ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 3036-0161
CODEN: MJHRBC

MALAYSIAN JOURNAL OF HUMAN RESOURCES MANAGEMENT (MJHRM)

DOI: http://doi.org/10.26480/mjhrm.01.2024.69.77

RESEARCH ARTICLE

MENTORSHIP PROGRAMS IN ROBOTICS AND THEIR IMPACT ON STUDENT DEVELOPMENT

Nancy Mohd Al Hamad[a], Ololade Elizabeth Adewusi[b], Chika Chioma Unachukwu[c], Blessing Osawaru[d], Onyebuchi Nneamaka Chisom[e]*

[a] Bridge the Gap, Dubai UAE
[b] Independent Researcher UK
[c] Ministry of Education, Lagos
[d] International School, Benin, Edo State, Nigeria
[e] National Examinations Council, Nigeria.
**Corresponding Author Email: lizzysogwa@gmail.com*

ARTICLE DETAILS

Article History:

Received 20 March 2024
Revised 10 April 2024
Accepted 20 May 2024
Available online 23 May 2024

ABSTRACT

Robotics education is at the forefront of preparing students for a technology-centric future. Anticipated trends include the integration of artificial intelligence (AI) and machine learning, a heightened focus on ethical considerations, and increased interdisciplinary collaboration. Virtual simulations and inclusivity initiatives aim to democratize access, ensuring diverse participation. Continuous professional development for educators and a global perspective on collaboration contribute to holistic student preparation. Challenges, including resource disparities and cultural biases, require strategic solutions grounded in equity and diversity. Navigating these trends and challenges collaboratively positions robotics education as a vital force in shaping a generation proficient in technical skills, critical thinking, and ethical awareness, ready to navigate the complexities of the technological landscape.

KEYWORDS

Robotics Education, Mentorship Programs, Student Development, Ethical Robotics

1. Introduction

In an era defined by rapid technological advancements, robotics has emerged as a pivotal field that encapsulates cutting-edge innovation and promises to shape the future of various industries. Integrating robotics into educational curricula has become imperative, aiming to equip students with the necessary skills to navigate the complexities of an increasingly automated world (Mubin et al., 2013; Papadakis et al., 2021). Within robotics education, mentorship programs have gained prominence as a transformative approach to enhancing the learning experience and fostering holistic student development (Anwar et al., 2019; Chalmers and Nason, 2017). This research endeavors to delve into the multifaceted impact of mentorship programs in robotics on students' educational journey, elucidating the intricate dynamics between mentors and mentees.

The backdrop against which this study unfolds is characterized by the omnipresence of technology in modern society. The proliferation of robotics has transcended its industrial roots, finding applications in fields as diverse as healthcare, manufacturing, and education (Javaid et al., 2021). As robotics becomes more pervasive, the demand for skilled professionals in this domain intensifies (Bongomin et al., 2020). Consequently, educational institutions must reevaluate and revamp their strategies to meet this demand and produce graduates with the competencies essential for success in a technology-driven landscape. Within this educational landscape, mentorship programs have emerged as a strategic response to the evolving needs of students aspiring to navigate the intricacies of robotics (Hossain et al., 2014). These programs represent a departure from traditional pedagogical approaches, introducing an interactive and personalized dimension to the learning process. By fostering one-on-one relationships between experienced mentors and aspiring students, mentorship programs in robotics aim to bridge the gap between theoretical knowledge and practical application, providing a scaffold for skill acquisition and professional development (Felten and Lambert, 2020; Nwaokorie, 2022).

Despite the increasing prevalence of mentorship programs in robotics education, a critical examination of their efficacy and the nuanced ways they contribute to student development remains notably absent from the existing literature (Rice et al., 2020). This research seeks to address this gap by systematically exploring the impact of mentorship programs on students immersed in the dynamic field of robotics. By doing so, it aspires to offer insights beyond the immediate benefits of such programs, unraveling the intricacies of mentor-mentee interactions and their enduring influence on students' academic and professional trajectories. The primary objectives of this research are twofold. First, it aims to comprehensively examine the existing landscape of mentorship programs in robotics education, identifying the diverse models and structures employed across educational institutions. Second, it endeavors to unravel the multifaceted impact of mentorship on student development, encompassing both technical proficiency and the cultivation of essential soft skills. Pursuing these objectives, this research seeks to contribute a nuanced understanding of mentorship's role in shaping the next generation of robotics professionals.

2. Literature Review

Within the educational context, mentorship is a dynamic and symbiotic relationship between an experienced individual, the mentor, and a less-experienced individual, the mentee, aimed at guiding the latter's intellectual, professional, and personal development (Felten and Lambert, 2020). In robotics education, this mentor-mentee dynamic takes on a specialized significance. It goes beyond the traditional academic model,

Quick Response Code	Access this article online	
	Website: www.mjhrm.com.my	**DOI:** 10.26480/mjhrm.01.2024.69.77

Cite The Article: Nancy Mohd Al Hamad, Ololade Elizabeth Adewusi, Chika Chioma Unachukwu, Blessing Osawaru, Onyebuchi Nneamaka Chisom (2024). Mentorship Programs in Robotics and Their Impact on Student Development. *Malaysian Journal Of Human Resources Management (MJHRM), 1(1): 69-77.*

incorporating practical guidance, industry insights, and a personalized approach to skill development (Wallace, 2014).

