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The Role of K-12 Teachers as Agents for Change (RTP)

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Teachers as In-School Engineering Agents for Change

Abstract

There is substantial evidence that most K-12 teachers who want to incorporate engineering design into their courses learn their skills independently or through an extracurricular professional development (PD) program. Regardless of the value of these PD programs, rookie teachers are frequently required to make personal sacrifices (e.g., time, money, and stress) to participate and thus hindering their long-term progress. To offer an alternative, four Teacher Leaders Engineering Network (TaLENt) fellows from primary and secondary schools served as change agents for novice engineering teachers for one academic year to promote the integration of engineering design in their classrooms. This research aimed to understand how school-based teacher leaders can support peer educators in authentically integrating engineering design within their core subjects. Our research questions were: 1) To what extent was the High-Quality Engineering Guidebook used within each TaLENt fellow's Project? 2) How did the TaLENt fellows characterize their values while collaborating with their novice peers?

Employing a qualitative method, we used constant comparative analysis and triangulation to understand our collected datasets: TaLENt fellow narratives (N = 4 autobiographical texts), teacher project artifacts, and focus group transcripts. We found that TaLENt engineering PD increased peer collaboration, instructional risk-taking, and connections to cross-curricular subjects for novice teachers. Moreover, the action-based research approach paired with the High-Quality Engineering framework allowed inexperienced educators a say in their education, which helped reduce common misunderstandings about content alignment with engineering (such as the extent to which it applies to fields like physics or biology) and subsided anxiety about the processes of incorporating engineering in the classroom. The significance of this study is to highlight the value of teachers as in-school leaders. As states continue to adopt Next Generation Science Standards or incorporate engineering processes into their state-level curriculum, novice teachers will rely on their peers to strengthen their teaching practices within the subject, all while supporting the cultural needs of students. Our research shows the importance of in-school engineering PD facilitated by teacher leaders, especially for new and inexperienced engineering teachers; therefore, we recommend more investigation into implementing this type of PD. This change in professional development will make planning engineering lessons less stressful for novice teachers due to a reduced sense of isolation.

Teachers as In-School Engineering Agents for Change

Introduction

There is substantial evidence that most K-12 science and math teachers who aim to incorporate engineering design processes into their courses acquire these skills through extracurricular professional development (PD) programs or self-directed learning [1-4]. Research has shown that PD programs are valuable in increasing teachers' engineering self-efficacy and the likelihood of implementing engineering processes in the classroom [5-7]. These programs offer flexibility in introducing engineering design to teachers in diverse formats (e.g., in-person versus virtual) [8], using various theoretical frameworks [9]. They often provide participation incentives such as stipends [9, 10]. However, despite the value of these PD programs, teachers are usually required to make personal sacrifices, such as investing their time, money, and energy, to participate.

Conversely, when novice teachers try to incorporate engineering design independently, they can choose a learning modality that suits their schedule. Typically, this approach involves searching the internet for pre-made lessons, watching YouTube videos, or joining social media groups for quick tutorials [11]. While this may be a fast and cost-effective method in the short term, it could be more sustainable. Learning in isolation often needs more attention to peer brainstorming and troubleshooting for material or classroom issues [12]. As a result, teachers may need to spend additional money on supplies for materials that may not meet the learning objectives. When novice teachers experience "failure fatigue," they may believe that integrating engineering design is unsuitable for their students [13].

Research Questions

Our research questions were as follows:

1. To what extent was the High-Quality Engineering Guidebook used within each TaLENt fellow's Project?
2. How did the TaLENt fellows characterize their values while collaborating with their novice peers?

Purpose of Study

In 2019, the National Science Foundation (NSF) launched the Teacher Leader Engineering Network, a collective impact model of 15 elementary, middle, and high school teachers. They aimed to create the High-Quality Engineering Guidebook [14] to increase the number of Black, Native American, Hispanic, or female students pursuing engineering. The High-Quality Engineering Guidebook was developed based on current frameworks such as the Framework for P-12 Engineering Learning, Engineering is Elementary, and Project Lead the Way's Activity-Project-Problem-Based Learning.

