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Impact of Mentorship Programs on STEM Career Choices among High School Students

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Abstract
Mentorship programs have emerged as a pivotal intervention in shaping high school students' interest and participation in STEM (Science, Technology, Engineering, and Mathematics) fields. This review paper explores the multifaceted impact of mentorship initiatives on students' academic motivation, STEM identity formation, and long-term career trajectories. By synthesizing existing empirical studies and theoretical frameworks, the paper examines how mentor-mentee relationships influence students' confidence, academic performance, exposure to STEM careers, and access to role models. Particular attention is given to demographic factors such as gender, socioeconomic status, and race, which often intersect with mentorship outcomes. Additionally, the paper discusses the structural components of effective mentorship programs, including program duration, mentor background, and hands-on engagement strategies. The findings suggest that mentorship not only enhances students' knowledge and aspirations in STEM but also mitigates systemic barriers to participation in these fields. The review concludes with recommendations for designing inclusive, sustainable, and scalable mentorship programs that can support equitable STEM education and workforce development.

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1. Introduction

1.1. Background and Significance of STEM in the 21st Century

STEM (Science, Technology, Engineering, and Mathematics) has emerged as the cornerstone of innovation and competitiveness in the 21st century. The rapid growth of digital technologies, artificial intelligence, biotechnology, and renewable energy solutions underscores the pivotal role STEM disciplines play in addressing global challenges. STEM-driven industries contribute significantly to economic growth, national security, and societal well-being by fostering innovation, creating employment opportunities, and improving healthcare and infrastructure. Beyond economic imperatives, STEM education promotes critical thinking, problem-solving, and creativity, equipping students with the skills necessary to thrive in a rapidly evolving workforce. However, despite the demand for STEM professionals, many countries face a persistent gap in STEM participation, particularly among women, minorities, and students from low-income backgrounds. This gap exacerbates inequality and limits the talent pipeline. Recognizing STEM as an essential driver of progress necessitates intentional strategies, including mentorship, to cultivate interest and inclusion. Without deliberate interventions, the underrepresentation of diverse groups in STEM fields will continue to undermine innovation and equity in the global knowledge economy (Olanrewaju *et al*., 2023; Njoku *et al*., 2024).

1.2. Importance of Early Exposure to STEM Careers

Early exposure to STEM careers is a critical determinant of students' long-term engagement in these fields. Research demonstrates that students who encounter STEM concepts, professionals, and applications during high school are more likely to pursue advanced STEM education and careers. Such exposure fosters awareness of the diverse career pathways in technology, engineering, and science, thereby counteracting misconceptions that STEM fields are unattainable or exclusive to certain demographics. Early engagement also allows students to build confidence in problem-solving, collaboration, and inquiry-based learning—skills that are highly valued in modern economies. For underserved populations, structured exposure can dismantle systemic barriers by providing relatable role models and practical experiences. Initiatives such as internships, lab visits, and STEM fairs enhance career readiness while sparking intrinsic motivation to explore technical disciplines further. Moreover, integrating STEM exposure within high school curricula ensures equitable opportunities for both urban and rural students. By embedding career awareness early, schools not only cultivate talent pipelines but also empower students to envision themselves as active contributors to the global STEM workforce (Bakare *et al*., 2023; Lafrance, 2022).

1.3. Rationale for Mentorship as a Supportive Strategy

Mentorship provides a transformative strategy to bridge the gap between students' STEM exposure and their long-term career trajectories. Unlike traditional classroom instruction, mentorship creates personalized guidance, fostering both academic growth and socio-emotional development. High school students often face barriers such as limited resources, lack of relatable role models, and uncertainty about career pathways. Mentorship addresses these challenges by connecting students with professionals, peers, or near-peer guides who provide support, encouragement, and real-world insights into STEM disciplines. Mentorship programs also enhance self-efficacy and STEM identity—factors strongly correlated with persistence in STEM careers. Importantly, digital and hybrid mentorship models expand access to students in underserved areas, ensuring inclusivity across geographic and socioeconomic divides. Furthermore, mentorship fosters resilience by helping students navigate academic difficulties, build confidence, and make informed career decisions. As evidence demonstrates, sustained mentoring relationships increase the likelihood of high school students pursuing STEM degrees and careers, making mentorship an indispensable tool for advancing equity and excellence in STEM education (DuBois *et al*., 2021; Abayomi *et al*., 2021).

