of the NAPDS Nine Essentials which talks about a comprehensive mission, we accomplished this outcome as one of many positive developments, due to a partnership among teachers and students and administrators, where the goal was to teach-beyond-the-test (Miller et al., in press).

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Participatory Research to Improve PDS Initiatives: Trying-on Problem-Based Pedagogies with High-School Students

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Introduction

For three weeks each June, our PDS hosts a summer program called the Academy for Future Teachers (AFT), serving high school students interested in a teaching career. Partners across the PDS convene to support high-school AFT participants, including master teachers (P-12 teachers from local school districts and university faculty) and PDS teacher candidates at our university. AFT is approaching 15 years as a meaningful component of our university programming in an ongoing partnership with our community's schools, teachers, and students.

As researchers involved with PDS initiatives at our urban research university, the Academy for Future Teachers is a highlight each summer. We join master teachers and PDS teacher candidates' planning and interview high-school AFT participants each year to increase our program's responsivity to our community's needs. We share results from data collected during the previous year at the first planning session each year. One year, we discussed our finding that while high school AFT participants enjoyed the program, they did not feel that real-world connections were prioritized. Upon hearing this, the master teachers and PDS teacher candidates who facilitate AFT decided to implement more problem-based pedagogy. In our role as researchers, we collaborated with master teachers and PDS teacher candidates on a participatory action research project about shifting AFT toward a problem-based learning (PBL) approach.

In this paper, we first describe the Academy for Future Teachers, including the roles of high-school participants, master teachers, and PDS teacher candidates. Next, we outline the characteristics of a PBL approach, and discuss the methods used in our participatory action research project. Then we share the results of implementing problem-based pedagogies at AFT. Finally, we conclude with recommendations for incorporating PBL within PDS initiatives.

Academy for Future Teachers

AFT is a program sponsored by our university's PDS. This program leverages PDS's strengths

by bringing together community stakeholders to reinforce and strengthen the teaching profession (Darling-Hammond, 1994). This teacher-cadet summer camp supports high-school-aged aspiring teachers while offering professional development for PDS teacher candidates working alongside master teachers sharing their craft.

During AFT, high-school participants:

1. Learn pedagogical strategies
2. Participate in STEM engagements modeling pedagogical approaches
3. Teach three lessons to pre-school and middle-school learners.

Three instructional teams (elementary, mathematics, and science) facilitate AFT. The program allows master teachers (P-20), university researchers, graduate students (PDS teacher candidates), and high-school participants to collaborate around innovative teaching practices.

Program Structure

Area high-school students interested in a career in STEM or teaching are recruited to participate in AFT. AFT participants, typically juniors or seniors in high school, participate in lessons taught collaboratively by instructional teams. Each week, high-school AFT participants plan and teach lessons to pre-school or middle-school aged learners enrolled in other university programs. Master teachers work at the university or at local P-12 schools. PDS teacher candidates take courses towards a Masters of Arts in Teaching while serving as a teacher resident in a local school. A master teacher and a PDS teacher candidate co-lead the instructional teams (elementary, math, or science). See Figure 1 below for a description of PDS partners involved with AFT.

Problem Based Learning

Building on constructivist learning theory, problem-based learning (PBL) facilitates student inquiry into authentic, real-world problems. PBL troubles the notion that students must first master content before applying it to the world's problems. Instead, problem-based approaches position learning alongside working collaboratively to address real-world issues (Boud & Grahame, 2013; Hmelo-Silve, 2004, Savery, 2006). Tenets of PBL include pedagogy that is student-led, authentic, collaborative, reflective, and addresses a real-world issue. In this paper, we share the outcomes of shifting AFT's pedagogical focus to problem-based learning, including three PBL engagements planned by PDS teacher candidates. These results inform future AFTs, and similar PDS programming focused on supporting novice teachers in using innovative pedagogical strategies.

A Participatory Action Research Approach

The research presented in this paper represents a participatory action research (PAR) approach (Wimpenny, 2016; Brydon-Miller & Maguire, 2008). PAR leverages multiple stakeholders to improve educational outcomes and is compatible with the aims of PDS. We collaborated in this research project alongside PDS teacher candidates who were part of the three instructional teams at AFT. This PAR's focus was to update the curriculum based on findings from the previous year's research, highlighting a need for problem-based approaches. We previously found that many high-school participants experienced difficulty relating to STEM and seeing STEM as disciplines that solve social problems (Martin & Fisher-Ari, 2021).