In robotics, mentorship transcends the mere transmission of technical knowledge. It involves cultivating problem-solving skills, critical thinking, and understanding the broader implications of robotics applications (Aoun, 2017). Effective mentors in this field impart domain-specific expertise and serve as role models, helping mentees navigate the complexities of the ever-evolving robotics landscape. This definition underscores the interactive, personalized, and holistic nature of mentorship within the specialized field of robotics education (Griffiths, 2019; Melo dos Santos, 2023).

The literature on mentorship programs within STEM (Science, Technology, Engineering, and Mathematics) fields provides a foundational understanding of the efficacy of mentorship across diverse disciplines. In the specific context of robotics, mentorship programs have gained traction due to the field's interdisciplinary nature (Pannier et al., 2020). Research has delved into various mentoring models, such as one-on-one, group, and peer mentoring, each offering unique advantages and challenges (Howell et al., 2003).

Studies within STEM emphasize the role of mentorship in fostering a sense of belonging and identity among students, especially those from underrepresented groups (Atkins et al., 2020). The literature also underscores the significance of mentorship in alleviating students' challenges in navigating the intricacies of STEM disciplines (Estrada et al., 2018). Within robotics, where the fusion of mechanical engineering, computer science, and artificial intelligence is commonplace, a mentorship emerges as a key catalyst in guiding students through this multidimensional educational journey (Atkins et al., 2020; Estrada et al., 2018).

The impact of mentorship on student development is a recurrent theme in academic literature. Within robotics, this impact extends across technical proficiency and holistic growth (Cangelosi et al., 2010). Mentorship has been shown to enhance students' problem-solving abilities, technical skills, and research capabilities. Beyond technicalities, it plays a pivotal role in developing soft skills, such as communication, teamwork, and adaptability—attributes essential for success in robotics's collaborative and fast-paced field (Carvalho and Santos, 2022; Rekha and Ganesh, 2012).

The existing body of literature also sheds light on the varied educational settings where mentorship programs have demonstrated their efficacy. From formal educational institutions to extracurricular robotics clubs and industry-sponsored initiatives, mentorship has proven adaptable to diverse environments (Phan and Ngo, 2020). The literature underscores the transferability of mentorship models, emphasizing their relevance in traditional classroom settings and experiential learning environments, where hands-on application of robotics concepts is paramount (Ninassi and Burrell, 2023).

In conclusion, the literature on mentorship in robotics education illuminates the nuanced and multifaceted nature of mentorship relationships. Combining knowledge from various STEM disciplines provides a solid foundation for understanding robotics education's unique challenges and opportunities (Rice et al., 2020). As this review establishes, mentorship in robotics is not merely an educational tool but a transformative force shaping the next generation of professionals in this dynamic and rapidly evolving domain.

3. The Role of Mentorship in Robotics Education

The landscape of robotics education is dynamic and multifaceted, marked by rapid technological advancements and an increasing demand for skilled professionals. In this complex milieu, mentorship plays a pivotal role in shaping the educational journey of aspiring robotics enthusiasts. The part of mentorship extends beyond the traditional classroom model, offering a personalized, interactive, and experiential approach that enhances technical proficiency and holistic student development (Andrew et al., 2020; Basheer, 2023).

One of the primary roles of mentorship in robotics education is to provide expert guidance in developing technical skills. In a field that spans mechanical engineering, computer science, and artificial intelligence, mentors serve as navigators, helping students traverse the intricate landscape of robotics (Basheer, 2023). They impart domain-specific knowledge, share practical insights, and facilitate hands-on learning experiences, ensuring students comprehensively understand theoretical concepts and real-world applications (Ahmadmehrabi et al., 2021; Winter and Boudreau, 2018). Mentors act as conduits for transferring specialized knowledge, bridging the gap between textbook theories and the practical challenges encountered in robotics projects. Through one-on-one interactions and mentor-led workshops, students acquire the foundational skills required for robotics and the ability to apply these skills in innovative and context-specific ways (Kaur and Singh, 2021).

In robotics, where problem-solving is integral to success, mentors are crucial in nurturing students' problem-solving and critical-thinking abilities (Wallace, 2014). Robotics projects often involve complex challenges that require innovative solutions. Mentors encourage inquiry, experimentation, and resilience in the face of setbacks. They guide students through identifying problems, formulating hypotheses, and iteratively refining solutions (Azman et al., 2021; Wallace, 2014). This skill set transcends robotics and applies to a broad spectrum of challenges in the professional world (Bakke, 2013). The mentor's role in fostering critical thinking is particularly pronounced when students encounter unforeseen obstacles or ambiguity in their projects. By encouraging a systematic approach to problem-solving, mentors empower students to navigate uncertainties, iterate on their designs, and ultimately arrive at effective solutions. Under the mentor's guidance, this iterative problem-solving process contributes significantly to developing a robust and adaptable mindset (Ahmadmehrabi et al., 2021; Bakke, 2013; Carvalho and Santos, 2022).