The group built upon these frameworks by identifying perceived implementation barriers for engineering design processes and discussing practical strategies to overcome these hurdles.

The High-Quality Engineering Guidebook includes five criteria for teaching engineering design at each school level (elementary, middle, and high) framed through culturally relevant pedagogy. Our 2019 paper, published in the American Society for Engineering Education (ASEE) conference proceedings, provides in-depth details on developing the High-Quality Engineering Guidebook [15].

This qualitative research aimed to assess the effectiveness of four TaLENt fellows, who are school-based teacher leaders, as in-school change agents for educators who are inexperienced in engineering design. Notably, this study's term "novice teacher" does not exclusively refer to first-year teachers. Instead, it pertains to educators who have yet to attempt to integrate engineering design into their lesson plans.

Literature Review

This literature review aims to provide an overview of the research conducted on teacher-led professional development for engineering design, the use of action-based research in K-12 settings, and the advantages of adopting an asset-based perspective in this work.

The Role of Teachers in Promoting Engineering Design

In schools, teachers perform various roles to enhance their students' learning experience. They function as facilitators of learning, evaluators of performance, and role models. They also collaborate with colleagues, sharing resources and aligning the curriculum with their students. Teachers rely on teamwork to provide their students with the best educational experience.

Often, teachers hold leadership positions that extend beyond their classrooms and support the professional development of their peers. These teacher leaders embrace new challenges, work collaboratively with their peers, seek feedback, and critically examine their teaching methods and those of others [17].

In engineering education, teacher leaders are crucial in integrating engineering into other subjects and fostering a culture of innovation and creativity in the classroom [18]. They provide professional development opportunities for their colleagues and mentor new teachers, sharing their expertise and knowledge of "best practices" in engineering education. As experienced educators who bring real-world engineering challenges into the classroom and provide firsthand learning experiences for their students, teacher leaders in engineering are instrumental in ensuring that novice teachers learn how to engage their students in rigorous engineering design processes alongside other subjects.

Action Based Research

Action-based research is a powerful tool that enables users to bring about change, assess its effects, and adjust to the demands of the team [19]. In this approach, team members are referred to as co-researchers since they actively participate in the action research project. Collaborative resources are utilized, and each participant's ideas are given equal importance as potential resources for building interpretive categories of analysis. The aim is to avoid credibility from being tainted by the status of an idea-priority bearer, facilitating the ability to form inferences from seeing internal and inter-perspective conflicts.

Several assumptions apply in education-related action research projects. Firstly, school instructors are more productive when uncovering problems independently. Secondly, they are more effective when analyzing their work for potential improvements. Finally, school instructors benefit from teamwork.

The action research process begins by identifying issues before developing an iterative action plan with strategies for pursuing optimal practice. The cyclical action research process comprises four key phases: contemplation, planning, action, observation, and reflection [20]. The authors identified five key stages of conducting an action research project. These include identifying a problem area, collecting relevant data, analyzing the data, acting on the evidence, and evaluating the results. Although these procedures may appear like everyday inquiry and research processes, the most critical aspect of action research is who participates in decision-making.

Moving Away from Deficit Thinking

Deficit thinking is a viewpoint that suggests low-income and historically marginalized science and engineering students struggle in school because of their cultures and families' inherent difficulties (deficits) that hinder their ability to learn [21]. Unfortunately, this perspective often blames the victim instead of examining how institutions impede children's development. Students are frequently accused of being unmotivated, having limited educational aptitude, or lacking parental support [21]. By attributing low academic achievement to cognitive and motivational deficiencies, the focus is shifted away from institutional structures and unequal educational practices [22]. These limited ways of thinking and teaching contribute to maintaining a muddled science and engineering identity and propagating the notion among diverse students that researchers are only for old, white males with superior intelligence [23].

Teacher instructional practices must be culturally relevant to avoid a deficit mindset. It is essential to combat Eurocentric thinking and provide value to marginalized students. While we do not focus on one specific Asset-Based framework, research has shown that engineering space cultural awareness methods such as Culturally Responsive Teaching, Culturally Sustaining Pedagogy, and Culturally Relevant Pedagogy can promote the development of a positive self-concept, employ anti-racist training, and connect the curriculum to students' home experiences [24]. By incorporating these approaches, teachers can foster a more inclusive and supportive learning environment that empowers students to thrive academically and personally.