Our goals were twofold. 1. We wanted to understand how instructional teams (master teachers and PDS teacher candidates) modeled a PBL pedagogical approach for high-school AFT participants. 2. We wanted to understand how high-school participants implemented PBL in lessons created for and implemented alongside younger learnings.

To explore these questions using PAR, first, we collaborated with instructional teams during AFT planning. We shared current research on Problem-Based Learning and participated in brainstorming sessions about applications for the current year. PDS teacher candidates then planned and modeled specific PBL engagements each day for high-school participants.

Next, we collaborated with instructional teams and decided to collect and analyze weekly PBL planning documents (see Appendix A) and conduct weekly reflective focus group interviews with high-school AFT participants. We worked alongside PDS teacher candidates to analyze data from focus-groups conducted after high-school participants taught lessons to pre-school and middle-school learners. Finally, PDS teacher candidates looked for instances of high-school participants taking up the pedagogical strategies modeled by instructional teams, using the analysis chart we created (See Appendix B).

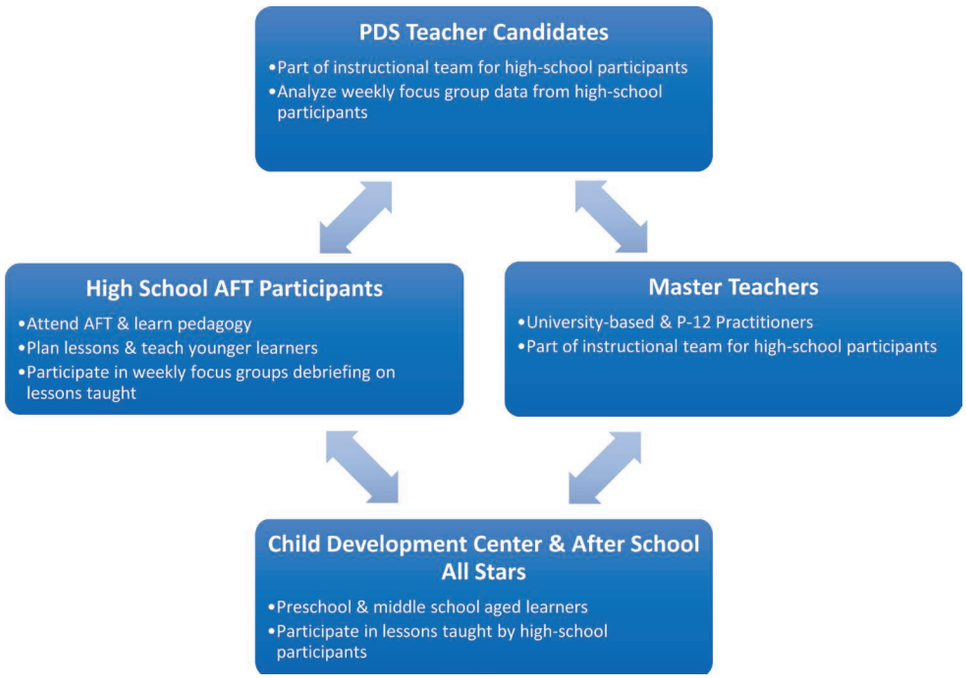

Figure 1: Roles Within AFT

Results of the Participatory Action Research

Part 1: In what ways did AFT instructional teams take up problem-based pedagogies?

Exploring Play-Based Lessons. The elementary instructional team focused on hands-on learning and making learning relevant. This instructional team collaborated with a local science group that gives hands-on presentations to young learners to introduce this strategy. The intention was to allow high-school students to play while learning to demonstrate the effectiveness of this approach. Students then engaged in a series of play-based math and science lessons, such as investigating density using the senses when dropping liquids. High-school participants used these engagements as inspiration in planning their play-based lessons for preschool-aged learners, including exploring gravity with paper rockets. This instructional team took up elements associated with PBL, such as inquiry, but did not engage participants in an authentic problem, a fundamental tenet of the approach (Savery, 2006).