Beyond technical expertise, mentorship in robotics education strongly emphasizes the cultivation of soft skills and the overall professional development of students. Given its inherently collaborative and interdisciplinary nature, effective communication, collaboration, teamwork, and adaptability are essential attributes for success in robotics (Ahmadmehrabi et al., 2021; Osborne et al., 2010; Shmatko and Volkova, 2020). Mentors serve as role models in demonstrating these soft skills, providing students with theoretical knowledge and practical insights into effective communication within a team, client interaction, and project management (Shmatko and Volkova, 2020). Through mentorship programs, students learn to work collaboratively, share responsibilities, and leverage diverse perspectives, mirroring the realities of professional settings in the robotics industry. Furthermore, mentors often offer valuable advice on career paths, industry trends, and networking opportunities (Herro et al., 2023; Sivaraj et al., 2020). This aspect of mentorship contributes to the holistic development of students, preparing them not only as competent roboticists but also as well-rounded professionals ready to navigate the challenges of the workforce (Sivaraj et al., 2020).

In the often-intimidating landscape of robotics education, mentorship fosters a sense of community and belonging among students. The mentor-mentee relationship provides a supportive framework where students feel encouraged to explore their interests, voice their ideas, and seek guidance without fear of judgment (Calabrese and Tan, 2018; Felten and Lambert, 2020). This sense of belonging is especially crucial in promoting diversity and inclusivity within the robotics field, where historically underrepresented groups may find themselves in the minority (Lezotte, 2021). Mentors create an inclusive environment where students from diverse backgrounds feel empowered to contribute, share their unique perspectives, and participate actively in the learning process. This sense of community not only enhances the overall learning experience but also contributes to the retention of students in the field, addressing potential disparities and ensuring a more equitable representation in the robotics community (Atkins et al., 2020; Estrada et al., 2018).

4. Types of Mentorship Programs in Robotics Education

Mentorship programs in robotics education come in various forms, each tailored to address specific needs and contexts within the dynamic landscape of this field. The diversity of these programs reflects the interdisciplinary nature of robotics and acknowledges the multifaceted development required for aspiring professionals. Table 1 presents some common types of mentorship programs in robotics education.

5. Factors Influencing the Effectiveness of Mentorship Programs

The effectiveness of mentorship programs in robotics education is influenced by many factors, encompassing the dynamics of mentor-mentee relationships, program structures, and the broader educational context. Understanding these factors is essential for designing and implementing mentorship initiatives that enhance student development. Table 2 presents the key elements that shape the effectiveness of mentorship programs in robotics education.

Table 1: Some common types of mentorship programs in robotics education

Type	Description	Applicability	Reference
Traditional One-on-One Mentorship	In this classical model, a single experienced mentor is paired with a mentee, creating a personalized and focused learning relationship. The mentor provides guidance, support, and expertise, addressing the individual needs and goals of the mentee.	Well-suited for in-depth skill development, personalized guidance, and fostering a strong mentor-mentee bond. Often used in formal educational settings or industry-sponsored programs.	(Forbes and Roberts 2021; Levy 2003)
Group Mentorship	In contrast to one-on-one mentorship, group mentorship involves a mentor working with a small group of mentees. This model encourages collaboration, peer learning, and diverse perspectives within the mentorship dynamic.	Effective for projects requiring teamwork, shared learning experiences, and exposure to different aspects of robotics. Often implemented in extracurricular robotics clubs, hackathons, or industry workshops.	(Huizing, 2012)
Peer Mentorship	Peer mentorship involves more experienced students mentoring their peers. While not as seasoned as professional mentors, these mentors provide relatable guidance, fostering a supportive and collaborative learning environment.	Particularly effective for creating a sense of community, peer mentorship is commonly used in educational institutions where students at different academic levels collaborate.	(Andersen and Watkins, 2018; Lorenzetti et al., 2019)
Virtual or Online Mentorship	With the advent of technology, virtual mentorship programs connect mentors and mentees online. This type of mentorship transcends geographical barriers, allowing participants to engage in mentorship relationships regardless of physical location.	Ideal for students in remote areas or those unable to access traditional mentorship opportunities. Virtual mentorship is increasingly utilized in online courses, webinars, and global collaborative projects.	(Junn et al., 2023)
Industry-sponsored Mentorship	In this model, professionals from the robotics industry mentor students, offering real-world insights, industry trends, and practical advice. These programs often include internships, site visits, and networking opportunities.	Bridges the gap between academia and industry, preparing students for the demands of the workforce. This is commonly found in partnerships between educational institutions and robotics companies.	Leeker, Maxey, Cardella, and Hynes
Long-Term Mentorship Programs	Long-term mentorship programs extend over an extended period, potentially spanning an entire academic year or multiple years. This allows for sustained guidance, skill development, and a deeper understanding of the mentor-mentee relationship.	Suitable for comprehensive skill development, academic and career planning, and fostering a lasting mentor-mentee bond. Often implemented in formal educational settings or mentorship initiatives with a progressive curriculum.	(Eby et al., 2006; Mayer et al., 2014)
Reverse Mentorship	In this unique model, a more junior participant mentors a more senior individual. While less common, reverse mentorship allows for exchanging contemporary knowledge, fresh perspectives, and the mutual sharing of skills.	This is particularly effective in settings where younger individuals may possess expertise in emerging technologies or trends. It can be implemented in educational institutions or industry settings to facilitate knowledge exchange.	(Chen, 2013; Marcinkus Murphy, 2012)