Methods

To address the research questions, we utilized a qualitative research approach. The advantage of using a qualitative approach is that it provides a comprehensive understanding of the research issue without limiting the scope of the study or the types of participant responses that can be collected. Qualitative research is particularly well-suited for studying complex phenomena that cannot be measured through statistical means and are best suited for studies with small sample sizes.

For this study, we recruited participants from various educational settings, including K-12 schools, community colleges, and universities. We used data collection methods, including semi-structured interviews, participant observation, and document analysis, to gather rich and diverse data about the participants' experiences and perspectives. Each participant was engaged in an engineering education project or initiative, which served as the context for their involvement in the study.

The data collected from these methods were analyzed using constant comparative analysis, which involved coding and categorizing the data to identify patterns and themes [25]. This method allowed us to identify similarities and differences in the participants' experiences and perspectives and to develop a comprehensive understanding of the research issue. Overall, the qualitative approach enabled us to gain a deep and nuanced understanding of the participants' experiences and perspectives and develop insights into the complex issues surrounding engineering education initiatives.

Participants

A convenience sampling approach was utilized to ensure participant selection for this study [26]. All fifteen original TaLENt fellows were informed and invited to participate in the research project. Among these fellows, four of them voluntarily served as change agents for novice engineering teachers for one academic year to promote the integration of engineering design in their classrooms. The demographic details of these TaLENt fellows are outlined in Table 1.

Table 1.

TaLENt Fellow Demographics

Gender	Race/ Ethnicity	State	Core Subject	School Student Demographic
Male	White/ NonHispanic	AZ	Elementary Science	Predominantly White
Female	Black/ NonHispanic	TX	High School Science	Predominantly Hispanic and African American/Black
Male	Black/ NonHispanic	AZ	High School Math	Predominantly White and Hispanic
Female	American Indian/Alaska Native/ Hispanic	TX	High School Science	Predominantly Hispanic

Context. TaLENt Fellow Action-Based Research Projects

The four action-based projects conducted during the 2021-2022 school year are briefly described in Table 2. These projects aimed to integrate engineering design into the participating schools' curriculum by implementing various strategies, such as creating engineering design challenges, developing a teacher professional development program, integrating engineering design into existing science curricula, and building partnerships with local engineers and industries. The TaLENt fellows led these projects, with support from their school colleagues and an engineering curriculum mentor from the "TaLENt." While this article does not provide a detailed account of each Project's implementation cycle, it does focus on reporting the TaLENt fellows' perceptions of their role and value in bringing engineering design to their schools

Table 2.

TaLENt Fellow Action-Based Project Descriptions

Novice Peers	*Purpose*	*Essential Question*	*Feedback Loop*
5 Elementary Teachers	PLC learning community to enhance the integration of engineering design into their classrooms. The shift from a direct instruction approach to a student-centered approach that focuses on experiential learning and student inquiry.	How prepared do elementary science teachers feel about teaching engineering-based standards?	Monthly Meetings Peer Assessment Reflections
2 Physics Teachers	The physics team used the High-Quality Engineering Guidebook as guidelines for integrating the engineering course curriculum through monthly meetings. Based on group discussions and reflection journals, the team will determine whether each teacher's perspectives are prepared to teach, incorporate engineering, and move on to challenging tasks.	What are physics teachers' perceptions of the instructional practice used to incorporate engineering into their curriculum?	Monthly meetings Lesson Plan exchange Intervention Workshops postsurvey on teacher
2 High Math Teachers	The goal was to add more relevance and real-world settings to math lessons using the engineering practices in the High-Quality Engineering Guidebook.	What effect does the High-Quality Engineering Guidebook have in helping math teachers increase the amount of real-world context in math lessons?	rubrics meaning the real world. 3-semester check-ins
5 Teachers (English, Biology, Alg I, World geo, & computer science)	This Project focused on teachers' understanding of the engineering design process and attitudes toward using engineering design lessons within their content area and evaluating their teaching effectiveness. The team built one individual lesson and one team project-based lesson geared toward 9th-grade students.	How does professional engineering development aligned with the High-Quality Engineering Guidebook objectives increase teacher perceptions of teaching engineering?	Weekly Meetings Rubrics Self and peer evaluation Survey to determine teachers' needs

Data Collection and Tools

Three forms of data were collected to understand the impact of the Teachers as change agents: TaLENt fellow narratives, project artifacts, and focus group transcript.