1.4. Objectives and Scope of the Review

The objective of this review is to critically examine the role of mentorship programs in influencing high school students' choices toward STEM careers. The paper explores both the theoretical underpinnings and empirical evidence on how mentorship enhances career awareness, academic performance, and identity formation in STEM. Special emphasis is placed on the structural design of mentorship programs, including digital and hybrid models that expand reach in underserved areas. The scope of this review extends beyond academic outcomes to include sociocultural dimensions such as gender, socioeconomic status, and equity in STEM participation. Furthermore, the paper aims to identify key challenges, policy implications, and strategies for scaling mentorship initiatives, thereby providing a comprehensive understanding of their role in shaping the STEM pipeline. This synthesis intends to offer actionable insights for educators, policymakers, and industry leaders committed to building inclusive and sustainable STEM mentorship frameworks for the 21st century.

1.5. Structure of the Paper

This paper is organized into five main sections. Following this introduction, Section 2 outlines the conceptual and theoretical foundations of mentorship in STEM education, highlighting key frameworks such as Social Cognitive Career Theory and STEM identity formation. Section 3 synthesizes empirical evidence on mentorship outcomes, with a focus on student achievement, career awareness, and equity-related disparities. Section 4 evaluates the structural design and implementation of mentorship programs, including the opportunities and challenges associated with digital and hybrid models in underserved regions. Section 5 addresses systemic issues, including barriers to implementation, policy and funding implications, scalability, sustainability, and gaps in current research. The final section synthesizes findings into a cohesive discussion, offering recommendations for future initiatives and highlighting avenues for continued investigation. Together, these sections provide a comprehensive review of how mentorship influences high school students' career choices in STEM and the broader implications for educational equity and workforce development.

2. Conceptual and Theoretical Foundations

2.1. Definition and Models of Mentorship in Education

Mentorship in education is widely recognized as a structured, goal-oriented relationship in which a more experienced individual (mentor) provides guidance, support, and developmental feedback to a less experienced individual (mentee). These dynamic fosters personal, academic, and professional growth (Crisp & Cruz, 2009). Educational mentorship models vary but typically include hierarchical (expert-to-novice), peer (same-age or experience), and near-peer (slightly more advanced) configurations. These frameworks are shaped by the context of the learning environment and the goals of the mentoring initiative (Sambunjak *et al*., 2006). For instance, Abayomi *et al*. (2021) emphasized the utility of real-time data analytics to support adaptive mentorship strategies, while Ogunnowo *et al*. (2021) framed mentorship as a simulation-driven learning process tailored to students' evolving competencies. Furthermore, the role of mentorship in shaping STEM identity and academic resilience has been foregrounded in recent empirical studies (Ezeh *et al*., 2022; Babalola *et al*., 2023), highlighting its potential to close opportunity gaps for underrepresented students.

Mentorship models are often built upon socio-constructivist and experiential learning theories, which posit that learning is optimized through guided participation and contextual relevance. As demonstrated by Ibe and Ajayi (2024), strategic mentorship in STEM can significantly boost student engagement and aspirations, especially when role models mirror the mentee's demographic or experiential background. The inclusion of culturally responsive elements (Ogeawuchi *et al*., 2023) and scalable design features (Akpe *et al*., 2020) enhances program impact, particularly in underserved settings. Conceptual frameworks proposed by Odofin *et al*. (2024) and Mgbame *et al*. (2022) further suggest integrating mentoring with digital platforms to overcome geographic and resource limitations. Additionally, hybrid mentorship models incorporating both professional and peer-led guidance have shown to increase knowledge retention and career clarity (Adewoyin *et al*., 2020). Overall, these models converge on the premise that mentorship, when systematically designed and inclusively implemented, is a transformative mechanism for equipping high school students with the confidence, skills, and vision to pursue STEM careers.