In conclusion, the varied types of mentorship programs in robotics education underscore the adaptability and inclusivity needed to meet the diverse needs of students within this rapidly evolving field. Whether through one-on-one relationships, group dynamics, or virtual connections, mentorship programs are crucial in nurturing the next generation of robotics professionals, providing them with the skills, insights, and support required for success (Wallace, 2014; Weise et al., 2018). The choice of mentorship program type depends on the specific goals, context, and resources available, ensuring a tailored approach to the ever-expanding realm of robotics education (Mubin et al., 2013).

Table 2: Key elements that shape the effectiveness of mentorship programs.

Factors	Description	Influence	Reference
Mentorship Relationship Quality	The quality of the mentor-mentee relationship is foundational to the success of any mentorship program. Communication, trust, mutual respect, and a shared understanding of goals significantly impact the effectiveness of the mentorship dynamic.	A positive and supportive relationship fosters a conducive learning environment, promoting open dialogue, effective guidance, and a sense of security for mentees to seek advice and share concerns.	(Rhodes et al., 2017)
Alignment of Goals and Expectations	Clear alignment of goals and expectations between mentors and mentees is crucial. Both parties should have a shared understanding of the objectives of the mentorship, the scope of involvement, and the desired outcomes.	Misalignment in expectations can lead to frustration and dissatisfaction. Establishing clear and realistic goals ensures that both mentors and mentees are on the same page, enhancing the overall effectiveness of the mentorship.	(Gandhi and Johnson, 2016; Sanyal, 2017)
Relevance of Mentor	The expertise and experience of mentors in the specific domains of robotics greatly	Mentor expertise enhances the quality of guidance, providing mentees with	(Barnett, 1995; Bello and

Table 2: Key elements that shape the effectiveness of mentorship programs.

Factors	Description	Influence	Reference
Expertise	influence the effectiveness of mentorship programs. Mentors with relevant industry experience or academic background bring practical insights and real-world perspectives to the mentorship relationship.	valuable knowledge, industry trends, and insights into potential career paths within robotics.	Mansor, 2013)
Structured Program Design	The design and structure of the mentorship program, including its duration, frequency of interactions, and defined goals, play a critical role in program effectiveness. Well-designed programs provide a framework for mentor-mentee engagement.	A structured program ensures that mentorship is purposeful and aligns with broader educational objectives. Clarity in program design helps mentors and mentees understand their roles and responsibilities, fostering a more effective learning experience.	(Fornari et al., 2014)
Institutional Support and Resources	Institutional support, including financial resources, time allocation, and administrative backing, significantly impacts the success of mentorship programs. Adequate support ensures the sustainability and scalability of mentorship initiatives.	Institutions that prioritize and invest in mentorship programs create an environment conducive to fostering meaningful relationships. Resources such as dedicated meeting spaces, training workshops, and recognition programs contribute to program effectiveness.	(Nakanjako et al., 2011)
Mentor Training and Development	The preparation and ongoing development of mentors are crucial factors. Training programs that equip mentors with effective communication skills, cultural competence, and guidance techniques enhance their ability to contribute meaningfully to the mentorship relationship.	Well-trained mentors are better equipped to navigate challenges, provide constructive feedback, and adapt their mentoring style to the unique needs of individual mentees, ultimately enhancing the overall effectiveness of the mentorship program.	(Forsbach-Rothman, 2007; Hunt and Michael, 1983)
Diversity and Inclusivity	Mentorship programs that prioritize diversity and inclusivity contribute to a richer learning experience. Ensuring a diverse pool of mentors and mentees fosters various perspectives and backgrounds within the mentorship dynamic.	Diversity enhances creativity, problem-solving, and a sense of belonging. Mentorship programs that embrace inclusivity create an environment where individuals from different backgrounds feel valued and supported, positively impacting program effectiveness.	(Osman and Gottlieb, 2018; Zachary and Fain, 2022)
Feedback and Evaluation Mechanisms	Establishing mechanisms for feedback and program evaluation allows for continuous improvement. Regular check-ins, surveys, and feedback loops provide valuable insights into the strengths and weaknesses of the mentorship program.	Programs that actively seek and incorporate feedback can adapt to changing needs, address challenges, and optimize mentorship experiences. Evaluation mechanisms contribute to the ongoing refinement and effectiveness of the program.	(Anderson, Silet, and Fleming, 2012)
Flexibility and Adaptability:	The ability of mentorship programs to adapt to the evolving needs of participants, changes in the field of robotics, and unforeseen challenges is critical. Flexible structures allow for responsiveness to dynamic educational environments.	Rigidity in program design may hinder its effectiveness. Programs that exhibit flexibility can accommodate diverse learning styles, evolving goals, and unexpected circumstances, ensuring sustained relevance and impact.	(Spencer et al., 2020)
Recognition and Incentives:	Recognizing and incentivizing the contributions of mentors and mentees is an influential factor in program effectiveness. Acknowledgment can take various forms, such as certificates, awards, or opportunities for mentorship program alumni.	: Recognition reinforces the value of mentorship, motivating participants to engage and contribute actively. Incentives provide tangible acknowledgment of the commitment and positive impact mentors and mentees bring to the program.	(Keyser et al., 2008)

