

Cite as: Hauk, S., & Speer, N. (2023). Decentering and interconnecting as professional skills in the preparation of new college mathematics instructors. In S. Cook, B. Katz, and D. Moore-Russo (Eds.). *Proceedings of the 25th Annual Conference on Research in Undergraduate Mathematics Education* (pp. 895-905). Omaha, NE.

Decentering and Interconnecting as Professional Skills in the Preparation of New College Mathematics Instructors

Shandy Hauk
San Francisco State University

Natasha Speer
University of Maine

Making progress in justice, equity, and diversity in post-secondary teaching and learning requires systemic change. The development of novice instructor professional knowledge is a critical subsystem of the undergraduate mathematics education system. Novices play key roles in instruction and have the potential to play key roles in change efforts later in their careers. Yet, there is little in the way of theory to support research and development in this area. In other fields, professional development that engages novices in building skill at self-sustaining, generative change as professionals is the ground in which agency for change is seeded and nurtured. We describe two dimensions of professional skills for interacting with ideas and people: decentering and interconnecting. In this report, we explore and illustrate the role of these dimensions in professional development for novice college mathematics instructors.

Keywords: professional development, novice instructors, TAs, decentering

Research in the undergraduate mathematics education (RUME) community has generated findings, materials, and programs that have shaped today's post-secondary mathematics instruction. Changes that leverage this research often occur as a result of efforts by "change agents"—people who notice and seize upon opportunities for improvement who work with others to enact change. Some things are known about the work and characteristics of change agents in undergraduate education (e.g., Froyd et al., 2008; Henderson et al., 2011). However, despite their key roles in undergraduate education, much remains to be learned about how someone becomes a change agent. The work of the RUME community has advanced the teaching and learning of undergraduate mathematics through curricula informed by research, innovations in assessment, programs to support instructors and many other things. For such efforts to reach more students, we need to ensure that future faculty have the knowledge, skills, and dispositions to be change agents and to successfully leverage the RUME work as they initiate and sustain change.

Twenty-first century approaches in professional learning about college teaching have included opportunities for novices to imagine and build purposefully towards future-self goals – addressing questions like “How will I define my professional success as an instructor? How will I measure that and be accountable for it?” If we also want instructors to consider and answer the question, “How will I contribute to innovative change in my professional community?” this needs to be a focus of professional learning opportunities we offer. Thus, we need to consider how professional learning can support novices to become effective instructors now while also positioning them as the next generation of those who act as agents of positive change.

Take any example where a department seeks to implement a program innovation and questions arise: What needs to be happening for new instructors so they can teach in the targeted ways? And, later, when a person graduates from Innovative U. and lands a job at Status Quo College, how does that person – who is a relative novice in college mathematics instruction and departmental politics – initiate and maintain productive exchanges with others to improve teaching and learning? The answers to both questions include building social and management skills for interacting with structures and power constraints in various ways (Elizondo et al., 2020). For change that disrupts the academic mathematics status quo, skills must be grounded in an understanding of the norms and values of the status quo, how those are different from and

similar to new norms and values (e.g., those anchored in justice and anti-racism), how to enact change from the former to the latter, and how to determine the nature of the success of the change (and start a new cycle of change based on it).

Change requires non-linear, multi-dimensional, and context-sensitive efforts. To succeed as a change agent, one needs awareness and knowledge about subsystems, understanding and anticipation about how those subsystems connect, interact, and influence one another, and skill at seizing opportunities to generate new learning from each professional encounter. Creating equitable, inclusive mathematics learning opportunities for students requires an analogous set of skills and knowledge. As part of a larger effort (Hauk & Speer, forthcoming), this report presents two theory-driven dimensions of professional learning and illustrates how they apply to the design of professional development about teaching for novice instructors. We argue that these dimensions (decentering and interconnecting) serve today's novice instructors both to be better equipped as instructors and to navigate future demands and function as change agents in tomorrow's departments and universities¹.

Decentering as a Professional Skill

Around the world, mathematics courses and programs in most post-secondary institutions are built on an instructor-centered model (PCAST, 2012). This approach has been effectively self-sustaining for many decades. The practice of lecturing has been passed on from generation to generation of college teachers through personal classroom experiences and through graduate school training with curricula that preserve lecturing as the status quo. Now, however, it is clear that an instructor-centered approach is not universally effective or appropriate (see, e.g., Abell et al., 2018; Bressoud et al., 2015; Freeman et al., 2014; Laursen et al., 2014). That is, instructor-DEcentered methods are needed.