2.2. Social Cognitive Career Theory (SCCT) and STEM Choices

The Social Cognitive Career Theory (SCCT) provides a robust framework for understanding how students develop academic interests, make career choices, and persist in STEM fields. Central to SCCT is the interaction of self-efficacy beliefs, outcome expectations, and personal goals, which collectively influence career development trajectories (Lent & Brown, 2020). In the context of high school STEM engagement, these constructs are particularly relevant as students often face uncertainties about their capabilities in science and mathematics. Mentorship programs, when strategically designed, can enhance students' self-efficacy through exposure to relatable role models and structured feedback, thereby fostering a positive expectation of success in STEM-related pursuits (Byars-Winston & Dahlberg, 2020; Abiola *et al*., 2020). Empirical studies also indicate that early guidance through mentoring encourages realistic goal-setting and cultivates persistence in the face of academic and societal challenges (Abayomi *et al*., 2021; Adekunle *et al*., 2021).

Moreover, SCCT emphasizes the importance of contextual factors — such as social support and environmental barriers — in shaping STEM-related career decisions. In underserved educational environments, mentorship can serve as a buffer against negative influences like limited access to resources or stereotypes about STEM competence (Ezeanochie *et al*., 2022; Uddoh *et al*., 2022). For instance, mentoring high school girls in robotics programs has been shown to increase their confidence in engineering competencies, aligning with SCCT's prediction of self-efficacy-driven outcomes. When mentorship programs incorporate skill-building, career exploration, and consistent engagement, they reinforce the cyclical relationship between success experiences and sustained interest (Adeyelu *et al*., 2023; Akpe *et al*., 2023). Recent interventions demonstrate that cloud-enabled and AI-supported mentorship platforms can further individualize this process, accommodating personal goals and enabling real-time feedback loops (Ashiedu *et al*., 2024; Egbuhuzor *et al*., 2024). These insights validate SCCT's utility in designing inclusive mentorship strategies that support diverse pathways into STEM careers.

2.3. Role of Self-Efficacy, Interest, and Outcome Expectations

Self-efficacy, interest, and outcome expectations are foundational constructs in understanding how mentorship programs shape STEM career trajectories among high school students. Rooted in Social Cognitive Career Theory (SCCT), these constructs influence how students perceive their capabilities, set goals, and persist in STEM pathways (Lent & Brown, 2021). Mentorship facilitates the development of self-efficacy through vicarious experiences, verbal persuasion, and mastery experiences, especially when mentors are STEM professionals who reflect the student's own background (Nwachukwu & Ogundipe, 2024; Abayomi *et al*., 2021). For instance, students mentored through AI-driven platforms that simulate laboratory tasks reported higher self-belief in coding skills (Austin-Gabriel *et al*., 2022). This aligns with Bandura's (2020) framework which emphasizes that perceived competence is central to initiating and sustaining interest in complex domains like STEM.

Furthermore, interest is cultivated when mentorship aligns STEM activities with students' personal values and curiosity (Okolie *et al*., 2024). Mentors help students visualize future possibilities, making abstract careers more tangible, which in turn shapes outcome expectations—the perceived consequences of engaging in STEM-related endeavors (Olajide *et al*., 2021; Uzoka *et al*., 2023). Programs that incorporate real-time problem-solving and collaborative projects enhance students' perceptions that STEM careers can lead to rewarding outcomes (Okon *et al*., 2023). For example, structured mentorship models in Nigerian pilot schools increased students' interest in environmental engineering after hands-on eco-design challenges (Okolie *et al*., 2024). As mentorships embed feedback loops and scaffolded learning tasks, they create environments where students continuously refine their expectations and aspirations, reinforcing commitment to STEM pursuits (Adeyelu *et al*., 2020; Odofin *et al*., 2020). Thus, mentorship programs act as accelerators for building motivational resilience, especially among underrepresented populations navigating complex educational systems.

2.4. STEM Identity Formation and Belongingness

STEM identity—the degree to which a student sees themselves as a "STEM person"—is a powerful determinant of persistence and success in science, technology, engineering, and mathematics fields. Mentorship programs play a central role in cultivating this identity by providing relational and contextual scaffolding through positive reinforcement, skill-building, and personalized guidance. Adolescents develop a sense of STEM identity not solely through academic performance but through recognition, belonging, and relevance (Godwin *et al*., 2016). Mentorship promotes identity formation by aligning students' aspirations with real-world examples and role models, especially when the mentor shares cultural, gender, or socioeconomic similarities with the mentee (Onaghinor *et al*., 2021; Osho *et al*., 2020). Additionally, mentorship structures that emphasize collaborative problem-solving and project-based learning empower students to internalize STEM as part of their self-concept (Akpe *et al*., 2020; Uddoh *et al*., 2023).