Correlations to Football Head Injuries. The mathematics instructional team focused on whether football head injuries are increasing because of bigger, faster players. This instructional group planned this engagement to help students experience how math can address a real-world

Our experience points to a continuum of development among teachers engaging with problem-based pedagogies to build responsive and authentic learning engagements.

issue. While students explored this data, they learned how data could be represented to demonstrate trends and analyze actual situations.

This multi-day engagement involved a trip to a local museum, the College Football Hall of Fame, and utilized concussion data from 1979-2018. According to the instructional team, this lesson was successful because "AFT participants enjoyed this field trip. Students were able to apply what they learned in the classroom regarding the safety concerns of players." This example of PBL addresses student interests, engaging with an authentic issue, and using community resources, such as local museums, to build students' knowledge of a topic. This approach was successful because it allowed students to learn how to perform calculations related to data representation and why exploring data can help address problems.

Ethical Considerations when Working with Tissues. The science instructional team focused on ethics in the biology classroom, mainly working with tissues. The instructional team presented a neuroscience lecture. Next, high-school participants dissected a mouse and discussed issues involved with obtaining mice tissue. The following question drove the discussion: What are your ethical concerns about humans performing dissections on living organisms (animals) for science? Finally, students visited a local museum, the Body's Exhibit, to deepen their knowledge of human anatomy and physiology. In reflecting, the instructional team said, "Through discussion, students contemplated the origin of a donated specimen from the BODIES Exhibit and how ethical concerns can impact the benefit of science." These engagements problematized the PBL approach by considering what ethical problems science causes.

These three arcs of engagements represent varying levels of embracing PBL as a pedagogical strategy. One instructional team engaged with an aspect commonly associated with PBL, such as learning through play/inquiry. Another instructional team taught students content to engage with a problem more indicative of the tenets of PBL as described by Savery (2006), such as head injuries. Yet another instructional team used a problem-based approach to help students explore ethical issues scientists encounter.

Part 2: What impact did participation in these engagements have on high-school AFT participants' teaching?

In addition to participating in the engagements previously discussed, high-school participants taught lessons to middle school and pre-school aged learners. After each lesson, high-schoolers met in focus groups reflecting on their experiences. We considered the strengths, emerging areas, struggles, and pedagogical concepts absent from AFT engagements based on these discussions. These perspectives will inform our future programming and offer insights to others trying out problem-based pedagogical approaches.

Strengths. One positive impact that the engagements had on high-school participants was the value of hands-on lessons. One GRA reflected, "They each elaborated on lessons where they incorporated hands-on activity because kids love to touch and explore." Participants often connected hands-on learning to student engagement, which was another instructional component important to high-school participants.

Another area of strength for some high-school participants was in connecting topics to real-world concepts. For example, some high-school participants created a house out of index cards to teach middle-schoolers measurement, including square footage. One student shared, "Learning math is more than solving an equation. It helps individuals analyze problems and think critically."

Emerging Areas. High-school participants often discussed the importance of making learning relevant for students; however, data reveal that students did not always have a realistic understanding of what is relevant. For example, one high-school participant shared that they taught a counting lesson to pre-k students because math is essential for calculating taxes, a skill these students won't likely need for some time. Similarly, when teaching mathematics lessons to middle-school learners, the instructional team noted that "Explicit instruction related to how the concepts taught connect to the real world was not evident." While the problem-based engagements students participated in resulted in an understanding of the importance of relevant learning, gaps remain regarding what relevant learning means and might entail for varying age groups.

Struggles. Planning and teaching authentic lessons was the main struggle identified in high-school participants' reflective focus groups. One instructional team member recalled that high-school participants struggled to "build a product that solves a problem." Many participants wished they would have incorporated more fun, real-world connections to the content. One student said they want to "put more emphasis on real-world connections with concepts learned."

For participants, engagement was often their benchmark for determining a lesson's success. For instance, one participant identified a way to assess learning, where the pre-k students were solving math problems. The participant reflected on observing if the pre-k students were grasping the addition and subtraction concept to indicate a successful lesson. Other than this, a lessons' success was solely gauged on if the pre-k students were engaged in the lessons. The engagement level is important, but it's also vital for the students to learn from the activities.