Research on instructor-decentered approaches has paralleled research about equity in post-secondary teaching. Both point to the value of student-centered methods. It is worth noting that explicitly, at this moment in the educational research and practice communities (and more broadly) there is not a well-defined, crisp, and shared definition of equity (Aguirre, et al. 2017; Gutiérrez 2012). Beyond “fairness,” equity is evidenced by the absence of disparities: membership in a group that has been historically disadvantaged or oppressed is not correlated to access to opportunities, attainment of educational outcomes, or achievement of life goals. Our use of equity is in the spirit of this definition.

The apprenticeship of observation is powerful. People tend to teach the way they were taught (Lortie, 1975). It is important for novice instructors to experience teaching that models and provides touchpoints in their efforts to teach differently (e.g., more equitably). For example, professional learning opportunities can be offered in ways that model instructor decentering. Thus, novices can refer to how they have recently been taught, in professional development, to contrast with the power-culture-driven, instructor-centered experiences that likely make up the bulk of their histories as learners.

What is Decentering?

Successful implementations of the kinds of instructional practices described as equitable call for teaching that elicits and utilizes student contributions and student choice (Jacobsen et al.

¹ Note: This report is not a primer on how to design professional learning about teaching for novice instructors (for that, see, e.g., Bragdon et al., 2017; College Mathematics Instructor Development Source [CoMInDS], 2021; Council of Graduate Schools, 2021; Deshler et al., 2015; Saichai & Theisen, 2020 and references therein).

2012). The expectation emerging from research and practice is that instructors facilitate discussions to which students contribute their thinking and voices. This kind of instructional decentering is, at its most basic, the act of seeing from someone else's point of view and has historical roots in the work of Piaget (1955). It entails the instructor engaging with students as a participant in interaction, rather than as the center of interaction.

In decentering, instructional attention is on uncovering, understanding, and expanding on what students know and do to include novel, non-standard, and standard mathematical ideas and methods (Carlson et al., 2007; Rahman, 2018; Teuscher et al., 2016). Being self-aware and facilitating self-aware learning by students are the focus (instead of attention and authority vested largely in the instructor). Decentering requires attention to other people as (potentially) different from oneself, noticing nuances in similarity and difference between one's own views or experiences and those of others. In its most developed forms, decentered instructors bridge across similarities and differences in formulating in-the-moment responses to situations.

An important step in building skill at noticing how the thinking of students is similar to or different from an instructor's own is creating the opportunity in one's classroom to hear and see student thinking. Decentering depends on a variety of individual instructor factors (e.g., self-knowledge, goals, orientations, beliefs, psycho-social challenges).

Novice instructors need to learn how to create, maintain, and manage classroom environments where undergraduates are participants in student-centered ways. This includes instructors learning about many things from a student-centered perspective, such as content, curriculum, and assessment (Bok, 2009), communication and interaction (e.g., related to classroom authority or socio-political factors, Gutiérrez, 2009, 2013; Winter & Yackel, 2000), as well as how to learn in and from instruction itself (Speer & Hald, 2008). Learning to elicit student thinking and learning how to shape instruction based on that thinking is the foundation on which generative change is built (Franke et al., 1998).

Development of Decentering Skills

Professional development can provide opportunities for instructors to build skill in decentering, along with other facets of cross- or intercultural competence. There is a developmental continuum for decentering: from an ethno-centric view that everyone is like me to an ethno-relative view, that any person (including me) is like and unlike every other person in identifiable and valuable ways (Bennett, 2004).

Some common components in professional development create opportunities for instructors to experience and learn about decentering (e.g., have novice instructors attempt the mathematics tasks from the course and come together to discuss them). Current research and development in RUME continues to provide ideas for the professional preparation of novices that include opportunities to model decentered instruction, from the CoMInDS collection (2021) to specific professional guidance on particular practices (e.g., cooperative learning using group-worthy tasks; Reinholz, 2018). We contend that if novices develop and use skills in decentering (and interconnecting, discussed next) in their work as instructors of mathematics they will be better prepared to leverage those skills in their future work as change agents.