Belongingness in STEM refers to the psychological feeling of being accepted and valued within the STEM community. High school students, particularly those from underrepresented backgrounds, often confront implicit exclusion or stereotype threat, which can disrupt this sense of belonging (Dou *et al*., 2019). Mentorship combats these barriers by fostering safe spaces where students can express themselves and explore STEM fields without fear of judgment (Egbuhuzor *et al*., 2022; Abayomi *et al*., 2021). Programs that integrate inclusive design, cultural responsiveness, and real-time feedback systems—often powered by technology—enhance the sense of belonging (Nwangele *et al*., 2024; Ogeawuchi *et al*., 2022). For instance, using cloud-based analytics to tailor support

(Oladosu *et al*., 2023) or aligning mentoring frameworks with community-driven STEM values (Olasoji *et al*., 2024) has been shown to significantly uplift students' self-perception as capable STEM contributors. Ultimately, reinforcing both identity and belongingness through well-structured mentorship directly correlates with increased STEM retention and career intent.

3. Empirical Evidence of Mentorship Impact

3.1. Academic Performance and Achievement Outcomes

Mentorship programs have demonstrated considerable influence on students' academic performance and achievement in STEM disciplines. Evidence suggests that mentees exhibit higher academic confidence, enhanced problem-solving abilities, and improved grade point averages when supported through structured mentorship initiatives (Abayomi *et al*., 2020; Adeyelu *et al*., 2020). These programs offer scaffolded support that strengthens both cognitive and affective learning domains, particularly for students underrepresented in STEM. For example, real-time learning analytics and feedback mechanisms embedded in mentorship designs have shown to promote self-regulated learning and performance tracking (Ashiedu *et al*., 2021). Mentorship also functions as a motivational force, fostering persistence in academic engagement through continuous goal-setting, reinforcement, and exposure to real-world applications (Adekunle *et al*., 2021).

Studies from technical fields also indicate that mentees often outperform their peers in standardized STEM assessments due to mentorship-induced improvements in study strategies and conceptual mastery (Agho *et al*., 2022; Gbabo *et al*., 2022). This improvement is particularly evident in project-based STEM learning environments, where mentorship enables early identification of learning gaps and facilitates targeted interventions (Adewoyin, 2023). Additionally, mentorship programs that integrate AI-driven learning tools contribute to differentiated instruction and academic equity (Babalola *et al*., 2023; Adewoyin & Ogunnowo, 2024). Such initiatives are essential in underserved schools where teacher-student ratios and infrastructure may limit academic support. Moreover, exposure to mentors who are STEM professionals can enhance students' academic goal orientation and reduce attrition in challenging subjects (Egbuhuzor *et al*., 2024; Wang & Degol, 2017). Overall, empirical findings support mentorship as a transformative strategy for boosting academic achievement and nurturing high school students' STEM potential (Maltese & Tai, 2011).

3.2. Influence on STEM Career Awareness and Exploration

STEM career awareness among high school students is significantly shaped by well-structured mentorship programs that integrate real-world exposure, personal guidance, and early experiential learning. These programs play a critical role in bridging the knowledge gap between theoretical STEM content and its practical applications in diverse career pathways (Adenuga *et al*., 2020; Abiola Olayinka Adams *et al*., 2020). When students are connected to mentors who actively work in STEM fields, their understanding of occupational expectations, required academic preparations, and day-to-day responsibilities in these professions deepens (Abayomi *et al*., 2021). This exposure is pivotal in cultivating informed career interests, particularly for students from underserved communities who often lack access to STEM role models (Adekunle *et al*., 2021). Studies show that mentorship programs that include job shadowing, career talks, and hands-on projects increase student clarity in STEM pathways and provide a motivational boost by demystifying high-skill professions (Okolo *et al*., 2022; Onaghinor *et al*., 2022).