The effectiveness of mentorship programs in robotics education is a nuanced interplay of interpersonal dynamics, program design, institutional support, and adaptability. By understanding and addressing these factors, mentorship initiatives can be crafted to maximize their impact, providing students with a transformative learning experience beyond technical skill development to encompass holistic growth within the dynamic field of robotics (George and Wooden, 2023; Saba and Shearer, 2017).

6. Student Development in Robotics

Robotics education catalyzes multifaceted student development, fostering a combination of technical proficiency, critical thinking skills, creativity, and a broader understanding of the societal implications of technology (You et al., 2021). Robotics education aims to equip students with the technical skills necessary to design, build, and program robots. This includes proficiency in programming languages, mechanical design, electronics, and control systems (Miller and Nourbakhsh, 2016; Tocháček et al., 2016). The technical ability not only empowers students to create functional robots but also instills problem-solving skills and a deep understanding of the underlying principles of robotics. This foundational knowledge lays the groundwork for students to navigate complex challenges within the field and adapt to emerging technologies (Munn, 2019; Papadakis and Kalogiannakis, 2020).

Robotics projects inherently involve challenges that require analytical thinking, problem-solving, and iterative design processes. Students are encouraged to identify problems, hypothesize solutions, and refine their approaches based on feedback and testing. Engaging in the iterative nature of robotics projects hones critical thinking skills. Students learn to approach problems systematically, think creatively to overcome obstacles, and apply logical reasoning to optimize their designs. This skill set extends beyond robotics, serving as a valuable asset in various academic and professional contexts.

Robotics education encourages students to think creatively and innovatively. Designing and building robots often involves finding novel solutions to problems, exploring unconventional ideas, and pushing the boundaries of what is possible (Chevalier et al., 2020). Cultivating creativity and innovation in robotics education contributes to a mindset that seeks out-of-the-box solutions. This creative thinking is transferable to diverse domains, enabling students to tackle real-world challenges with fresh perspectives and innovative approaches (Tan and Ng, 2021).

Many robotics projects are collaborative endeavors that require teamwork. Students work in groups, sharing responsibilities, ideas, and skills to achieve a common goal. Learning to collaborate in a team setting is crucial to student development. Robotics education provides an experiential platform for students to develop interpersonal skills, effective communication, and an understanding of collective problem-solving (Hoffman and Breazeal, 2004; Taylor, 2016). These skills are essential in professional settings where collaboration is integral to success (Taylor, 2016). Robotics projects often culminate in presentations, reports, or demonstrations. Students must communicate their ideas, methodologies, and results effectively to diverse audiences. Developing communication skills is a key outcome of robotics education. Students learn to articulate complex technical concepts in a clear and accessible manner. This skill is vital for conveying ideas to colleagues, stakeholders, or the broader community, enhancing students' ability to share their knowledge and insights (Jawaid et al., 2020; Nostrand, 2000).

Robotics education goes beyond technical aspects and encourages students to consider technology's ethical and societal implications. This includes discussions on responsible use, privacy concerns, and the impact of robotics on various aspects of society. Integrating ethical and social considerations into robotics education cultivates a sense of responsibility in students. It prompts them to reflect on the broader consequences of their work, fostering ethical decision-making and a commitment to using technology for the greater good (Lin et al., 2014; Smakman et al., 2021). Robotics projects often involve setbacks, failures, and unexpected challenges. Students learn the importance of persistence, resilience, and adaptability in facing difficulties. Overcoming obstacles in robotics projects contributes to the development of strength. Students learn to embrace failure as a part of the learning process, iterate on their designs, and persist in pursuing solutions. This resilience is a valuable life skill that extends beyond robotics (Holland et al., 2014).

Exposure to robotics education can influence students' academic and career trajectories. It may spark an interest in pursuing further studies in robotics, computer science, engineering, or related fields. Robotics education serves as a gateway to diverse career paths. Whether students enter academia, industry, entrepreneurship, or interdisciplinary areas, the foundational skills acquired in robotics education position them for success in various professions.

