of the 39th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* Indianapolis, IN: Hoosier Association of Mathematics Teacher Educators.