(RESEARCH ARTICLE)

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Bridging the Gap: Assessing K-12 educators' needs for design, engineering, and technology implementation in underfunded schools in United States

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Abstract

This study investigates the perceived needs of K-12 educators in implementing design, engineering, and technology (DET) education within underfunded schools across the United States. Using a mixed-methods approach combining the DET Needs survey with qualitative interviews and focus groups, the research examines both educators' specific resource requirements and the relationship between professional development needs and effective STEM content delivery. Through a quasi-experimental design comparing educators with varying years of experience, the study aims to identify critical gaps in support and resources that impact STEM education quality in economically disadvantaged schools. Grounded in educational equity theory and incorporating perspectives from critical race theory and funds of knowledge framework, this research seeks to provide evidence-based insights for policymakers and educational leaders to develop targeted interventions and resource allocation strategies. The findings will contribute to ongoing efforts to bridge achievement gaps in STEM education and ensure equitable access to quality DET instruction across diverse socioeconomic contexts.

Keywords: STEM Education; Educational Equity; DET Education; Underfunded Schools; K-12 Education

1. Introduction

The integration of Design, Engineering, and Technology (DET) education into K-12 curricula is widely acknowledged as critical for equipping students with the skills needed to succeed in an increasingly technology-centered and innovation-driven global economy (Honey et al., 2014; National Research Council, 2012). As demand grows for expertise in Science, Technology, Engineering, and Mathematics (STEM) fields, educational institutions are urged to deliver programs that foster skills in problem-solving, creativity, and analytical thinking—qualities that are essential in fields such as engineering and technology (Bybee, 2013). However, educators often encounter numerous obstacles in implementing effective STEM and DET programs. These challenges include inadequate resources, limited professional training opportunities, and systemic constraints within schools that can limit access to quality DET education (Margot & Kettler, 2019).

Given these challenges, it is crucial to understand the perceived needs of educators in delivering DET instruction effectively. The DET instrument developed by Yasar et al. (2006) serves as a valuable tool for exploring these needs, offering insight into the specific resources, knowledge, and support teachers feel are essential for successful DET education. By examining the perceptions and challenges faced by educators, this study aims to contribute to a better understanding of how professional development and systemic support can enhance DET instruction in K-12 settings.

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1.1. Problem Statement and Problem Background

The problem is that many educators lack the necessary resources and training to effectively implement STEM programs, which hampers their ability to meet the educational demands of the 21st century. Research highlights that insufficient access to essential resources—such as technology, instructional materials, and professional development—can significantly undermine the quality of STEM education (Gonzalez et al., 2018; National Institutes of Health, n.d.; Science Buddies, n.d.). For instance, a study by Wang et al. (2019) revealed that teachers in underfunded schools often feel ill-equipped to deliver STEM content, resulting in lower student engagement and diminished interest in these crucial disciplines.

The DET instrument evaluates four key areas of educators' perceived needs: curriculum development, instructional strategies, assessment methods, and professional development (U.S. Department of Education, n.d.). Gaining insight into these specific needs is critical for addressing the gaps in support and resources faced by educators. Without targeted research, policymakers may overlook these challenges, exacerbating the existing inadequacies in STEM education and perpetuating negative impacts on student outcomes. Addressing these gaps with evidence-based interventions is vital to fostering more effective and equitable STEM education (Gonzalez et al., 2018; Wang et al., 2019).

1.2. Purpose Statement

The purpose of this research is to identify the specific perceived needs of educators regarding design, engineering, and technology education and to explore the barriers they face in implementing effective STEM programs. By utilizing a comprehensive mixed-methods approach, including both qualitative and quantitative data collection through the DET instrument, this study will assess the specific needs of educators across diverse educational environments. The focus is to identify core areas requiring support and highlight barriers that inhibit effective STEM program implementation. These insights will guide policymakers and educational leaders in developing targeted interventions and resource allocation strategies to foster equitable access to DET education, addressing the pressing gap in STEM preparedness for students from underfunded schools (Bertram et al., 2022; Xie & Reider, 2021; Hackett et al., 2020).

Studies consistently reveal that DET education is vital for preparing students to participate in an increasingly technology-driven economy, yet many educators in underfunded schools encounter considerable resource constraints that impede their ability to implement these programs effectively. According to Bertram et al. (2022), educators cite inadequate access to equipment, training, and administrative support as major obstacles, indicating a need for both resources and professional development. Xie and Reider (2021) similarly found that educators in under-resourced settings often lack access to modern technologies and curriculum materials, limiting their capacity to integrate STEM effectively. Hackett et al. (2020) emphasize that understanding these challenges at the policy level is essential for crafting programs and allocating resources that can bridge educational gaps in DET access, especially for schools in economically disadvantaged areas.