TaLENt Fellow Narratives. Each TaLENt fellow provided an independently written statement that described their fall and spring Action Research project iterations. These statements were in the form of personal narratives. The fellows had autonomy in generating their narratives; however, they were asked to include general program descriptions and independent, in-depth reflections on their Project's perceived benefits, flaws, and future plans.

Project Artifacts. These project artifacts included PowerPoint presentations, formative data, peer reflections, and engineering design project outlines. The Engineering Mentor used the project artifacts to provide guidance to the TaLENt flows regarding their action research project. TaLENt fellows shared the project artifacts and the engineering mentor over one academic school year. Each fellow provided evidence of their time with their peer teachers. The Project Artifacts served as formative feedback for their Action Research projects. They helped the mentor provide targeted suggestions on how the TaLENt fellows could ensure their project stayed focused on their goals.

Focus Group. The TaLENt focus group session was a semi-structured Zoom meeting lasting one hour. The session aimed to determine each participant's and the overall group's emotions, sentiments, and perspectives about the implementation, motivation, and effectiveness of action research projects. The primary benefit of focus groups is that they enable researchers to obtain meaningful data while communicating with all members simultaneously [27]. In addition, the semi-structured technique gave participants freedom regarding the interview's flow. It allowed them to build on one other's comments, allowing for the creation of conclusions that were not originally intended to be drawn [28]. All four fellows attended the session. As author one has engaged with the fellows in various projects since 2019, a trained postgraduate researcher led the focus group. This was to ensure that power dynamics did not influence participant responses. Table 2 below shares excerpts from the semi-structured protocol, aligning each question with a particular purpose. Questions asked during the focus group can fall into three categories: participants' engineering background, project motivation, or participants' sense of project effectiveness.

Table 3.

Sample Excerpt from Focus Group Protocol

Focus Group Questions	Background Information	Motivation	Project Effectiveness
What is your role in your school, and what subject do you teach?	✓		
Can you describe the demographics of your school?	✓		
What led you to be an engineering leader at your school?		✓	
How did you use the High-Quality Engineering Guidebook?		✓	
Do you believe your Project impacted your peer teachers?			✓
Do you believe your Project met its goal? Can you describe it to help me understand your response?			✓

Data Analysis

The constant comparison method (CCM) is a qualitative data analysis approach that utilizes grounded theory as its basic framework [25]. According to Tesch (1990), the primary objective of almost all qualitative research strategies is to identify conceptual commonalities, improve the discriminative ability of categories, and uncover patterns employing comparing and contrasting [29]. The CCM was selected as the data analysis method because it relates to external validity, allowing for the generalization of ideas and their connections to units that were not included in the sample but represented the same phenomenon when sampling is conducted correctly on a homogeneous sample [30].

To utilize the CCM, we first familiarize ourselves with each specific dataset -- personal narratives and focus group transcripts – involved in the analysis process. For each dataset, we created particular codes by conducting a literature review. We then examined the generated codes among datasets to identify overlapping patterns. This process was repeated several times to ensure that all cross-coding could occur.

Finally, we created themes by combining the codes discovered across datasets to achieve our research goals. Each subject was identified, titled, and addressed in the findings section.

Findings

This study aimed to address the stress experienced by novice teachers when incorporating engineering design into core science content areas. Our primary research questions were: 1) To what extent did the High-Quality Engineering Guidebook feature in each TaLENt fellow's Project? and 2) How did the TaLENt fellows describe their value in collaborating with novice peers?

