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# BOARD # 224: Analysis of a Teaching School Model for Improving STEM Teacher Education, Development, and K-12 STEM Learning

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# NSF IUSE: Analysis of a Teaching School Model for Improving STEM Teacher Education and K-12 STEM Teaching

Providing meaningful and ambitious science, technology, Engineering, and mathematics (STEM), learning opportunities for all students requires an extremely high level of professional skill and judgment from teachers [1], [2], [3]. Fragmentation in teacher education, field experiences, and university learning is common for future teachers learning professional practice [4]. Broader systemic issues of educational inequity disproportionately exclude students from minoritized backgrounds from high-quality STEM learning environments [2], [5]. This demand for rigorous and rich STEM teaching is occurring while teachers, teaching, and teacher education have come under intense scrutiny, thus providing a moment of opportunity for dramatic re-envisioning of how we support practicing teachers and the education of the next generation of STEM teachers. In this paper, we present findings of our NSF IUSE funded study, an ongoing development and research effort that re-envisions STEM teaching, learning, and teacher education in a cradle-to-career learning campus that is a part of a large public school district. 96% of our students identify as Black or Brown and we are serving about 650 students. The vision of the learning campus, opened in 2019, is "Leaders Designing Change," which emphasizes human-centered design and Engineering (HCD-E) and social and community engagement.

Guided by sociocultural theory [6] and calls for dramatic systems change in education [7], we have developed and enacted innovative structures and systems for teaching, learning, and teacher education within a single school site that highlights and supports ambitious problem- and place-based teaching and learning (PPBL) in a model called the "Teaching School" (TTS). Like a teaching hospital, TTS hosts an intergenerational teaming structure from preservice educator development through residency for certified teachers in the first three years of teaching. TTS extends the time that university partners can continue to educate and support early career teachers to enact ambitious instruction. Research shows that student-centered, project- and place-based pedagogies are a vehicle for learning robust and rigorous content of STEM as well as generating a sense of belonging in STEM [8], [9]. Our campus centers and supports these pedagogical approaches, trains, and supports instruction through TTS model. The aims of TTS are to support deep knowledge of content, knowledge of and practice in how to teach STEM, understanding of our community, families, youth, and urban context. We have hosted over 100 preservice and student teachers, and 15 resident teachers who are teachers of record at the school for three years; 15+ attending teachers serve as veteran, expert teachers where novice teachers learn professional practice. We ask the following research questions as a part of this study:

1. How do beginning resident engineering teachers engage in the program and structures of the Teaching School and what PPBL inquiries were co-designed with members of TTS?
2. What are the constraints and affordances of the Teaching School model?
3. What student learning outcomes have been demonstrated?

## Design and method

This study draws on data collected over the last five years (2019-2024) in a high school in the midwestern United States operating in partnership with a large research university. We focus on four threads of data collection: 1) teaching video and reflections on teaching and learning in

residents' classrooms; 2) curricular materials, planning artifacts, co-development documents; 3) interviews, focus groups, and surveys of those participating and working within the Teaching School; and 4) student learning and survey data. Primary data were:

- Video of classes (residents' classes, focal video n=~25 each year/teacher) taught by three engineering teachers in grades 9, 11, and 12;
- Curricular maps, vertical alignment documents, inquiries and student projects co-developed with residents and attending teachers;
- One-on-one semi-structured interviews with resident teachers, attending teachers, student teachers, and interns (1-2x/year; over 50 hours of interviews)
- Residency seminars, professional development, and focus groups that highlighted instructional planning and pedagogical decision-making;
- Student learning data including standardized test data, formative assessments enacted by the district, and student survey data.

To document the opportunities for learning, learning outcomes, and teaching practice and development overtime, we used mixed and multiple methods of research to investigate the Teaching School and the learning outcomes of students. Data were analyzed using constant comparative method [10].

## Findings

The Teaching School model emphasizes the extended training of interns, student teachers, and then residents within a single school site as a way to learn deeply about a context and community and thus plan and enact meaningful and ambitious teaching and learning. Key activities that teachers engage in include aligned undergraduate coursework and pathways, intensive and scaffolded clinical experiences, and extended support through professional learning, one-to-one coaching, seminars during a three-year residency as a full teacher of record. Attending teachers also engage in professional learning and intergenerational mentorship around shared visions of ambitious teaching and learning. Our findings indicate positive outcomes for early career teachers who are enacting ambitious instruction, together with meaningful STEM learning outcomes for students. We have also documented that the Teaching School appears to keep both novice and veteran teachers in practice by offering extended and embedded teacher supports. Veteran teachers also express enthusiasm for their work because they are helping to develop a new generation of teachers.