Absent. Finally, there were a few concepts that PDS teacher candidates expected to see in reflective focus group transcripts but did not. The primary concept that was absent from reflective data was problem-solving through STEM. All three instructional teams focused on the learning experiences high-school participants engaged in during AFT on the idea that STEM solves real-world problems. Even though this problem-solving approach was central through AFT, participants did not discuss applying this concept to their lessons planned and implemented. In reflecting on this absence, one PDA teacher candidate said, "The students' goal for their lesson was to introduce them to information they can use later on in life, but did not touch on how they could use the information today."

Conclusion

In this study, instructional teams, researchers, high-school participants, and young learners implemented PBL and explored how STEM can solve problems that matter to them and our communities. PAR results reflected that two instructional teams successfully created engagements about relevant issues for students (obtaining human tissues, head injuries). However, one instructional group (the one focused on younger learners) focused more on possible strategies supportive of PBL, such as hands-on and play-based learning, rather than critical and community-based issues that learners wanted to influence. Similarly, high-school participants often struggled to create lessons that authentically engaged with a problem. This indicates teachers of all levels need support and further collaboration in planning lessons around authentic issues that resonate and are meaningful and important to learners and communities.

This paper highlights the successes and potential points of entry of using a problem-based pedagogical approach to teaching STEM in a PDS-sponsored summer program in which

master teachers, PDS teacher candidates, and high-school students endeavored to try the approach. Our experience points to a continuum of development among teachers engaging with problem-based pedagogies to build responsive and authentic learning engagements. Understanding how teachers take up problem-based pedagogies is informative for supporting teachers and learners in this approach. We found some high-school participants had a challenge with implementing PBL through issues that concern students.

Recommendations & Significance

Considering these findings, we offer three broad recommendations for those supporting teachers embracing problem-based approaches.

1. Encourage teachers' entry into PBL even if they take on just one component, such as hands-on learning, as the elementary team did. To support teachers' emerging pedagogical practice, consider frequently implementing group planning sessions where teachers share examples of their PBL approach and collaborate to give others suggestions. For example, teachers might meet monthly and share a PBL approach they are teaching. Through discussion, the group may offer suggestions to augment current plans with engagements more congruent with the tenets of PBL.
2. Prioritize PBL engagements addressing issues in students' lives. Consider including students in the planning process to brainstorm ideas about problems in their lives they want to explore. Keeping problems students are concerned with central to planning is critical.
3. Leverage the power of PDS to support teachers implementing a PBL approach. Partnerships could extend beyond traditional PDS collaborations to include local organizations and non-profits for field trips and site-based work/internships for students. Consider collaborating with field-based experts as guest speakers in P-20 classes and as consultants for students addressing community-based concerns and partnering with local community groups advocating for similar issues.
4. Incorporate professionalizing experiences for teachers centered on reflective practice. This could include opportunities for teachers during their planning process to draft a rationale for their pedagogical decisions by drawing upon the tenants of PBL. Next, engage teachers in reflecting on how PBL engagements went. At the end of a unit, implement opportunities for peer critiques over the arc of engagements about strengths, struggles, and absent components of PBL. See Appendixes 1 and 2 for examples.

The story of this unique partnership and program highlights ways that PDSs are well-situated to foster participatory action research where stakeholders from various vantage points collaborate to develop a particular instructional strategy that centers on the community and equity, such as PBL. This study shows that PDS is a model for partnership as an active problem-solving space creates a fertile community in which stakeholders from multiple vantage points come together for the common good. PDS's long tradition of augmenting the teaching profession through increased professional development at the heart of partnerships strengthens all stakeholders.

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Appendix A: Teacher Candidate Reflective Reports Documenting Planning and Student Engagement

Before Teaching		After Teaching
	Rationale & Connections to AFT Purposes/Pedagogies	
Engagement and Description	*Chosen Pedagogical Focus: STEM matters in the real world*	**Reflect:** How did it go? How did students take up these opportunities?
(including field trip experiences)	*Learning is Experience + Reflection*	Additional reflections, critiques, and recommendations
	Teaching is asking questions alongside learners	

Appendix B: AFT Focus Group Interview Reflective Conversation Summary

Section:	Date:
Strengths **What went well?** **What are students understanding?**	
Approaching **What ideas are students partially understanding?**	
Struggles **What are students grappling with?**	
Absent **What did you expect to hear based on your teaching but didn't?**	
Next Steps **Based on these conversations, what should instructors focus on this week?**	