1.3. Theoretical Framework

This research is founded on the theoretical framework of educational equity, which centers on ensuring that all students, regardless of their socioeconomic status, geographic location, or other potential barriers, have access to high-quality educational opportunities. Rooted in the work of seminal scholars like John Dewey and Paulo Freire, educational equity theory underscores the moral and practical necessity of addressing disparities in education so that each learner can reach their fullest potential (Dewey, 1916; Freire, 1970). Dewey's progressive education philosophy highlighted the need for an inclusive education system that adapts to meet diverse student needs, while Freire's critical pedagogy emphasized empowerment through education as a means of social equity. This study leverages these foundational ideas to examine how disparities in resources and professional development access affect educators' capacity to deliver effective STEM programs, particularly in underfunded schools.

The principles of educational equity applied in this research are further informed by more contemporary frameworks such as critical race theory (CRT) and the funds of knowledge framework. Critical race theory, notably introduced in education by Gloria Ladson-Billings and William F. Tate, sheds light on the structural and systemic inequities that persist in educational settings, highlighting how factors such as race and economic inequality intersect to limit educational opportunities (Ladson-Billings & Tate, 1995). In tandem, the funds of knowledge framework, developed by Luis Moll and colleagues, suggests that educators who recognize and value the cultural assets that students from diverse backgrounds bring to the classroom can better bridge the equity gap by creating inclusive, culturally relevant learning experiences (Moll et al., 1992).

This research operates on several assumptions related to the study of educational equity in STEM. First, it assumes that educators in underfunded schools face unique challenges, particularly a lack of resources and professional development opportunities, which limit their ability to effectively implement design, engineering, and technology (DET) education. Second, the study presupposes that disparities in educator support and training directly affect student outcomes and access to STEM pathways. Additionally, the research expects to identify specific needs and barriers that educators encounter, revealing critical areas where targeted interventions could foster more equitable STEM education. Underlying these assumptions is the belief that high-quality education should be accessible to all students and that systemic support for educators in under-resourced environments is essential to achieving this aim (Xie & Reider, 2021; Bertram et al., 2022).

1.4. Research Questions

In recent years, the critical need for robust design, engineering, and technology (DET) education has become increasingly evident, particularly as the demand for STEM skills continues to rise across various industries. Despite the importance of DET in preparing students for future careers, educators in underfunded schools face significant challenges in implementing effective STEM programs. These challenges often stem from limited access to resources, outdated curriculum materials, and insufficient professional development opportunities. To address these critical gaps, it is essential to understand educators' perceived needs and the specific barriers they encounter.

This study aims to investigate these needs and their implications for classroom instruction, providing insights that will inform future support systems, policy decisions, and resource allocation aimed at improving DET education for underserved student populations. By examining these needs and barriers, this research seeks to highlight the urgent requirements for targeted interventions and resources that can enhance the effectiveness of STEM education. Research indicates that educators in underfunded schools encounter substantial obstacles in implementing DET programs, primarily due to limited resources and professional development opportunities (Xie & Reider, 2021). Understanding these needs is crucial for developing support systems that can help bridge the gap in STEM education quality and accessibility, particularly in underserved communities.

Ultimately, this research will provide valuable insights into the necessary steps to create a more equitable and effective educational environment. By addressing these issues, stakeholders can equip students with the skills needed for their future careers in STEM fields, ensuring that all students, regardless of their socioeconomic background, have the opportunity to succeed.

Research Question 1: What are the perceived needs of K-12 educators in implementing design, engineering, and technology (DET) education within underfunded schools across the United States?

Research Question 2: How do educators' perceived needs for professional development in STEM education relate to their ability to effectively deliver STEM content in the classroom?

1.5. Hypotheses

The hypotheses developed for this study are directly aligned with the research questions to enable a rigorous examination of educators' needs in implementing design, engineering, and technology (DET) education within underfunded schools. For the first research question, the null and alternate hypotheses aim to determine whether K-12 educators indeed perceive specific needs related to DET program implementation. This inquiry is essential, as research has shown that the lack of adequate resources and support in economically disadvantaged schools often limits the breadth of DET and STEM education they can offer, impacting students' preparedness for STEM careers (Bertram et al., 2022; Xie & Reider, 2021). By examining the perceived needs of educators, this study seeks to uncover critical areas where interventions and resources may be required.