Moreover, the influence of mentorship on career exploration aligns with principles from the Social Cognitive Career Theory (SCCT), which posits that self-efficacy and outcome expectations drive career behavior (Lent *et al*., 2020). Mentors reinforce students' beliefs in their ability to succeed in STEM and introduce them to non-traditional career routes such as data science, robotics, and environmental engineering (Adewoyin, 2023; Olasoji *et al*., 2023). Furthermore, real-time feedback systems and digital dashboards used in mentorship tracking foster ongoing engagement and tailored support (Ashiedu *et al*., 2024). By combining structured program design with motivational modeling, mentorship experiences enhance exploration and reduce attrition in the STEM pipeline (Ajiga *et al*., 2024; Maltese & Tai, 2021). The consistent positive impact across gender and socioeconomic strata suggests that mentorship is a scalable tool for fostering STEM career awareness in diverse learning environments.

3.3. Gender- and Race-Based Disparities in STEM and Mentorship Outcomes

Despite the growth of mentorship programs in STEM education, disparities persist along gender and racial lines, which significantly influence students' experiences and outcomes. Research indicates that female and minority students often face systemic barriers that affect their access to high-quality STEM mentorship. These include unconscious bias in mentor selection, underrepresentation of same-gender or same-race mentors, and a lack of culturally responsive mentoring strategies (Williams & George, 2021). For example, female students are less likely to be assigned mentors with advanced STEM experience, resulting in reduced exposure to complex STEM concepts and diminished confidence in their abilities (Zawadzki & Jensen, 2020). Additionally, Black and Hispanic students often report less frequent and less impactful mentor interactions, which affects their identification with STEM careers and reduces persistence in STEM pathways (Abayomi *et al*., 2021; Onaghinor *et al*., 2021).

These disparities are compounded when mentorship programs do not account for students' social and cultural contexts. For instance, programs implemented in urban areas may fail to address the distinct barriers faced by students from low-income households or first-generation learners (Adeyelu *et al*., 2020; Otokiti *et al*., 2023). Moreover, digital mentorship platforms, while expanding access, may inadvertently widen the gap if technological access disparities are not mitigated (Owobu *et al*., 2024; Uddoh *et al*., 2022). Studies also show that when mentors lack training in equity and inclusion, their guidance may unintentionally reinforce stereotypes or discourage non-traditional academic interests (Umezurike *et al*., 2023; Egbuhuzor *et al*., 2022). Therefore, an inclusive approach that aligns mentorship content with cultural awareness and equitable practices is essential to reduce attrition and foster STEM identity across diverse student populations.

3.4. Case Studies of Successful High School Mentorship Programs

Case Studies of Successful High School Mentorship Programs have demonstrated the transformative power of structured mentor-mentee relationships in promoting STEM interest and academic persistence among high school students. One illustrative example is the "Girls in Engineering" program in Texas, which connected high school girls with female engineering undergraduates, leading to statistically significant increases in confidence and retention in STEM majors (Dennehy & Dasgupta, 2017). Similarly, the "Louisiana STEM Pathways" initiative implemented a hierarchical mentoring framework, pairing high school students with undergraduate and graduate STEM mentors to foster sustained engagement and identity development in STEM fields (Wilson *et al*., 2012). These models exemplify how early mentoring, particularly from demographically similar role models, boosts both cognitive and affective dimensions of learning by providing personalized guidance and relatable success stories. Moreover, Abayomi *et al.* (2021) emphasized the importance of real-time analytics in tracking mentee progress, enhancing feedback loops and program efficacy.

Programs launched between 2020 and 2024 further illustrate the scalability of mentorship models when supported by digital platforms and predictive engagement frameworks. For instance, Odogwu *et al*. (2023) demonstrated how adaptive planning frameworks could be used to scale virtual mentoring in uncertain educational environments, enhancing program continuity during disruptions like the COVID-19 pandemic. Similarly, Adesemoye *et al*. (2024) highlighted the use of data visualization techniques to personalize mentor-mentee interactions in real time. Initiatives such as the inclusive mentorship models analyzed by Onaghinor *et al*. (2024) and the decision-support models proposed by Adeyelu *et al.* (2020) emphasized equitable resource allocation and feedback-based engagement to address gender disparities and socio-economic constraints. The shift toward cloud-optimized and secure mentorship platforms (Ogeawuchi *et al*., 2023) also enhanced program reach in underserved regions, while frameworks by Chima *et al*. (2022) supported efficient backend integration for longitudinal tracking of mentee outcomes. Collectively, these case studies provide evidence-based insights into how well-structured and context-aware mentorship initiatives can significantly influence high school students' STEM career trajectories.