Qualitative analysis of the participants' data sets revealed that the TaLENt fellows utilized the High-Quality Engineering Guidebook in several ways to address the needs of their teams. In addition, personal narrative and focus group transcripts generated four themes (Teacher By, Motivation, Autonomy, and Reduced Stress) that explain how the participants viewed themselves as valuable for mitigating novice teacher stress.

The findings are presented in response to the two research questions. It was found that the TaLENt fellows used the High-Quality Engineering Guidebook in multiple ways while responding to their teams' needs. Furthermore, the generated themes highlight the participants' perceptions of themselves as valuable resources for alleviating stress among novice teachers.

To what extent was the High-Quality Engineering Guidebook used within each TaLENt fellow's Project?

Table 4.

TaLENt Fellow Use of High-Quality Engineering Guidebook in Action-Research Projects.

Theme	Explanation of Use	Focus Group Excerpt	Personal Narrative Excerpt
Engineering Self-Reflections	Used to help novice teachers think about their teaching methods.	*We talk a lot about their need to overcome barriers to instruction.*	*The participating teacher wrote a reflection on her experience using the High-Quality Engineering Guidebook.*
Real-World Relevance	Used to help novice teachers connect engineering to existing lessons and real-world events.	*High-Quality Engineering Guidebook or these criteria were relevant to their classroom, and their projects are the two big projects they do.*	*The goal was to add more relevance and real-world settings to math lessons using the engineering practices in the High-Quality Engineering Guidebook.*
Planning	Used to help novice teachers build confidence in planning to use engineering design with their curriculum.	*After the completion of the Project, a meeting was held with teachers to evaluate how the High-Quality Engineering Guidebook was practical or could have been used to improve the planning of the Project. Self-efficacy, to see how they felt about teaching engineering.*	*She also used the High-Quality Engineering Guidebook to guide her in developing a new PBL lesson that would be more robust than the original lesson and implemented it the following year.*
Training	Used to help TaLENt fellows plan the Action-Research project and consider hurdles they may face regarding their teaching methods.	*We could use any of these five criteria that we come up with in the High-Quality Engineering Guidebook to influence the math curriculum.*	*The two non-STEM teachers (English and Social Studies) need to see the connection between engineering design principles and the curriculum in their class after using the High-Quality Engineering Guidebook to plan lessons.*

A total of 25 unique codes across the focus group and personal narratives were merged to produce the four themes related to participants' use of the High-Quality Engineering Guidebook.

How did the TaLENt fellows characterize their values while collaborating with their novice peers?

Table 5.

TaLENt Fellow Descriptions of Value

Theme	Definition of Value	Focus Group Excerpt	Personal Narrative Excerpt
Teacher Buy-in	The TaLENt fellows stated they played a critical role by highlighting the benefits of engineering design and providing evidence that the process is worth attempting.	*So as the year went on, it was evident that we were all doing great; they were all doing PBL. And the High-Quality Engineering Guidebook or these criteria were relevant to their classroom, and their projects are the two big projects they do.*	*It also helps me to see the possibilities.* *Help teachers understand the engineering mindset.* *Enriches instruction by providing criteria to support.*
Motivation,	The TaLENt fellows, stated they played a critical role by mentoring, modeling, and collaborating with novice engineering teachers, helping them to develop their skills and confidence as educators.	*It was like a coaching cycle because we would have to review that lesson and see what criteria they wanted to work on. And then, we just kept working on that criterion for the following Project.*	*I kept changing my Project by modeling how to support a classroom culture rich in collaboration, teamwork, student-centered problem-solving, and a risk-taking environment.* *Help with progress on communicating with each other.*
Autonomy,	The TaLENt fellows shared they played a critical role by encouraging trial and error and new ways of thinking about growth as a science teacher. This led to more willingness to try latest ideas to support their students' needs.	*Teachers [are] willing to do something new, especially this year.* *This year some new project work will come out that's already being developed and implemented soon.*	*Our sessions allowed novice teachers [to] think about that their classroom was dynamic.* *This PD helped teachers take instructional risks that may be outside of their comfort zone.*
Reduced Stress,	The TaLENt fellows shared they played a critical role by actively listening, displaying empathy, and promoting personal voice.	*They are intimidated by imposter syndrome. And why me? I'm pretending. And I shouldn't be doing this.* *The other teachers will be able to see what they're doing because, peer-wise, engineering seems like one of those words that do scare them.*	*There was an overall improvement in anxiety and self-efficacy amongst teachers, especially with the new science elementary team.* *The big adjustment throughout the year slowed down everything.*

A total of 47 unique codes across the focus group and personal narratives were merged to produce the four themes related to participants' descriptions of their value in the Project.

