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Creating Systems for Improving the Quality of Mathematics Teaching and Learning on a Large Scale

In this paper, I outline a theory of action for improving the quality of mathematics teaching and students' learning on a large scale. This theory of action was developed in the course of an eight-year collaboration with four large urban school districts in the US that served a total of 360,000 students. These collaborations provided a context in which we could iteratively test, revise, and elaborate our conjectures about potentially productive instructional improvement strategies.

Our four partner districts were all attempting to support teachers' development of instructional practices that would enable their students to attain rigorous student learning goals that encompass conceptual understanding, problem solving, and mathematical communication as well as procedural fluency. The development of ambitious instructional practices of this type requires significant learning for most US mathematics teachers (Franke, Kazemi & Battey 2007). In consultation with district leaders, we then selected approximately six middle-grades (or lower secondary) schools in each of the four districts that were representative of district schools in terms of their capacity for instructional improvement. We then recruited 30 middle-grades mathematics teachers in each district, the school leaders and the mathematics coaches who served these schools, as well as district leaders across central office units, for a total of approximately 50 participants in each district. The data collected in each district each year included: audio-recorded interviews conducted with all participants; online surveys for teachers, coaches, and school leaders; an assessment of teachers' and coaches' mathematical knowledge for teaching; video-recordings of two consecutive lessons in each teacher's classroom; video-recordings of professional development; and audio-recordings or video-recordings of teacher collaborative meetings.

Each year, we conducted a data collection, analysis, and feedback cycle in each district that involved 1) documenting the district's improvement strategies, 2) collecting and analyzing data to assess how these strategies were playing out in schools and classrooms, and 3) reporting the findings to district leaders together with recommendations about how they might revise their strategies to make them more effective. A retrospective analysis indicated that the districts took up 67% of the 162 recommendations that we made to them on the course of the project. This gave us an opportunity to investigate and, as necessary, revise, the conjectures on which our recommendations were based.

In: Kerstin Hein, Cathleen Heil, Silke Ruwisch & Susanne Prediger (Hrsg.). Beiträge zum Mathematikunterricht 2021. Münster: WTM Verlag. https://doi.org/10.37626/GA9783959871846.0
Online unter https://eldorado.tu-dortmund.de/handle/2003/30630

Theory of Action for Instructional Improvement in Mathematics at Scale

The resulting theory of action comprises three top-level components: a coherent instructional system, school leaders' practices as instructional leaders in mathematics, and district leaders' practices in supporting the development of school-level capacity for instructional improvement (Cobb, Jackson, Hendrick, & Smith, 2018). The first of these components, a coherent instructional system, in turn comprises three broad elements as shown in Figure 1: goals for students' mathematics learning and a vision of high-quality mathematics instruction; instructional materials and assessments; a teacher learning (sub)system; and additional supports for currently struggling students (see Figure 1). Due to space limitations, I focus primarily on the teacher learning (sub)system, in the remainder of this paper.