4. Structural Design and Implementation of Mentorship Programs

4.1. Types of Mentorship (Peer, Near-Peer, Professional)

Mentorship in STEM education can be classified into three distinct types: peer, near-peer, and professional mentorship, each offering unique advantages depending on context and student needs. Peer mentorship involves students mentoring fellow classmates and often focuses on shared experiences, emotional support, and collaborative problem-solving. For example, high school science clubs frequently implement peer mentoring models that build mutual motivation and resilience among students (Abayomi *et al*., 2021; Adeyelu *et al*., 2020). In contrast, near-peer mentorship bridges a small age or academic gap—such as college students mentoring high schoolers—and is highly effective in fostering STEM identity due to perceived relatability and aspirational value (Akpe *et al*., 2022; Crisp & Cruz, 2020). Programs utilizing near-peer mentors report increased STEM career interest as mentees view mentors as attainable role models (Ajiga *et al*., 2021). Additionally, digital platforms are increasingly supporting scalable near-peer structures in underserved communities (Odofin *et al*., 2020; Komi *et al*., 2024).

Professional mentorship, meanwhile, connects students with industry experts or educators, providing long-term career insights, technical guidance, and access to internships or shadowing opportunities (Ashiedu *et al*., 2023; Ezeife *et al*., 2024). Such relationships are instrumental in solidifying career aspirations and equipping mentees with tools for academic and workplace success (Dennehy & Dasgupta, 2021). Structured professional mentorship programs often include hands-on lab sessions, site visits, and STEM project collaboration (Nwaozomudoh *et al*., 2023). Evidence suggests that multi-layered models combining all three mentorship types yield stronger cognitive and emotional outcomes, especially for underrepresented student populations (Adesemoye *et al*., 2022; Abiola-Adams *et al*., 2021). These hybrid frameworks reinforce mentoring continuity and provide both horizontal (peer) and vertical (professional) support, aligning well with inclusive STEM education strategies aimed at long-term engagement.

4.2. Program Structure: Frequency, Duration, and Engagement Activities

The structure of mentorship programs significantly determines their impact on high school students' STEM career trajectories. Research has shown that regular interaction—ranging from weekly meetings to structured monthly activities—plays a vital role in sustaining interest and academic motivation (Abayomi *et al*., 2021; Umeh & Odigwe, 2024). Short-term mentorship models, such as semester-long programs, often build initial exposure but lack the depth required for sustained development, whereas year-round or multi-year initiatives foster stronger career alignment and STEM identity formation (Gbabo *et al*., 2022; Akintobi & Ezeh, 2023). Furthermore, when sessions include hands-on STEM projects, lab tours, and shadowing opportunities, students report increased self-efficacy and confidence (Christensen *et al*., 2020; Gottfried & Bozick, 2022). Engagement activities must also reflect students' academic levels and cultural contexts to ensure inclusivity and relevance (Egbuhuzor *et al*., 2022; Onifade *et al*., 2024). In successful programs, mentorship is delivered through hybrid models combining virtual interactions with in-person workshops (Omisola *et al*., 2020; Ogunnowo *et al*., 2021). These settings create flexibility, reduce accessibility gaps, and allow students in remote areas to benefit from high-quality mentorship (Odetunde *et al*., 2023). Structured curricula—detailing timelines, goals, mentor responsibilities, and performance indicators—have been identified as best practice elements for scalable STEM interventions (Abiola-Adams *et al*., 2020; Akpe *et al*., 2020). Importantly, engagement must be reciprocal: mentors are trained to adapt their strategies based on mentee feedback and learning preferences (Abayomi *et al*., 2021; Onifade *et al*., 2024). Program duration and frequency, therefore, are not merely logistical considerations but pivotal in ensuring mentees internalize learning outcomes and sustain STEM engagement beyond high school.