Interconnecting as a Professional Skill

While decentering is awareness from within the perspectives of others, interconnecting uses meta-awareness to make connections across perspectives and contexts. This can occur at many levels and grain sizes. Such linking is essential in developing and nurturing coalitions, an essential component of local and systemic change (Kotter, 2012). A mathematics class is a

foundational opportunity for coalition. Many other structures and groups rely on and influence it. Figure 1 offers one way of seeing the relationships among people and instructional structures.

RUME reports describe many instructional practices, what happens inside the disk labeled INSTRUCTION in Figure 1. Some reports describe content aspects (Figure 1, MATH), others cognition by students (individually or jointly, as represented by the arrows in Figure 1). A few reports address what happens from the perspective of another layer in Figure 1, the region labeled PROFESSIONAL DEVELOPMENT. For those involved in *providing* professional development to new instructors, this report itself is a contribution to the outermost region in Figure 1, LEADERSHIP DEVELOPMENT.

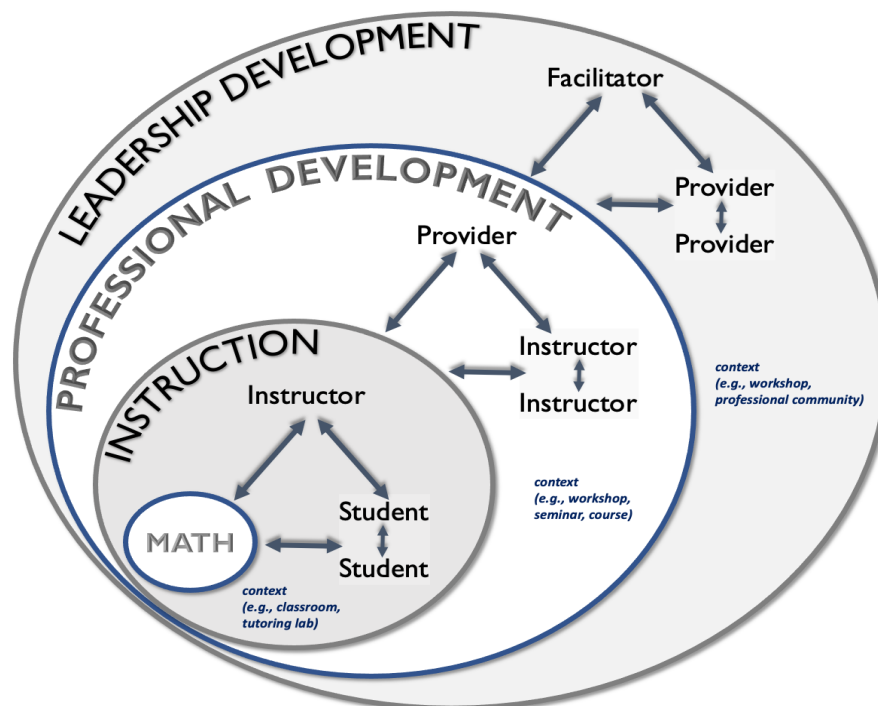


Figure 1. Model of the nested, self-similar systems of learning in mathematics (based on Carroll & Mumme, 2007).

Interconnecting: Examples

As an example, consider interconnecting rooted in the concept of derivative (MATH in Figure 1). If an instructor is aiming to help students learn about the idea of a derivative, instructional goals are influenced by what the instructor understands about students' knowledge of slope, ratio, and change. Interconnecting by the instructor involves noticing how students' conceptions may support or constrain the way learning progresses. That is, the instructor considers what is happening at the Students $\leftrightarrow$ Students node in Figure 1, where the kind of thinking brought to mind for students might include m in $y = mx + b$, previous experience with unit rate, experiences that discretize change (e.g., compare slope at point A to slope at point B), or treating change as covariational. Instructors develop skill at interconnecting by knowing these student conceptions as well as the dynamics of communicating about them in a multi-contributor, student-centered, context (the arrows in INSTRUCTION). Instructors also consider and link to students' thinking in selecting formats (e.g., group work on some problems, viewing a pre-class video for a topic). Instructors connect across and prioritize the mathematical and contextual factors, to decide what is instructionally useful. Novices learn about these interacting connections in and from their teaching and through professional development.