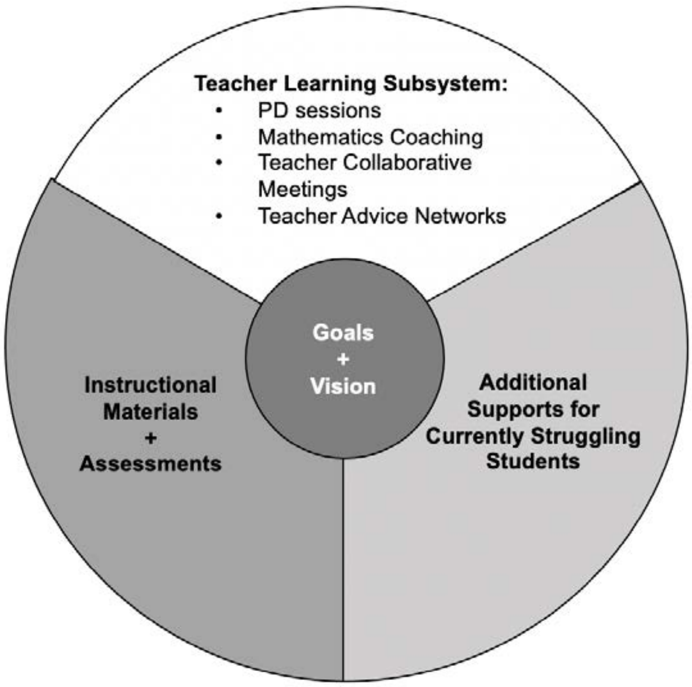

Figure 1: Elements of a coherent instructional system

US mathematics educators have reached a broad consensus on worthwhile learning goals, which emphasize both conceptual understanding of key mathematical ideas and procedural fluency. A substantial body of evidence indicates that ambitious instructional practices that aim at these rigorous learning goals involve engaging students in cognitively demanding tasks that have multiple entry points and can be solved in a range of different ways, thereby enabling the teacher to organize a productive discussion of students' mathematical reasoning. It is therefore important that the instructional materials teachers use as the basis for their instruction include sufficiently challenging tasks. Our four partner districts all provided teachers with such materials.

Teacher Learning (Sub)System

The vision of ambitious instruction located at the center of the instructional system constitutes the goal for teachers' learning. Our analysis of the participating teachers' instruction indicated that their development of such practices would involve significant learning for most of them. There is evidence that, at least in the US context, that PD sessions alone are frequently insufficient to support teachers' development of ambitious practices (Borko, 2004). Although all four partner districts providing PD, mathematics coaching, and time for mathematics teachers to collaborate during the school day, these different types of support typically differed in their intent and focus. Our analyses of the participating teachers' instruction served to emphasize the importance of systematically coordinating these supports so that teachers' efforts to improve particular aspects of their practice in one setting either built on or foreshadowed their work in the other settings (Jackson & Cobb, 2013).

Teacher professional development. US school districts often organize teacher professional development (PD) sessions for teachers from multiple schools by grade level. The PD is typically designed and led by either the district's mathematics specialists or by an external contractor. Although PD sessions on their own might be insufficient to support teachers' development of ambitious instructional practices, they can be an important element of a teacher learning (sub)system as they enable district leaders to communicate consistent expectations for mathematics teaching and learning to teachers from multiple district schools. PD sessions are particularly appropriate for activities in which teachers investigate the impact of aspects of their instruction on students' learning (e.g., analyzing students' work). However, additional types of support are needed to enable teachers to learn to enact new practices in their classrooms.

Teacher collaborative meetings. At various points during our work with the four districts, they all required principals to schedule time during the school day for teacher collaborative meetings. However, we found that teachers' work in these meetings was unlikely to support their development of ambitious instructional practices. In reaching this conclusion, we followed Coburn and Russell (2008) in distinguishing between low-depth and high-depth activities. Low-depth activities include sharing instructional materials and coordinating the pacing of instruction so that all the participating teachers are teaching the same topics. High-depth activities include working on mathematics tasks together in order to identify the central mathematical ideas, and analyzing student work in order to identify the range of student thinking on which they can build during lessons. In addition to assessing the types of activities in which teachers engaged, we also investigated how those activities were enacted during teacher collaborative meetings. This analysis found that in meetings that had the potential to support the participating teachers' development of ambitious instructional practices, the teachers connected mathematical learning goals, students' reasoning, and instruction as they enacted high-depth activities (Horn, Kane, & Garner, 2018). Unfortunately, only a minority of teacher collaborative groups engaged in high-depth activities, and that only a small proportion of these groups' enactments of high-depth activities connected mathematical learning goals, students' reasoning, and instruction (Horn et al., 2018). It was also noticeable that productive teacher collaborative meetings were almost invariably facilitated by a coach or teacher leader who had already developed ambitious instructional practices and who had expertise in supporting teachers' learning. These facilitators engaged teachers in potentially productive activities and continually pressed them to justify their pedagogical claims and proposals in terms of students' learning opportunities. The establishment of this norm for what counted as a legitimate pedagogical argument in turn enabled teachers to better understand each other's pedagogical reasoning by making the why of instruction an explicit focus of group conversations (Horn et al., 2018).

Mathematics coaching. The position of mathematics coach has become relatively common in large US districts. Some districts expect coaches to support groups of teachers as they plan for and then analyze their instruction whereas others expect coaches to work one-on-one with individual teachers in their classrooms. In our view, it is crucial in the US context that coaches spend at least a portion of their time working one-on-one with teachers given the significant learning required for most teachers to develop ambitious instructional practices.