*Co-development of Engineering curriculum and PPBL with resident teachers.* We analyzed the ways that residents in three grade levels of high school engineering teaching enacted literacy and language practices specific to this domain. We considered the ways that students engaged in this language and talk within work samples and outcomes. Using engineering disciplinary literacies framework, we documented the ways that students engaged in the engineering specific practices of "delimiting a social problem," "realizing a design solution," and "warranting a design solution" [11], [12]. Some of the inquiries developed through these design cycles of student learning, included the following questions:

- How can we make classroom spaces and shared spaces of our community comfortable and useful? How can these spaces advance the values of the school community?
- What are the assets of our community and how do we build on them?

- How can we advance student well-being when we are in an online and remote learning context (during COVID-related remote learning)?
- How does climate change impact on my local community, my state, and the world?
- What are the ethical dilemmas and possible benefits of AI and robotics in our everyday life?
- How can we strengthen community partners businesses and endeavors through internships and design work?

These inquiries were advanced in a design cycle fashion that engaged students in investigating challenges and celebrations of community and how to advance and act within these contexts for good. From 9th through 12th grade, students made use of engineering literacies and tools, such as *root cause analysis, 5 whys, stakeholder mapping, pitches,* and *design challenges*. We found that the co-development of these inquiries with teachers, attending teachers, university coaches, and university-based engineering colleagues, we were able to construct meaningful problem-spaces for students to develop these engineering tools, language, and design practices. Evidence indicates that teachers increasingly aligned their teaching to essential questions and honed instructional skills advancing this student learning. Additionally, through the analysis of teaching video and instruction, we found that engineering teaching residents, across courses and years, routinely attended to engineering literacy practices; overtime, engineering residents' instruction has become increasingly integrated and has grown in sophistication as observed by tailored scaffolding, navigation of literacy practices, and public-facing advocacy work for students to engage in their communities and neighborhoods.

*Structures of the Teaching School: Affordances and constraints.* Some of the affordances regularly cited by Teaching School participants were collaboration, shared visions for teaching, professional development and learning, and the ability to enact teaching that was meaningful and honored the skill of the teachers. Within the context of the Teaching School, interns, student teachers, and residents describe important constraints to the enactment of PPBL and for teaching within this particular context and public-school, district-based partnership. Some of the constraints cited were funding challenges, grading, and life/work balance among early career teachers. The structures of the Teaching School, an intergenerational team of support including a university coach, other embedded veteran teachers, and the attending mentor teacher that supported during student teaching, were cited regularly as helpful and important to enacting high quality engineering and STEM teaching. As one first year resident described:

> "I think the main thing for me right now is the support systems I have. So, I have [my mentor teacher], and I have a lot of other teachers at the school who are very helpful…Also, obviously, [my coach] is like amazing and has helped like basically do all of the work that I would have really struggled to do elsewhere, and has given me like a really solid footing."

The intergenerational and extended support provided "footing," meaningful and trusted mentorship inside the school community. It isn't only the breadth of the support, it is also about having a community with shared commitments to PPBL for social and community engagement. Residents cite the importance of a resident support seminar that created opportunities to explore "problems of practice" and refine a vision for teaching and learning in a community of practice with other residents and their intergenerational mentors.

*Student learning and experience outcomes: Is the model good for student learning?* Our findings to date suggest that the Teaching School model and re-envisioning systems and structures of schooling and teacher education has positive outcomes for student learning, although we have more work to do. In what follows, we provide initial findings on student achievement outcomes as measured by standardized test data, together with findings of a sub-sample of student interviews and survey data regarding their experiences at the school. Although we cannot causally link these outcomes to the Teaching School model or to our curriculum innovations at this point, it is nevertheless important to ask whether students are learning and growing in their sense of identification with STEM fields.

Student standardized achievement data and readiness examinations show mixed results, which we continue to probe and to work with teachers/school leaders to address. Data reported are the percentages of children who met the standard for mathematics at each grade level as assessed by either the PSAT or the SAT across multiple years. PSAT is taken in Grades 9-10 and the SAT is administered in Grade 11.

| **Math PSAT/ SAT** | **2019-2020** | | **2020-2021** | | **2021-2022** | | **2022-2023** | | **2023-2024** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | School | District | School | District | School | District | School | District | School | District |
| **9th** | 38% | 16% | 32% | 21% | 15% | 9% | 28% | 15% | 8% | 13% |
| **10th** | | | 23% | 16% | 26% | 16% | 49% | 37% | 18% | 11% |
| **11th** | | | | | 11% | 8% | 11% | 12% | 6% | 11% |

In the case of science, we can compare to state-level science test scores (PSAT/SAT does not assess science or social studies) of our students to District and State scores for the three years that this has been administered to our students.