When someone embarks on providing professional development to support instructors to learn to teach, they are taking on the challenge of thinking at another layer out: a meta-meta-awareness of connections is required. Providers of professional development need to think about how to have novice instructors interact with ideas of mathematics teaching (and each other) in ways that will help those instructors think about how to support students to interact productively with mathematical ideas (and each other). Continuing the derivative example in the PROFESSIONAL DEVELOPMENT region of Figure 1, for the Provider there are additional considerations about what instructors will need to know and do if they are to create the desired learning opportunities for students. For example, identifying learning goals might occur in various professional activities (e.g., as a step in lesson design, or as a provided component in a set of curricular materials). Novice instructors also may need opportunities to learn about, have practice with, and connect across the mathematics of limit, limit quotient, and derivative along with instructional approaches that may be particularly effective (e.g., students working on a group-worthy task in which limits, rates, and limits of ratios are compared and contrasted). This, too, may occur through various professional learning tasks that are designed for use with novice college instructors (e.g., in an interactive activity, or in a teaching guide).

Also needed by novice instructors— as they notice and structure their understanding of a web of interconnections — is guidance about how to orchestrate mathematical and instructional ideas while decentering. This includes building knowledge about working in racially, ethnically, and linguistically diverse classrooms (e.g., a reading about student funds of knowledge and how to leverage those in teaching; González, et al., 2011) as well as creating and maintaining socio-mathematical and social norms in the classroom (e.g., a professional learning activity about what to do the first day of class to begin setting norms). These all make up the “content” of the professional development (in Figure 1, this includes the MATH, information about students and instructors as well as context knowledge from research and practice about the interaction arrows in INSTRUCTION back and forth among MATH, instructor, and students). Also part of the information that novice instructors interconnect is the learning about teaching they encounter in hallway conversations with colleagues and other informal interactions (Latulippe, 2009).

In particular, interconnecting includes instructors thinking about students’ thinking about mathematics. In an analogous fashion, those who provide professional learning opportunities must concern themselves with an additional level of interconnecting: Providers think about how instructors are thinking about how students are thinking about mathematics.

Development of Interconnecting Skills

Like decentering, skill at interconnecting develops from an ethno-centric to ethno-relative orientation (Hauk et al., 2015). It may begin in a self-focused denial of differences (e.g., no connections are needed since it is only MATH that matters). Further development of skills for interconnecting will go through a phase characterized by a tendency to polarize, to focus on mathematics as disconnected from human interaction (e.g., there is one best or right way to solve every problem). From there, development moves to a search for universals, connections that are compressed into a single process, but not multiple interconnected processes (e.g., there are “objective” or “mastery based” ways that are universally applicable to assess *all* students, and grades become the essential element of interaction for instructor and student, disconnected from students’ mathematical funds of knowledge). With time and intentional development, one can learn more about mathematical ideas, contexts, and human interactions and reflect on teaching with greater attention to relational details (e.g., learning about implicit bias and suddenly

noticing it in every word problem in the text), but how to use this knowledge to improve opportunities to learn, classroom climate, and interactions with others remains elusive. At its most developed, interconnecting is adaptive— networks of people and their interactions can be anticipated (enough) that teaching serves the needs of the people, and networks of people, in and outside the room (Hauk et al., 2014).

Interconnecting is important for change agents because they need to know how people, policies, and perspectives function in and across interacting systems (e.g., in and beyond those shown in Figure 1). The knowledge from that is extremely valuable when advocating for a change in one part of a (sub)system: one can anticipate how change in one place will cause or necessitate change in another.

Data-Driven Interconnecting and Decentering

It is clear from the variety in approach and the nature of successes in the research and practice literature that collecting and examining data for decision-making is valuable (Laursen, 2019). One method for planning for and examining the success of change that has been used effectively in RUME is the four frames or “lenses” model (Bolman & Deal, 1991; Reinholz & Apkarian, 2018). This model is one way of describing what is interconnected in change efforts. It involves considering the evidence of change in terms of **Structures**: rules, policies, procedures, management; **Power**: resource allocation, formal and informal seats/sources/sinks of power; **People**: demographics, experiences, needs; **Symbols**: meaning and culture, rituals and habits, stories, sensemaking.