As a first step in clarifying key aspects of high-quality one-on-one coaching, we sought to identify coaching activities for which there is evidence that they can support teachers' development of ambitious instructional practices. This analysis resulted in the identification of three types of activities: modeling instruction, co-teaching, and enacting the coaching cycle by co-planning an upcoming lesson with the teacher, then teaching the lesson, and finally debriefing the lesson and the students' learning (Kane, Cobb, & Gibbons, 2018). Recent findings also indicate that the initial planning phase of the coaching cycle can support teachers in understanding the function of particular instructional practices in supporting students' learning (Russell et al., 2020), and that the final debrief phase can support them in assessing the influence of instruction on students' learning and in identifying areas for future improvement (Kochmanski, 2020). However, these teacher learning opportunities only arise if the coach supports the teacher in connecting mathematical learning goals, students' reasoning, and instruction when planning a lesson and when analyzing the enactment of the lesson. In this regard, there is a striking parallel between high-quality one-on-one coaching, productive teacher collaborative meetings, and high-quality formative assessments as they all involve analyzing instruction in order to understand why the students learned what they actually learned, and lead to the identification of instructional weaknesses that can then become instructional improvement goals.

Teacher advice networks. Prior research indicates that teachers' interactions with colleagues in which they seek advice about instruction can be an important support for their adoption of new technologies (Daly, Moolenaar, Bolivar, & Burke, 2010). These findings led us to investigate whether this is also the case for mathematics teachers' development of ambitious instructional practices. An initial analysis of our network data found that teachers' interactions with colleagues whose instructional practices were more sophisticated supported the development of the advice seeking teacher's practices (Sun, Wilhelm, Larson, & Frank, 2014). However, we found that teachers' advice-seeking interactions with colleagues with more sophisticated mathematical knowledge for teaching (MKT) supported improvements in the teachers' MKT only in schools in which the coach's MKT was relatively sophisticated. One possible explanation for this finding concerns coaches' influence on how teachers interact with each other. Coburn and Russell (2008) found that coaches who had developed sophisticated MKT were more likely to press teachers on content-specific issues, and that this in turn influenced issues on which teachers sought advice from colleagues.

A subsequent project analysis investigated whether teachers' participation in collaborative meetings influences their advice seeking outside the meetings (Horn, Garner, Chen, & Frank, 2020). The findings indicate both that it is the quality of the conversations in teacher collaborative meetings rather than the number of meetings that influences teachers' advice seeking, and that the influence of productive teacher collaborative meetings on teachers' advice seeking appears to hold up for at least a year. It is likely that teachers learned about their colleagues' expertise and began to build trust in the meetings, which led them to turn to each other for advice outside of meetings. Thus, the work of accomplished facilitators in ensuring that teacher collaborative meetings are productive can lead to more productive teacher collaboration outside the meetings, thereby further supporting teachers' development of ambitious instructional practices.

Taken together, these findings extend previous work by indicating that network interactions can also be an important support for teachers' learning when the focus is on ambitious instructional practices. The findings also indicate the crucial contribution that teachers whose instructional practices are relatively sophisticated can make to instructional improvement efforts. In our view, a key aspect of school and district instructional leadership involves identifying such teachers and leveraging their expertise.

Supplemental Supports for Currently Struggling Students

This final element of a coherent instructional system emerged as significant only after we had begun working with our partner districts. As part of their responses to accountability pressures, all 30 participating schools invested significant resources to identify and provide supplemental instruction to students who were likely to perform badly on external assessments. This supplemental instruction typically consisted of either tutoring or second mathematics classes that focused on procedural competencies. A retrospective analysis revealed that these supplemental supports were, for the most part, ineffective but were also sometimes detrimental (Schmidt, 2013). However, there were some indications that second mathematics classes might be productive if their primary goal is to enable students who are currently struggling to participate fully in and learn from their primary mathematics classes and if the teachers of the primary and supplement classes coordinate the two classes (Wilson & Kelly, 2018).

Conclusion

In the first part of this article, we gave an overview of the approach we took for partnering with educational systems to investigate what it takes to support improvements in the quality of mathematics instruction on a large scale. We then focused on a key component of our theory of action for instructional improvement, a coherent instructional system. It is important to acknowledge that the theory of action was developed in the US educational context. Some adaptations will therefore be required to take account of how educational systems are organized in other countries and of contextual factors such as teachers' positioning in education systems and of traditions of pedagogy in those countries (Ryve & Hemmi, 2019). However, we anticipate that the general approach of framing instructional improvement at scale as a problem of organizational learning will prove relevant across national contexts.