Mentee Comments

To illustrate the degree of the impact the mentor/mentee relationship produced, **Table 5** shares comments made by mentee teachers.

Table 5.

TaLENt Mentee Teacher Feedback and Recommendations

Feedback & Recommendations	
Novice engineering teachers	Think Differently There will always be more than one way to arrive at a solution. Develop a Clear Understanding of the Process Includes MUCH more than just building. Utilize Makerspaces to the fullest extent possible Create a Positive Environment Risk-taking is a huge component of engineering Practices (Teacher 5A) I recommend this book study to Novice engineering teachers and Novice teachers since the teaching practices discussed are cross-curricular. (Teacher 3)
Engineering PD:	am still trying to figure out PD. But it would be nice to have training that allows us teachers to work through an engineering problem just like our students. That always inspires me and excites me to share it with my kids. It also helps me to see the possibilities. PD on how to shift instruction based on delivering facts to exploring phenomena. PD on how to make ALL science instruction inquiry based. PD on how to use engineering practices in all content areas (Teacher 5A) My favorite part of the book study was learning what other teachers do in their classes. We had rich discussions, and I learned a lot about Engineering teaching practices based on what my colleagues were doing. (Teacher 3) I would love opportunities for more engineering PD and welcome more ideas and techniques for teaching Engineering in the classroom. (Teacher 3)
Guidebook	It was user-friendly and to the point. This specific PD opened my eyes to another way of looking at engineering practices in the classroom. I had initially thought it would help me plan for more science/engineer-based activities, but I feel like I received more based on the discussions we had as a group and the content itself. I received great feedback on what I was doing in the classroom and got great ideas for some activities. But what struck me was the content principles. The term TEAMWORK hit a nerve with me because I teach a self-contained classroom where students move with each other from grade level to grade level. This results in a familial dynamic among the students, and teamwork with each other is sometimes nonexistent. I reflected extensively on the term and tried incorporating variations in the classroom. Sometimes it worked, but sometimes it didn't. It is an ever-changing process. Overall, this PD helped me more than others because it made me think about my classroom dynamic. It provided me feedback that I thought was valuable and gave me ideas on how to improve the incorporation of engineering principles into my lessons.

Discussion

This study's findings clearly show the importance of in-school engineering PD facilitated by teacher leaders, especially for inexperienced teachers of the engineering design process. These findings are connected to the literature on professional development, action-based research, and deficit thinking.

Buy-In. The theme of Buy-In was essential to getting the teachers new to engineering design engaged in-school professional development. The TaLENt fellows reported themselves as valuable to their peers by highlighting the benefits of the engineering design and providing evidence of why the method benefits students and the instructional process. Aligning with current research, [17] found that experienced teachers should emphasize the positive outcomes that novice engineering teachers can expect from implementing their teaching methods. This could include improved student engagement, better learning outcomes, and increased job satisfaction. Furthermore, [31] asserts experienced teachers can provide evidence-based research that supports their teaching methods. This can help convince novice teachers that the techniques are practical and worth trying.

Motivation. This study found that teachers who have changed agents were a source of positive inspiration. These findings directly align with previous literature on how in-service teachers can serve as valuable assets for mentoring modeling and collaboration in peer professional development. According to [32], experienced teachers can mentor novice teachers, providing guidance, support, and encouragement. They can share their experiences and strategies for success and help novices navigate the challenges of teaching engineering design.