The second research question examines the relationship between educators' perceived needs for professional development in STEM and their capacity to effectively deliver STEM content in the classroom. The corresponding hypotheses address whether a significant relationship exists, recognizing that effective professional development is often instrumental in equipping educators with the skills to implement STEM initiatives despite limited resources (Hackett et al., 2020). If a significant relationship is established, it would underscore the importance of targeted professional development initiatives for educators in underfunded schools, thereby providing policymakers with actionable insights for fostering a more equitable DET education landscape (Blanchard et al., 2019).

1.5.1. Research Question 1

- Null Hypothesis (H0): K-12 educators in underfunded schools do not have specific perceived needs regarding the implementation of design, engineering, and technology (DET) education.

- Alternate Hypothesis (H1): K-12 educators in underfunded schools have specific perceived needs regarding the implementation of design, engineering, and technology (DET) education.

1.5.2. Research Question 2

- Null Hypothesis (H0): There is no significant relationship between educators' perceived needs for professional development in STEM education and their ability to effectively deliver STEM content in the classroom.

- Alternate Hypothesis (H1): There is a significant relationship between educators' perceived needs for professional development in STEM education and their ability to effectively deliver STEM content in the classroom.

2. Research Design and Methodology

This study employs a quasi-experimental design, chosen to closely align with the research objectives and questions by enabling comparisons between existing groups within educational contexts. Quasi-experimental designs are particularly well-suited for educational research, as they facilitate analysis without requiring random assignment, which is often impractical in real-world school settings (Shadish et al., 2002). This design's flexibility allows for an examination of key variables—such as educators' years of experience and access to resources—and their effects on perceived needs and challenges in STEM implementation. By leveraging naturally occurring groups, this study can provide contextually relevant insights while preserving practical applicability, an approach noted for enhancing the external validity of findings in educational research (Creswell & Creswell, 2018).

The independent variable in this study is educators' years of experience, categorized as less than five years versus five or more years. The dependent variables include the average perceived needs for STEM resources and the average perceived barriers encountered in implementing STEM programs, both measured quantitatively.
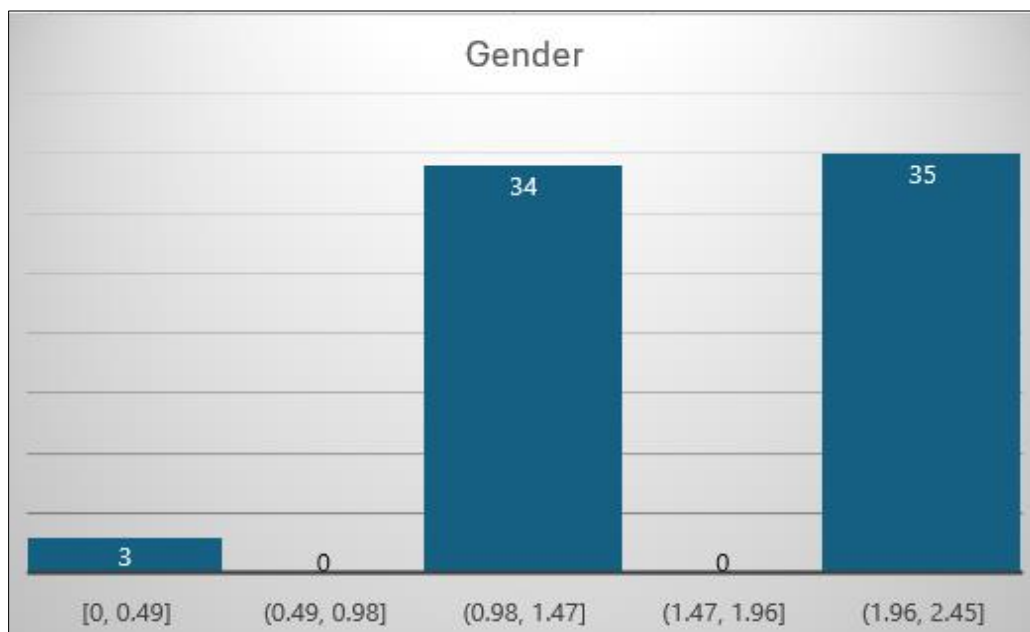
Note. The graph presents a breakdown of the educators' gender, highlighting the demographic composition of participants in the study.

