Developing and Supporting Underrepresented Prospective Teachers' Pedagogical Content Knowledge for Teaching Diverse Students in High Needs Schools

Yaomingxin Lu
California State University, Fresno

Rajee Amarasinghe
California State University, Fresno

Sarah Hough
University of California, Santa Barbara

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Having an experienced, well-prepared teacher makes a difference to student outcomes (Cardichon, et al., 2020) and retaining teachers in high-needs schools is even more challenging. In particular, teachers of students in high needs schools need to transform content knowledge into a form appropriate for the diverse interests and abilities of students by drawing on culturally and linguistically appropriate instructional strategies and by building supportive and productive classroom practices. We operationalize components of Pedagogical Content Knowledge (PCK) (Shulman, 1987,1986) and Pedagogical Ways of Knowing (Cochran, et al, 1993) using the coding framework proposed by Meir et. al (2020) which draws from the mathematical practices (National Governors Association, 2010) and sets of instructional strategies for supporting students' mathematical literacy. The purpose is to understand in particular, how participants develop and utilize PCK that speaks to teaching diverse students in high needs schools.

A mixed methods sequential case study design (Creswell & Plano Clarke, 2018) was used, and participants are five Noyce scholars who have graduated from the program and transitioned to teaching in high-needs schools. We use longitudinal evaluation data collected from these participants during their sophomore and senior years in the integrated mathematics credential program as sources, in particular beginning teacher assessment data (TAD), open-ended interview transcripts and responses to closed and open-ended questionnaires.

Our result shows that participant average scores on the Beginning Teacher Assessment were higher than campus averages and that the Noyce mentoring program increases retention of integrated mathematics credential students in the major. In addition, thematic analysis of their TAD lessons and interviews evidenced the ways in which Noyce activities supported them as they integrated understanding of student characteristics and learning context, of mathematics specific pedagogy with their strong mathematical knowledge acquired in the Integrated Mathematics Credential Program. While an integrated Math Credential program is well positioned to foster in prospective teachers' connections between subject matter expertise and pedagogical competence our results suggest that the additional opportunities offered in the Noyce mentoring program are critical in order to develop the types of pedagogical content knowledge necessary to teach in high-needs schools.

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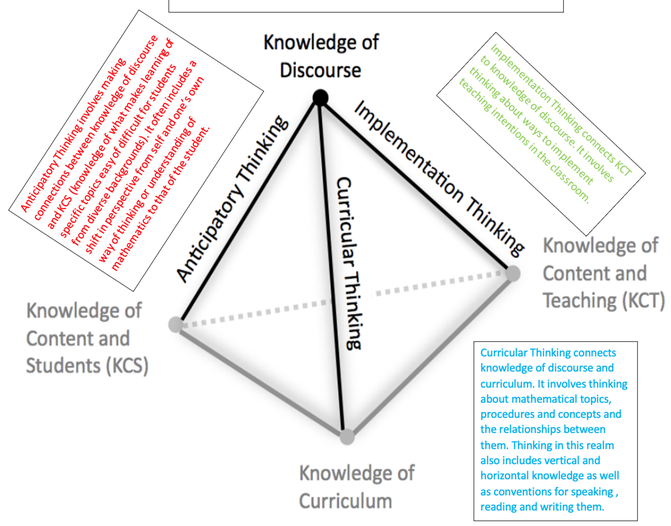
Yao Lu, Rajee Amaral Nair, Sarah Hough
California State University, Fresno

Introduction

Having an experienced, well-prepared teacher makes a difference to student outcomes (Cardichon, et al., 2020) and retaining teachers in high-needs schools is even more challenging. In particular, teachers of students in high needs schools need to transform content knowledge into a form appropriate for the diverse interests and abilities of students by drawing on culturally and linguistically appropriate instructional strategies and by building supportive and productive classroom practices. This study, set in the context of a Noyce-funded mentoring program where participants are underrepresented and talented integrated mathematics credential majors, addresses how prospective teachers can be concurrently supported in a rigorous mathematics program as they develop the deep pedagogical knowing so necessary for teaching students in high needs settings.

Framework for Pedagogical Content knowledge

Discourse refers to the socio-mathematical norms of the classroom. It includes the roles and communication pathways between students, between student and teacher and what counts as "doing mathematics" in that classroom



Methods

A mixed methods sequential case study design (Creswell & Plano Clarke, 2018) was used. Participants are five Noyce scholars who have graduated from the program and transitioned to teaching in high-needs schools. We use:
Longitudinal evaluation data collected during sophomore and senior years in the GotMATH program sources:

- Beginning teacher assessment data (TAD)
- Open-ended interview transcripts
- Responses to closed and open-ended questionnaires
- Reflections from teaching and learning seminars.