Additionally, experienced teachers can model effective teaching practices and provide examples of high-quality engineering instruction. They can invite novices to observe their classes, provide feedback, and encourage them to try innovative approaches in their classrooms. This can lead to reduced anxiety and stress with novice teachers.

Autonomy. This study found that the TaLENt fellows are valuable assets to the classroom. They reported providing engineering design guidance and support. The study participants help their novice engineering peers develop the confidence and skills to take ownership of their teaching practices. This finding relates to the historical literature on deficit theory. [22] Addressing deficit thinking in teaching can help promote a more positive and strengths-based approach to education, leading to greater autonomy and engagement for teachers and students. By adopting an asset-based approach, teachers can cultivate a sense of independence in their teaching practice, leading to increased student engagement, motivation, and success [33]. Autonomy in teaching means having the ability to make choices and decisions about how to teach, what to teach, and how to assess learning. It also means having a sense of ownership and control over the learning process. The TaLENt fellows in the study supported the teacher's growth mindset by providing options to tackle science instruction. The novice teachers then chose what they wanted to use based on knowledge instead of limited knowledge.

Reduced Stress. This study found that TaLENt flows are valuable assets for promoting a change in teachers' novice to engineering stress levels. The finding reported that this was done by supporting teachers' social and emotional needs. Specifically, TaLENt fellows can support novice teachers emotionally by incorporating active listening, empathy, and encouragement into their professional development sessions. These findings are linked to the purpose of using Action-Based Research to promote changes by teachers. Using action-based research as a methodology is conducted by researchers to encourage buy-in groups and mitigate stress and anxiety [34, 35].

Addressing the gap

This study provides a nuanced approach to addressing the problem of authentically supporting teachers in engineering design education by reducing their dependence and stress. While literature exists on being a teacher leader and providing new teachers with support from within the school, this study contributes to the literature by explicitly focusing on the engineering design space. Additionally, the TaLENt fellows utilized the TaLENt guidebook to structure their work and find unique ways to support their teacher peers. This paper does not recommend a one-size-fits-all approach. Each teacher already has the experience that must be validated and built upon to encourage growth in incorporating engineering design processes. Honoring their strengths, beliefs, and assets creates a space for teachers and students to achieve realistic goals.

Limitations

This study focused on the value of in-service teachers as change agents for novice engineering teachers. One limitation of the study was convenience sampling, whereby we intentionally selected teachers known to use engineering within their classrooms from our organization. Doing so excludes the potential to observe how the Engineering High-Quality Engineering Guidebook could be adapted and used by in-service teachers who were previously unfamiliar with it.

Another study limitation was the methodology used to answer the research questions. We specifically focused on the term "value," Thus, in our constant comparative method, we did not incorporate any statements or artifacts in which the teachers did not see themselves as valuable. This limits our findings as it only provides one perspective on the outcomes.

Future Work

Future work focuses on addressing our research limitations. To overcome the convenience sampling limitation, future studies could consider using a more diverse sample, including in-service teachers with no prior experience with the Engineering High-Quality Engineering Guidebook. This would allow for a more comprehensive understanding of how the High-Quality Engineering Guidebook can be utilized and adapted in different contexts.

To address the methodology limitation, future studies could incorporate a broader range of statements and artifacts from the teachers, even those that may not relate to the concept of "value." This would provide a more holistic perspective on the outcomes and enable researchers to identify additional insights that may have been missed in the initial analysis.

By addressing these limitations, future research will provide a complete understanding of the value of in-service teachers as change agents for novice engineering teachers.

Conclusion.

The significance of this study is to highlight the value of teachers as in-school agents for change [36, 37]. The central message from this Project is that teachers as in-school agents for changes can potentially enhance novice teacher engagement in engineering design processes. As states continue to adopt Next Generation Science Standards [38] or incorporate engineering processes into their state-level curriculum, novice teachers will rely on their peers to strengthen their teaching practices within the subject, all while supporting the cultural needs of students. Future work regarding the emphasis on science teachers as agents for change will focus on the in-school context of the action research projects. In this regard, qualitative and quantitative data will be reported on novice teachers' engineering and cultural self-efficacy for teaching engineering processes.

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