The project on which I have focused was large, spanned multiple years, and required significant funding. It is therefore important clarify that relatively small studies that investigate the development of key aspects of system-level capacity for instructional improvement can also make significant contributions. The field of mathematics education has made significant progress in documenting trajectories of students' learning in specific mathematical domains, clarifying instructional practices that support students' attainment of worthwhile learning goals, and investigating PD models for supporting teachers' development of those practices. However, this work has had only limited impact on typical mathematics instruction in most countries. There is abundant evidence that the standard approach of researchers first developing innovative curricular materials and instructional models, and then handing them over to practitioners for implementation is ineffective. In my view, there is a pressing need for investigations that both challenge this seemingly take-for-granted division of labor between researchers and practitioners and that frame large scale instructional improvement as an explicit focus of investigation. In the absence of such investigations, mathematics education research is unlikely to realize its potential and contribute to improvements in the quality of mathematics instruction for large numbers of students.

References

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

Cobb, P., Jackson, K., Henrick, E., & Smith, T. M. (2018). *Systems for instructional improvement: Creating coherence from the classroom to the district central office*. Cambridge,MA: Harvard Education Press.

Coburn, C. E., & Russell, J. L. (2008). District policy and teachers' social networks. *Educational Evaluation and Policy Analysis, 30*(3), 203-235.

Daly, A. J., Moolenaar, N. M., Bolivar, J. M., & Burke, P. H. (2010). Relationships in reform: The role of teachers' social networks. *Journal of Educational Administration, 48*, 359–391.

Franke, M. L., Kazemi, E., & Battey, D. (2007). Mathematics teaching and classroom practice. In F. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 225–256). Greenwick, CT: Information Age Publishing.

Horn, I. S., Garner, B., Chen, I.-C., & Frank, K. (2020). Seeing colleagues as learning resources: The influence of mathematics teacher metings on advice-seeking social networks. *AERA Open, 6*(2), 1-19. doi:10.1177/2332858420914898

Horn, I. S., Kane, B. D., & Garner, B. (2018). Teacher collaborative time: Helping teachers make sense of ambitious teaching in the context of their schools. In P. Cobb, K. Jackson, E. Henrick, T. Smith, & MIST team (Eds.), *Systems for instructional improvement: creating coherence from the classroom to the district central office* (pp. 93-112). Cambridge, MA: Harvard Education Press.

Jackson, K., & Cobb, P. (2013). Coordinating professional development across contexts and role groups. In M. Evans (Ed.), *Teacher education and pedagogy: Theory, policy and practice* (pp. 80-99). Cambridge, UK: Cambridge University Press.

Kane, B. D., Cobb, P., & Gibbons, L. (2018). Understanding content-specific instructional coaching. In P. Cobb, K. Jackson, E. Henrick, T. Smith, & MIST team (Eds.), *Systems for instructional improvement: creating coherence from the classroom to the district office* (pp. 113-134). Cambridge, MA: Harvard Education Press.

Kochmanski, N. (2020). *Aspects of high-quality mathematics coaching: What coaches need to know and be able to do to support individual teachers' learning.* (Doctoral dissertation). Vanderbilt University, Nashville, TN.

Russell, J. L., Correnti, R., Stein, M. K., Thomas, A., Bill, B., & Speranzo, L. (2020). Mathematics coaching for conceptual understanding: Promising evidence regarding the Tennessee Math Coaching Model. *Educational Evaluation and Policy Analysis, 42*, 439–466.

Ryve, A., & Hemmi, K. (2019). Educational policy to improve mathematics instruction at scale: conceptualizing contextual factors. *Educational Studies in Mathematics, 102*, 379–394.

Schmidt, R. (2013). *Unpacking tracking: The role of instruction, teacher beliefs and supplemental courses in the relationship between tracking and student achievement.* (Unplublished doctoral dissertation). Vanderbilt University, Nashville, TN.

Sun, M., Wilhelm, A. G., Larson, C. J., & Frank, K. A. (2014). Exploring colleagues' professional influence on mathematics teachers' learning. *Teachers College Record, 116,* 1-30.

Wilson, J., & Kelley, D. (2018). Supplemental supports for currently struggling students. In P. Cobb, K. Jackson, E. Henrick, T. M. Smith, & t. M. team (Eds.), *Systems for instructional improvement: Creating coherence from the classroom to the district office* (pp. 169-179). Cambridge, MA: Harvard Education Press.