| **State-level Grade 11 Science** | **2021-2022** | | | **2022-2023** | | | **2023-2024** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **School** | **District** | **State** | **School** | **District** | **State** | **School** | **District** | **State** |
| | 63% | 21% | 52% | 52% | 24% | 53% | 52% | 28% | 52% |

These achievement measures show some positive outcomes, especially in science and some growth in math at certain grade bands. We remain optimistic about growth, especially given that these results reflect the scores of learners who came to school during a global pandemic. We are focused on improving math scores through collaboration of Engineering and math teachers to reinforce learning across domains. Our science scores are some of the highest in the district and are approaching or exceeding state science achievement levels (depending on grade level) suggesting that we are on the right trajectory, especially with our work in PPBL science and engineering. We are working closely with the district and for AY 24-25 hired a veteran math teacher to lead the department; we anticipate with co-design and support that math scores will continue to improve.

Student learning and educational outcomes are paramount and can be further understood in relationship to how young people see themselves as belonging in the fields of STEM or able to engage in challenges of their community as powerful actors using knowledge from their STEM learning. In a survey distributed to students (n=173; 58% of the high school responded) across grade levels, we learned that a majority of students felt they learned about things that were interesting to them with frequency (66%), that students learned about important HCD-E tools and felt confident using them for other challenges they encounter (63%), felts motivated,

challenged, and engaged in their HCD-E work (60% agreed). In an area for future development and focus, about a third of our student body reports the desire to pursue STEM careers and/or learning in the future with another quarter reporting they were neutral. We plan to investigate further to understand how to support the pursuit of STEM in postsecondary contexts.

## Conclusions and Next Steps

The positive outcomes for teachers and students in this design and research effort offers a proof-of-concept for the Teaching School model as a way not only to recruit and retain STEM teachers, but also to ensure that they are offering robust and compelling STEM education to students. Especially important is the fact that this approach is supporting the development of teachers to serve in typically under-resourced communities and appears to be putting students who have historically been undereducated on a strong growth trajectory. Our findings are also encouraging as they indicate more young people from a range of backgrounds are interested in entering STEM professions (including STEM teaching). More work needs to be done to document outcomes, to improve outcomes, to develop and disseminate the curricula we have produced, and to systematically examine the relationship between students' outcomes and professional and curriculum development efforts, but these initial results show great promise for the Teaching School concept to transform STEM education not only in this one city, but across the nation.

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**References**

[1] President's Council of Advisors on Science and Technology. *Prepare and Inspire: K-12 education in science, technology, engineering, and math (STEM) for America's future*. 2010.

[2] National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* National Academies Press, 2012.

[3] U.S. Department of Education. "U.S. Department of Education Awards Over $60 Million to Strengthen the Teacher Pipeline, Increase Educator Leadership, and Support Quality Teaching and Learning to Further Address Teacher Shortage," 2022. Available: *https://www.ed.gov/news/press-releases/us-department-education-awardsover-60-million-strengthen-teacher-pipeline-increase-educator-leadership-and-supportquality-teaching-and-learning-further-address-teacher-shortage*

[4] R. Bain & E.B. Moje, Mapping the teacher education terrain for novices. Phi Beta Kappan, 93(5), 62-65, 2012.

[5] M. Windschitl, M. & A. Calabrese Barton, "Rigor and equity by design: Locating a set of core teaching practices for the science education community," in *Handbook of research on Teaching,* 5th ed, pp. 1099–1158, American Educational Research Association, 2016.

[5] D. Morales-Doyle. "Justice-centered science pedagogy: A catalyst for academic achievement and social transformation," *Science Education*, 101(6), 1034–1060, 2017.

[6] L. S. Vygotsky, *The collected works of L.S. Vygostky, Vol. 4: The history of the development of higher mental functions* (R.W. Rieber, Vol Ed; Hall, Trans) New York: Plenum Press, 1997. (Original work published 1941).

[7] M. Fullan, The new meaning of educational change, New York: Teachers College Press, 2016.

[8] M. Windschitl, J. Thompson, & M. Braaten, M. *Ambitious science teaching*. Harvard Education Press, 2018.

[9] B. Glaser & A. Strauss, *The discovery of grounded theory: Strategies for qualitative research*. New York: Aldine de Gruyter, 1967.

[10] C. Giroux, "How do youth engage in engineering literacies?: A study of literacy learning in middle and high school engineering design" Ph.D dissertation, Dept Educational Studies, University of Michigan, Ann Arbor, MI , 2019.

[11] B.L. Maher, E.B. Moje & C Giroux, Meaningful scientific and engineering engagement: Disciplinary literacy in secondary classrooms, postsecondary learning, and professions. Roundtable presentation at the 2017 at the Literacy Research Association Annual Conference, Tampa, FL, 2017.