7. Challenges and Limitations in Robotics Education

While robotics education offers a wealth of opportunities for student development, it has challenges and limitations. A nuanced understanding of these issues is crucial for educators, institutions, and policymakers as they work towards optimizing the learning experience. Disparities in access to robotics education resources exist, with some schools or regions having state-of-the-art facilities while others lack basic robotics equipment. High costs associated with robotics kits, components, and maintenance may pose barriers for schools or students with limited budgets. Unequal access limits the exposure of certain demographics to robotics education, potentially perpetuating existing disparities in STEM participation (Susilo et al., 2016; Vandevelde et al., 2016).

The dynamic nature of robotics technology can outpace curriculum development, making it challenging for educators to keep pace with the latest advancements. A lack of standardized robotics education curricula may lead to inconsistent learning experiences across institutions (Chen et al., 2020; Xia and Zhong, 2018). A static curriculum may result in students learning outdated technologies or missing out on emerging trends, limiting their preparedness for the evolving field of robotics (Oke and Fernandes, 2020).

Educators may have insufficient access to professional development opportunities to enhance their knowledge and teaching skills in robotics. Some teachers may struggle with integrating robotics into existing curricula due to a lack of training or familiarity with the technology. Inadequately trained teachers may face challenges in delivering engaging and effective robotics education, impacting student learning outcomes.

Robotics education often faces gender imbalances, with female students underrepresented. Societal stereotypes and biases may discourage girls from pursuing robotics. Minority groups may also be underrepresented, limiting the diversity of perspectives and experiences within robotics classrooms. Lack of diversity may result in missed opportunities for innovation, creativity, and problem-solving that stem from diverse perspectives (Cannon et al., 2007; Jackson et al., 2021; Reich-Stiebert and Eyssel, 2017).

Robotics education programs may face challenges in integrating seamlessly with other disciplines, hindering a holistic understanding of the interdisciplinary nature of robotics. Traditional departmental structures in educational institutions may challenge collaborative efforts across engineering, computer science, and other relevant departments (Lin and Chen, 2023). The failure to bridge disciplinary boundaries may limit students' ability to appreciate the interconnectedness of various fields within robotics, potentially impacting their ability to address complex real-world challenges (Aoun, 2017).

Robotics education often competes with other subjects for limited classroom hours, reducing the time for hands-on projects and practical application (Altin and Pedaste, 2013). Time constraints and scheduling conflicts may limit extracurricular robotics activities or competitions, preventing deeper student engagement. Limited time for hands-on activities may hinder students' ability to delve deeply into complex robot projects, impacting the depth of their learning experience (Bakke, 2013). The absence of standardized assessments for robotics education makes evaluating and comparing students' proficiency across different programs challenging. Assessing qualitative aspects such as problem-solving, creativity, and collaboration can be subjective, posing challenges for fair evaluation. The lack of standardized assessments may lead to inconsistent recognition of students' achievements in robotics education, potentially impacting their academic and professional trajectories (Dulan et al., 2012; Goldenberg et al., 2018).

Robotics education may introduce students to ethical considerations, such as privacy concerns and the societal impact of robotics, without providing clear guidance on navigating these complex issues (Smakman et al., 2021). Students may not have sufficient opportunities to explore the ethical dimensions of robotics due to time constraints or a lack of dedicated curriculum components. Students may graduate from robotics programs without a robust understanding of the ethical implications of their work, potentially leading to unintended consequences in their future endeavors (Serholt and Barendregt, 2014; Smakman et al., 2021).

8. Future Directions in Robotics Education

As robotics continues to evolve and integrate into various aspects of society, the future of robotics education holds significant promise and presents unique challenges. Anticipating and navigating these future directions is essential for educators, policymakers, and stakeholders to prepare students for the demands of a rapidly advancing technological landscape. This in-depth exploration delves into the potential future directions in robotics education.

8.1 Integration of Artificial Intelligence (AI) and Machine Learning (ML)

Future robotics education will likely incorporate a more comprehensive understanding of artificial intelligence and machine learning (Wang and Siau, 2019). Students may engage in projects that involve programming robots to learn and adapt to dynamic environments (Howard, 2019). Integrating AI and ML into robotics education will reinforce the field's interdisciplinary nature, fostering collaborations between computer science, engineering, and data science (Gubenko et al., 2021; Roy and Roy, 2021). Addressing the potential resource challenges associated with integrating AI and ML into robotics education, including the need for specialized hardware and software. Ensuring educators receive adequate training to effectively teach and guide students in applying AI and ML concepts within robotics projects (Gubenko et al., 2021; Roy and Roy, 2021).