End-of-term grades are only one form of readily accessible local data (like hearing from only one student in the classroom). In taking a systems approach to change, useful data for determining need and success are generated in intentional and inclusive ways, from across diverse stakeholder groups. Identifying stakeholder groups happens when change agents decenter, look outside themselves and the voices of the status quo.

More can be learned from collecting and analyzing types of data that are largely absent in existing reports: instructor and implementation data. Now is the time to interconnect across contexts. Examples of how to do that as part of the professional development of novice instructors include activities in which novices and/or providers:

- Gather observational data about the nature of classroom questions and answers (American Association for the Advancement of Science, 2013).
- Data-mine learning management systems for evidence of equitable and inclusive instruction (e.g., an audit of time/contributions to discussion fora broken down by student demographics, or a review with feedback to instructors of course sites in learning management systems using a rubric; Baldwin et al., 2018).
- Conduct surveys of instructors about practices and instructor interactional experiences of teaching – including experiences of racialized or sexualized or gendered interactions (Sue et al., 2011), repeat these types of data gathering, analysis, and reporting in and through the professional development experiences, where instructors are the learners.

Some tools for such data collection exist already (e.g., Laursen, 2019). However, next steps include moving into data gathering at the broader levels in Figure 1 and a group-level decentering that includes identifying and inviting outside experts to support connected knowledge growth about each other as thinkers and doers of instruction (Henderson et al., 2011; Reinholz, Stone-Johnson, et al., 2020). Such expertise will help programs create professional learning opportunities that are informed by research on equitable and just teaching development (including ideas learned in other disciplines, e.g., in biology, Gormally et al., 2016).

Generating the Future

As in any field, organizational change requires a multi-threaded effort across personal reflections, development, cycles of professional preparation, implementation, evaluation, administrative-level accountability, within and across-institution continuous improvement work, and broad policy efforts to support large scale change within and across subsystems (Deszca et al., 2019). Although individual humans play key roles in change, some have found it productive to view organizational change focused on interaction, foregrounding relationships among people as they communicate with each other and interact with organizational structures, symbols, and power (Elizondo et al., 2020; Kotter, 2012; Reinholz, Rasmussen, et al., 2020; Slemph et al., 2021). Students can only benefit from the efforts of the RUME community if people residing in mathematics departments can initiate and help sustain organizational change.

Many members of the undergraduate mathematics community have taken on roles as change agents, responding to needs and shaping efforts to improve teaching and learning. There may be additional benefits to the community if, in parallel with these efforts, we aim to develop and refine theory. The history of mathematics education includes many examples of the productive interplay between empirical research and theory development (e.g., studies of problem-solving and theory about meta-cognition, studies of teachers and theory about mathematical knowledge for teaching). Having additional theory-development around the characteristics, roles, knowledge, and skills of effective change agents would certainly be welcomed. That can further inform the theory-building efforts we have begun to lay out in this report.

We have asserted that decentering and interconnecting are key to success as a change agent. We based this assertion on examination of what organizational change entails. The research and practice communities will likely benefit if these claims are investigated in conjunction with organizational change efforts. Parallel efforts to create theory and enact change can lead to the accumulation of knowledge which can, in turn, inform the next cycle of efforts.

It is worth noting that change efforts can fail because people do not know about, or do not know to, pay attention to interconnected-ness and the complexity that comes from decentering. For example, it can be fatal to a change effort to focus attention on one thing (e.g., “all that is needed to reform how this course is taught is changing the textbook” or “student-centered instruction will fix the problem” see, e.g., Henderson, 2011). If we design and test ways of helping novices develop skill at decentering and interconnecting in their mathematics classrooms, that creates a foundation for further design and theory development for analogous skills used more broadly to contribute to change efforts in their departments.

As is true in the broader literature, collaboration by a group of change agents, not all of whom are mathematicians, is valuable (Laursen & Austin, 2020; McShannon & Hynes, 2005; Saichai & Theisen, 2020; Theobald et al., 2020). A corollary of acquiring skill at decentering is that it prepares one to be a participant in a collective effort (e.g., with a classroom full of students, with a department full of colleagues, with a cross-professions team). With attention to decentering and interconnecting, the next generation of change agents will be equipped to participate in the collective action required for future change.

Acknowledgments

A more extensive exploration of the ideas in this paper can be found in Hauk and Speer (in press). This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1432381, DUE DUE-1625215, and DUE-2021139.

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