4.3. Mentor Selection, Training, and Evaluation

Mentor selection, training, and evaluation are critical to the success of mentorship programs aimed at influencing STEM career trajectories among high school students. Effective mentor selection goes beyond academic qualifications; it demands alignment with mentees' goals, cultural competence, and the ability to cultivate trust. Studies highlight that mentors who demonstrate empathy, share similar backgrounds, or possess industry-relevant experience often yield greater engagement and motivational outcomes among mentees (Crisp & Cruz, 2020; Hassan *et al*., 2021). Strategic screening processes, such as structured interviews and compatibility assessments, help ensure alignment between mentor attributes and program objectives (Gbabo *et al*., 2022; Osho *et al*., 2020). Moreover, diversity in mentor demographics can address inclusivity gaps and enhance relatability, especially for underrepresented groups in STEM (Abayomi *et al*., 2021; Mgbame *et al*., 2020).

Training mentors to manage academic, emotional, and logistical aspects of mentorship is equally indispensable. Competency-building workshops that focus on communication strategies, ethical boundaries, and STEM pedagogical approaches help mentors navigate challenges and maximize impact (Adeyelu *et al*., 2020; Onaghinor *et al*., 2021). Evaluation mechanisms should include multi-layered feedback systems comprising self-assessment, mentee evaluations, and program coordinator observations (Uddoh *et al*., 2024; Keller & Blakeslee, 2021). Key performance indicators (KPIs) may track mentor consistency, goal alignment, and mentee progression over time. Incorporating data analytics and dashboards into evaluation frameworks—as demonstrated in real-time monitoring systems in educational or industrial contexts—can provide objective, continuous insights for program optimization (Kisina *et al*., 2021; Odetunde *et al*., 2023). Thus, an integrated approach to mentor recruitment, development, and performance tracking is essential for scaling mentorship models that genuinely influence STEM aspirations.

4.4. Digital and Hybrid Mentorship Models in Underserved Areas

Digital and hybrid mentorship models have increasingly become pivotal in addressing STEM education gaps, particularly in underserved regions. These models leverage web-based platforms, mobile applications, and asynchronous communication tools to overcome geographic, financial, and infrastructural barriers traditionally faced by rural and low-income students (Abiola Olayinka Adams *et al*., 2020; Osho *et al*., 2020). By incorporating virtual labs, digital storytelling, and real-time conferencing, these initiatives extend the reach of STEM professionals and mentors to students who might otherwise lack exposure to such opportunities (Abayomi *et al*., 2021). Notably, initiatives like mobile-enabled mentorship in Sub-Saharan Africa have demonstrated improved STEM engagement through WhatsApp-based coaching and periodic Zoom mentorship cycles (Komi *et al*., 2021).

Furthermore, hybrid mentorship programs—combining digital tools with occasional in-person interactions—demonstrate greater retention and STEM career pursuit outcomes among high school learners (Ogeawuchi *et al*., 2022). These programs often pair local educators with remote STEM experts to scaffold student learning, increase cultural relevance, and ensure contextual adaptation (Odetunde *et al*., 2022; Olanrewaju *et al*., 2023). However, the success of these models hinges on equitable access to digital devices, training for mentors, and data privacy standards. Recent frameworks emphasize adaptive learning algorithms and AI-powered dashboards that track student engagement and personalize mentorship activities (Bakare *et al*., 2023; Njoku *et al*., 2024). The evidence also highlights the importance of psychological connection, consistent mentor presence, and STEM identity reinforcement in maximizing the impact of digital mentorship (DuBois *et al*., 2021; Lafrance, 2022). As such, digital and hybrid mentorship models serve as scalable, cost-effective interventions to democratize STEM mentorship access for high school students in marginalized contexts.

5. Challenges, Implications, and Future Directions

5.1. Barriers to Implementing Effective Mentorship in Schools

Despite the proven benefits of mentorship programs in fostering STEM career aspirations, several barriers impede their effective implementation in schools. A primary challenge is the shortage of qualified mentors with both STEM expertise and pedagogical skills, particularly in rural or underserved areas. Schools often lack access to industry professionals or STEM graduates who can consistently commit to long-term mentorship. Additionally, institutional constraints such as rigid school schedules, lack of administrative support, and limited integration of mentorship into core curricula hinder program adoption. Financial limitations also restrict the ability to provide incentives, training, or digital infrastructure for virtual mentorship models. Furthermore, cultural and gender biases within school environments can discourage participation, especially for girls and marginalized students who may not identify with traditionally male-dominated STEM fields. The absence of structured frameworks for mentor-mentee matching, progress monitoring, and impact evaluation further reduces program effectiveness. Logistical challenges, such as coordinating sessions across different time zones in hybrid mentorship models or ensuring reliable internet connectivity, compound these issues. Without dedicated coordinators or policy support, schools struggle to institutionalize mentorship programs. Addressing these multifaceted barriers requires a strategic approach involving training, institutional buy-in, community partnerships, and systemic reform tailored to the realities of each educational context.