8.2 Emphasis on Ethical Robotics

Future robotics education programs are expected to emphasize ethical considerations more strongly. Students will discuss responsible design, privacy, and the societal impact of robotics (Lin et al., 2014). Integration of real-world case studies involving ethical dilemmas in robotics, encouraging students to think critically about the consequences of their designs. Challenges could be crafting and updating curricula to address robotics's rapidly evolving ethical considerations. Effectively guiding students through complex ethical considerations and balancing innovation with responsibility (Serholt and Barendregt, 2014; Smakman et al., 2021).

8.3 Hands-On Learning Through Simulation

Virtual simulations will become more prevalent, allowing students to experiment with robotics concepts in simulated environments. Collaboration in virtual spaces will enable students to work on robotics projects remotely, fostering teamwork and overcoming geographical barriers (Berland and Wilensky, 2015; Choi et al., 2021). The potential challenges could be ensuring equitable access to technology and high-quality simulation tools for all students, irrespective of their geographical location or financial constraints. Striking a balance between virtual simulations and hands-on, physical experiences to provide a comprehensive learning environment (Azunna, 2018; Chidolue and Iqbal, 2023; Choi et al., 2021).

8.4 Interdisciplinary Collaborations

Encouraging interdisciplinary collaborations among students studying robotics, computer science, engineering, and other relevant fields. Strengthening ties between educational institutions and industries to provide students with real-world exposure and collaborative opportunities (Kitts and Quinn, 2004; Kuo et al., 2019). One major challenge is overcoming institutional barriers that may hinder interdisciplinary collaborations, promoting a culture of collaboration among different departments. Developing effective communication channels between students with diverse academic backgrounds to facilitate collaborative projects (Calvo et al., 2017; Kuo et al., 2019).

8.5 Inclusive and Diverse Representation

Future directions in robotics education will likely see increased efforts to address gender and minority disparities by implementing targeted initiatives. Ensuring educational materials and curricula feature diverse role models and examples fosters a more inclusive learning environment (Ozkazanc-Pan, 2021). As a challenge, overcoming deeply ingrained biases and stereotypes may dissuade certain groups from pursuing robotics education. Addressing socio-economic factors that may limit access to robotics education for underrepresented groups, ensuring inclusivity at all levels (Dhiman, 2023; Sullivan, 2019).

8.6 Continuous Professional Development for Educators

Recognizing the dynamic nature of robotics technology, future directions will involve establishing mechanisms for continuous professional development for educators. Opportunities for educators to engage in industry-sponsored programs, internships, or collaborative projects to stay abreast of industry trends (Rusk et al., 2008; Zhao et al., 2010). Overcoming time constraints faced by educators for ongoing training while balancing teaching responsibilities. Ensuring institutions allocate resources for educators' professional development, recognizing its crucial role in enhancing the quality of robotics education (Chidolue and Iqbal, 2022; Ewim, 2023; Ikwuagwu et al., 2020; Olanike et al., 2023).

8.7 Global Collaboration and Knowledge Exchange

Facilitating global collaboration among students and educators through virtual platforms, enabling knowledge exchange and cultural diversity. Increasing participation in international robotics competitions to expose students to diverse perspectives and challenges. Addressing disparities in technological infrastructure and internet accessibility to ensure equal participation in global collaborations. Developing approaches that consider cultural nuances in education to foster meaningful international partnerships.

8.8 Focus on Lifelong Learning

Recognizing the need for lifelong learning, future robotics education will encourage students to cultivate a mindset of continual skill development. Implementation of adaptive learning platforms that cater to individual learning styles and pace. Adapting traditional educational models to accommodate a more flexible and continuous learning approach. Addressing the challenge of reskilling and upskilling the existing workforce to keep pace with rapid technological advancements in robotics.

9. Conclusion

In the ever-evolving landscape of robotics education, the anticipated trends and challenges underscore the dynamic nature of preparing students for a technology-driven future. As artificial intelligence, ethics, and interdisciplinary collaboration take center stage, educators, institutions, and policymakers must proactively adapt to these shifts. Integrating AI and machine learning into curricula, emphasizing ethical considerations, and fostering interdisciplinary collaborations are pivotal for creating well-rounded robotics education programs. Virtual simulations and a focus on inclusivity aim to democratize access, ensuring that students from diverse backgrounds can engage meaningfully with robotics. Continuous professional development for educators and a global perspective on collaboration further contribute to the holistic preparation of students.

However, challenges such as resource disparities, cultural biases, and the need for lifelong learning demand strategic solutions. Addressing these challenges must be grounded in a commitment to equity, diversity, and ethical awareness. By navigating these anticipated trends and challenges collaboratively, stakeholders in robotics education can empower students to excel in technical skills and critically evaluate their work's societal implications. The future of robotics education holds immense promise. With thoughtful adaptation and inclusive practices, it can become a cornerstone in shaping a generation of innovative, ethically conscious, and globally aware individuals ready to tackle the complexities of the technological frontier.

References

Ahmadmehrabi, S., Farlow, J.L., Wamkpah, N.S., Esianor, B.I., Brenner, M.J., Valdez, T.A., Francis, H.W., 2021. New age mentoring and disruptive innovation—navigating the uncharted with vision, purpose, and equity. JAMA Otolaryngology–Head & Neck Surgery, 147 (4), Pp. 389-394.