Figure 1 Gender Representation of Educators

To analyze the relationship between experience and perceived needs, the study will compare two subgroups: Group A, consisting of educators with less than five years of experience, and Group B, consisting of educators with five or more years of experience.

Note. The graph illustrates the distribution of years of experience among the educators who took part in the study, providing insight into the range of professional expertise represented in the participant group.

Figure 2 Graphical Representation of the Educators' years of experience

The study operates under several assumptions. It is assumed that the sample size will be sufficiently large to detect statistically meaningful differences between groups, which is essential for robust analysis. The validity and reliability of the DET Needs instrument are assumed to ensure that it accurately captures educators' perceptions of needs and challenges. Consistency in data collection procedures across all participants is also assumed to maintain reliability. Additionally, it is assumed that groups are similar in relevant characteristics, except for the independent variable of experience level, allowing for valid comparison.

However, the quasi-experimental design comes with specific limitations. Confounding variables may influence results without random assignment, impacting internal validity (Shadish et al., 2002). Findings may be less generalizable to broader educational settings or diverse populations (Creswell & Creswell, 2018). Pre-existing groups may introduce potential selection bias, as they may differ systematically. Lastly, self-reported data, while informative, can be influenced by personal perceptions and biases.

2.1. Data Collection

Data for this study will be collected through the DET Needs survey, which will be administered using both online platforms and in-person sessions during professional development workshops. Online administration will allow for broad reach and flexibility, enabling educators from various geographical regions to participate, while in-person sessions will provide opportunities for more localized and context-specific insights. By utilizing these two methods, the study ensures that the data collection process is inclusive and accessible, allowing for a diverse range of participants to share their perspectives.

To further enrich the findings, qualitative data will be collected through in-depth interviews and focus groups. These qualitative methods are crucial for gaining a deeper understanding of the nuances behind the survey responses. While the DET Needs survey will provide quantitative data on educators' perceived needs and barriers, interviews and focus groups will offer detailed, personal accounts of the challenges educators face in implementing design, engineering, and technology (DET) education. These qualitative methods will enable participants to express their experiences, frustrations, and successes in their own words, providing valuable context to the survey data. Additionally, interviews and focus groups will allow for probing into specific areas, such as how the lack of resources, professional development opportunities, or administrative support impacts educators' ability to effectively teach STEM subjects.

By combining both quantitative and qualitative data, this study adopts a mixed-methods approach, which is particularly effective in educational research. The quantitative data from the survey will provide broad, generalizable trends, while the qualitative data will deepen the understanding of the personal and institutional barriers that shape those trends.

This methodological triangulation strengthens the validity of the findings and helps ensure that the study captures a comprehensive picture of the challenges and needs facing educators in underfunded schools (Xie & Reider, 2021).

2.2. Data Analysis

The data analysis will employ a mixed-methods approach, combining both quantitative and qualitative methodologies to provide a comprehensive understanding of educators' needs in implementing Design, Engineering, and Technology (DET) education. Quantitative data, collected through the DET Needs Survey, will be analyzed using statistical software such as SPSS or R to ensure accuracy and reliability. Descriptive statistics, including measures of central tendency and variability, will be utilized to summarize the dataset, offering an overview of trends and distributions within the survey responses (Field, 2018). To address the research hypotheses, inferential statistical methods, such as T-tests and ANOVA, will be employed to identify significant differences between groups, such as educators in underfunded schools versus those in well-resourced institutions, and to examine relationships between variables, including professional development needs and teaching effectiveness. This quantitative analysis aims to uncover patterns and disparities in educators' perceived needs and resources, thereby providing an evidence-based foundation for targeted interventions (Creswell & Creswell, 2018).

Qualitative data from interviews and focus groups will be analyzed using thematic analysis, which is well-suited for identifying and interpreting patterns within textual data. This process will involve systematically coding the data to extract recurring themes related to educators' challenges, needs, and experiences in delivering DET education (Braun & Clarke, 2006). Key themes such as resource availability, professional development gaps, and instructional barriers will be explored to provide rich, contextual insights that extend beyond the quantitative findings. These qualitative perspectives will offer depth and nuance by capturing the lived experiences of educators, illuminating systemic issues that may not be evident through survey data alone (Merriam & Tisdell, 2016).

By integrating the quantitative and qualitative findings, the study will achieve a holistic understanding of the barriers to effective DET education. This mixed-methods approach will allow for a more comprehensive exploration of the research questions, offering actionable insights for improving resource allocation and professional development in DET education. The combination of numerical analysis and thematic interpretation will ensure that the study addresses both broad trends and individual experiences, contributing to a deeper understanding of how to support educators in fostering effective DET practices.