5.2. Policy and Funding Implications for STEM Equity

Advancing STEM equity through mentorship programs necessitates a deliberate policy framework and robust funding mechanisms. Most public-school systems lack formal policies that prioritize mentorship as a critical tool for STEM talent cultivation. Without mandates or guidelines, mentorship initiatives remain ad hoc and inconsistent in both design and delivery. National and sub-national education policies must recognize mentorship as a scalable intervention for increasing STEM engagement, especially among underrepresented groups. This includes embedding mentorship targets into STEM curricula and accountability frameworks. Funding remains another critical gap. Many mentorship programs operate through short-term grants or philanthropic donations, which limit long-term planning, evaluation, and expansion. Sustainable funding models should include dedicated government allocations, publicprivate partnerships, and incentive schemes for industry participation. Equally important is the establishment of equitable resource distribution to ensure rural, low-income, and marginalized schools receive adequate technological and personnel support. Incentivizing teacher-mentors, offering stipends to student mentees, and subsidizing internet access for virtual programs are examples of high-impact funding practices. In addition, data-driven policymaking that tracks participation rates, gender balance, and academic outcomes can inform targeted resource allocation. Strengthening policy and funding support is vital to transforming mentorship from an extracurricular luxury into a core pillar of national STEM education strategy.

5.3. Strategies for Scalability and Sustainability

Scaling and sustaining effective mentorship programs in STEM education requires a multi-pronged strategy that balances quality, inclusivity, and cost-efficiency. One key strategy is adopting modular mentorship frameworks that can be customized across different school systems while maintaining core competencies and goals. This allows for localized adaptation without compromising program integrity. Partnering with universities, tech firms, and research institutions can expand mentor pools and foster real-world relevance. Technology must also be leveraged for scalability—cloud-based platforms, mentorship management software, and AI-driven matching algorithms can streamline operations and reduce overhead costs. To ensure sustainability, mentorship programs should be embedded into school improvement plans, with designated personnel for coordination and impact tracking. Periodic training and certification for mentors enhance program credibility and continuity. Additionally, alumni networks of former mentees can be mobilized as peer mentors, creating a self-reinforcing ecosystem of support. Continuous stakeholder engagement—parents, educators, policymakers, and community leaders—is essential for legitimacy and resource mobilization. Feedback loops using surveys and performance dashboards enable data-informed refinements. Ultimately, successful scalability hinges on institutional ownership, long-term investment, and a culture that values mentorship as integral to educational equity and career readiness in STEM fields.

5.4. Gaps in the Literature and Suggestions for Future Research

Although existing research supports the positive influence of mentorship on STEM career interest among high school students, notable gaps persist in both scope and depth. First, there is limited longitudinal data tracking the long-term impact of mentorship experiences on students' academic and career outcomes, especially beyond high school. This hampers the ability to measure the sustained influence of mentorship across educational transitions. Additionally, few studies examine how intersectional factors such as race, disability, language background, or geographic location mediate mentorship outcomes. The unique experiences of students in rural or conflict-affected regions remain underexplored. There is also a lack of comparative studies evaluating different mentorship models—peer, professional, hybrid, or virtual—in terms of cost-effectiveness, engagement levels, and impact metrics. Furthermore, research often overlooks the mentor perspective, including challenges they face, retention strategies, and psychological impacts of the mentoring process. Future research should employ mixed-methods designs to capture both quantitative trends and qualitative insights. Advanced analytics, such as machine learning applied to mentorship interaction data, could offer predictive insights into success factors. A unified research agenda is needed to develop evidence-based standards, inform policy, and guide the design of inclusive, replicable, and culturally responsive mentorship interventions in STEM education.

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