Integrated Mathematics Teaching Credential

Year 1	Year 2	Year 3	Year 4
Calculus II and III, Transition to proof, Physics I	Differential equations, Linear algebra, Math problem solving , Social context of teaching and learning	Intro statistics,Principles of algebra, Real analysis, Capstone math for teaching, computer programming	Student teaching seminars, Secondary math methods, Adolescant development & learning, Teaching English learners, Math literacy and communication, Differentiated instruction.
		1st Noyce Year	2nd Noyce Year

Individual Content Mentoring

Early Field experiences (eg. Math circles, tutor, grading)

Student teaching experience

Instructional Assistant

Noyce Teaching and Learning Seminars

Conference attendance

The mathematics integrated credential program gives students opportunities to complete a B.S. in mathematics and a secondary teaching credential in four years. The **Got MATH scholarship and mentoring program** supports high achieving, diverse students in the program who are committed to teaching in high needs schools.

GotMATH provides individual and group content mentoring. Early field experiences allow mathematical and pedagogical knowledge to develop simulataneously and Noyce Teaching and Learning seminars given by university and school based mathematics educators model math specific PCK appropriate for underrepresented students in high needs schools.

Category	Code	Example of instance	Lorry	Jacob	Nathan	Bella	Nadine
Creating a meaningful context for instruction	KCS	Using a jeopardy game context for math exam review.	x	x			
	KCT	Group work with small white boards/game format.	x	x	x	x	x
Helping students produce discourse	Anticipatory Thinking	Asking questions to promote focus on math problem solving, strategies and argument.	x	x	x	x	x
	Implementation thinking Using sentence frames and/or sentence starters to support mathematical oral and written discourse.	Student answers to strategic questions were scaffolded with sentence frames to help them justify their reasoning about a problem.	x	x	x	x	x
	Implementation thinking Using word walls	Teacher creates written strategy bank as they are discussed in groups (for later use)			x	x	
	Anticipatory Thinking Using multiple modes for language (speaking, listening, reading, writing)	White boards/notebooks/ posters/exit tickets verbally expressing solutions to near peers and whole group/using visual aids	x		x	x	x
Making input comprehe nsible	Implementation thinking	Vocabulary and/or syntax support		x	x	x	x
		Implementation thinking Using visuals, drawings, gestures, or realia		x	x		x
Organizing instruction	Anticipatory thinking Strategically placing students in small groups based on needs	Group members are given responsibilities for ensuring all students understand how to solve the equations, so students with stronger understanding are instructed how to give helpful hints and explain their thinking.	x	x		x	x
	Anticipatory thinking	Monitoring student work during small group work to select groups to present.	x			x	
	Socio mathematical norm	Students self-select level of difficulty of problem type and progress upward.		x	x	x	x
	KCS	Working in teacher led small groups for extra instruction			x	x	x

Table 1. Mathematical Literacy Strategies to Engage in Mathematics Discourse Used by Noyce Beginning Teachers.

Results and Discussion

Participant average scores on the Beginning Teacher Assessment were higher than campus averages and our analysis of their TAD evidenced the ways that participants used anticipatory and implementation thinking as they drew from their strong mathematical backgrounds with and understanding of students and teachings to provide opportunities for their students to participate in mathematical discourse. In particular students in scholar classrooms were given opportunities to construct viable arguments and critique the arguments of others (MP3), use appropriate tools strategically (MP5), make sense of problems and persevere in solving them (MP1), look for and make use of structure (MP7) and/or make use of repeated reasoning (MP8) while learning important content standards.

Themes from our stage II analyses show that students in the mentoring program:

1. Valued multiple opportunities during Noyce seminars to experience and reflect on practices and strategies learned during credential courses within the specific context of teaching mathematics.
2. Learned about pedagogical issues specific to students living in poverty from experienced teachers working in local high-needs schools through the Noyce seminars.
3. Gained knowledge of students and content as well as knowledge of content and pedagogy from concurrent opportunities to work as instructional assistants on campus and tutors in elementary settings while themselves learning higher level mathematics content in major coursework (offered through Noyce)

Conclusions

Our result shows that participant average scores on the Beginning Teacher Assessment were higher than campus averages and that the Noyce mentoring program increases retention of integrated mathematics credential students in the major.

- In addition, thematic analysis of their TAD lessons and interviews evidenced the ways in which Noyce activities supported them as they integrated understanding of student characteristics and learning context, of mathematics specific pedagogy with their strong mathematical knowledge acquired in the Integrated Mathematics Credential Program.

While an integrated Math Credential program is well positioned to foster in prospective teachers' connections between subject matter expertise and pedagogical competence our results suggest that the additional opportunities offered in the Noyce mentoring program are critical in order to develop the types of pedagogical content knowledge necessary to teach in high-needs schools.

Contact

Yaomingxin Lu
California State University, Fresno
yaomingxinlu@csufresno.edu

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