2.3. Research Findings

The findings of this study will be presented in a detailed and comprehensive report that integrates both quantitative and qualitative results to provide a holistic view of the research outcomes. Statistical analyses, including descriptive and inferential statistics, will be summarized to highlight key trends and significant differences in perceived needs and barriers among various groups of educators. These findings will be contextualized with qualitative insights, derived from interviews and focus groups, to illustrate the lived experiences of educators and offer a deeper understanding of the challenges they face in implementing Design, Engineering, and Technology (DET) education. This integration of quantitative data with qualitative narratives will ensure that the findings are both evidence-based and grounded in real-world experiences (Creswell & Creswell, 2018; Braun & Clarke, 2006).

The report will also include actionable recommendations for policymakers and educational leaders. These recommendations will be informed by the identified needs, barriers, and gaps in resources and training, aiming to guide future interventions and resource allocation strategies. For instance, specific suggestions may address professional development programs, equitable access to instructional materials, and the implementation of supportive policies to enhance STEM education quality (Merriam & Tisdell, 2016). The findings and recommendations will emphasize the importance of addressing systemic disparities to ensure that all educators are equipped to meet the demands of 21st-century education.

By providing evidence-based insights and practical solutions, this report will serve as a valuable resource for stakeholders invested in improving DET education, bridging the gap between research and practice, and fostering more equitable and effective teaching environments.

2.4. Reliability and Validity

After data collection, the reliability and validity of the research instruments will be rigorously assessed to ensure the accuracy and credibility of the findings. Reliability will be evaluated using Cronbach's alpha, a widely used statistical measure that assesses the internal consistency of the items within the DET Needs Survey. This analysis will determine

whether the survey items reliably measure the constructions they are intended to capture, with a Cronbach's alpha value of 0.70 or higher typically indicating acceptable reliability (Field, 2018). Ensuring high reliability is essential to establish confidence in the consistency and dependability of the survey results.

Validity will be assessed through multiple strategies, with a primary focus on content validity. Content validity involves evaluating whether the survey items comprehensively represent the constructs of interest, such as educators' perceived needs in curriculum development, instructional strategies, assessment methods, and professional development. Expert reviews and alignment with existing literature will be utilized to confirm that the survey accurately reflects the theoretical framework and practical realities of DET education (Creswell & Creswell, 2018).

To further strengthen the validity of the findings, triangulation will be employed by integrating quantitative data from the survey with qualitative data from interviews and focus groups. Triangulation enhances construct validity by cross verifying the data through multiple sources, providing a richer, more nuanced understanding of the challenges and needs faced by educators (Patton, 2015). By combining quantitative and qualitative perspectives, the study ensures that the findings are robust and reflective of the complex dynamics in DET education.

This comprehensive approach to assessing reliability and validity will enhance the rigor of the research and ensure that the results provide meaningful and actionable insights for improving DET education.

3. Conclusion

This research is designed to identify the specific perceived needs of educators regarding design, engineering, and technology (DET) education, while also investigating the challenges and barriers they face in successfully implementing STEM programs. As educational systems across the United States strive to prepare students for a rapidly evolving and technology-driven world, it is crucial to understand the factors that hinder or support the effective delivery of STEM education. By examining these perceived needs, the study aims to uncover the underlying gaps in resources, professional development, administrative support, and instructional materials that educators encounter, particularly in underfunded schools. The findings will not only provide a clearer picture of these challenges but also highlight critical areas where intervention and support are necessary to strengthen the capacity of educators in the field of STEM.

Furthermore, this research has significant implications for policymakers and educational leaders. By identifying the specific needs of educators, the study offers data-driven insights that can inform the development of targeted policies, professional development programs, and resource allocation strategies. These insights will guide decision-makers in creating more effective, equitable, and sustainable systems for STEM education, especially in schools that face financial and resource limitations. In addition, the research aims to contribute to a broader effort to improve the overall quality of STEM education, ensuring that all students, regardless of their socioeconomic status, are equipped with the skills and knowledge necessary to succeed in a technology-driven future.

Ultimately, this study aspires to support the ongoing efforts to bridge the achievement gap in STEM education, ensuring that all students are not only exposed to but also excel in disciplines that are essential for success in the 21st century. By better understanding the needs of educators, this research will contribute to a more informed, inclusive approach to STEM education, promoting long-term success for both educators and students in underfunded school environments.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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