Altin, H., and Pedaste, M., 2013. Learning approaches to applying robotics in science education. Journal of baltic science education, 12 (3), Pp. 365.

Andersen, T., and Watkins, K., 2018. The value of peer mentorship as an educational strategy in nursing. Journal of Nursing Education, 57 (4), Pp. 217-224.

Anderson, L., Silet, K., and Fleming, M., 2012. Evaluating and giving feedback to mentors: new evidence-based approaches. Clinical and Translational Science, 5 (1), Pp. 71-77.

Andrew, M., Marler, T., Lastunen, J., Acheson-Field, H., and Popper, S.W., 2020. An Analysis of Education and Training Programs in Advanced Manufacturing Using Robotics: RAND.

Anwar, S., Bascou, N.A., Menekse, M., and Kardgar, A., 2019. A systematic review of studies on educational robotics. Journal of Pre-College Engineering Education Research (J-PEER), 9 (2), Pp. 2.

Aoun, J.E., 2017. Robot-proof: higher education in the age of artificial intelligence: MIT press.

Atkins, K., Dougan, B.M., Dromgold-Sermen, M.S., Potter, H., Sathy, V., and Panter, A., 2020. "Looking at Myself in the Future": how mentoring shapes scientific identity for STEM students from underrepresented groups. International Journal of STEM Education, 7, Pp. 1-15.

Azman, H.H., Maniyam, M.N., Nawawi, N.M., Hassan, K.B., Kamaruddin, H.H., Sout, N.M., Moid, M.M., 2021. The Impact of the Near-Peer Mentoring Approach to Nurture Scientific Enquiry Skills: A Case Study in Kuala Selangor's School. International STEM Journal, 2 (1), Pp. 15-25.

Azunna, C., 2018. Post-colonial agricultural participat ion in livelihood strengthening. Research, Society and Development, 7 (2), Pp. 772144.

Bakke, C.K., 2013. Perceptions of professional and educational skills learning opportunities made available through K-12 robotics programming. Capella University,

Barnett, B.G., 1995. Developing reflection and expertise: can mentors make thedifference? Journal of Educational Administration, 33 (5), Pp. 45-59.

Basheer, H., 2023. Artificial Intelligence and Robotics Towards the Evolution of Sustainable Graduate Employability Ecosystem: A Contemporary Perspective for Higher Education Stakeholders in the UAE. Doctoral dissertation, University of Bath). https://ethos. bl. uk …, Bello, M., and Mansor, Y., 2013. Strengthening professional expertise: Mentoring in knowledge transfer, the cataloguers' perspective. The International Information & Library Review, 45 (3-4), Pp. 139-148.

Berland, M., and Wilensky, U., 2015. Comparing virtual and physical robotics environments for supporting complex systems and computational thinking. Journal of science education and technology, 24, Pp. 628-647.

Bongomin, O., Gilibrays Ocen, G., Oyondi Nganyi, E., Musinguzi, A., and Omara, T., 2020. Exponential disruptive technologies and the required skills of industry 4.0. Journal of Engineering, 2020, Pp. 1-17.

Calabrese, B.A., and Tan, E., 2018. A longitudinal study of equity-oriented STEM-rich making among youth from historically marginalized communities. American educational research journal, 55 (4), Pp. 761-800.

Calvo, I., Cabanes, I., Quesada, J., and Barambones, O., 2017. A multidisciplinary PBL approach for teaching industrial informatics and robotics in engineering. IEEE Transactions on Education, 61 (1), Pp. 21-28.

Cangelosi, A., Metta, G., Sagerer, G., Nolfi, S., Nehaniv, C., Fischer, K., Nori, F., 2010. Integration of action and language knowledge: A roadmap for developmental robotics. IEEE Transactions on Autonomous Mental Development, 2 (3), Pp. 167-195.

Cannon, K., Lapoint, M.A., Bird, N., Panciera, K., Veeraraghavan, H., Papanikolopoulos, N., and Gini, M., 2007. Using robots to raise interest in technology among underrepresented groups. IEEE Robotics & Automation Magazine, 14 (2), Pp. 73-81.

Carvalho, A.R., and Santos, C., 2022. Developing peer mentors' collaborative and metacognitive skills with a technology-enhanced peer learning program. Computers and Education Open, 3, Pp. 100070.

Chalmers, C., and Nason, R., 2017. Systems thinking approach to robotics curriculum in schools. Robotics in STEM education: Redesigning the learning experience, Pp. 33-57.

Chen, R., Rodrigues Armijo, P., Krause, C., Force, S.R.T., Siu, K.C., and Oleynikov, D., 2020. A comprehensive review of robotic surgery curriculum and training for residents, fellows, and postgraduate surgical education. Surgical endoscopy, 34, Pp. 361-367.

Chen, Y.C., 2013. Effect of reverse mentoring on traditional mentoring functions. Leadership and Management in Engineering, 13 (3), Pp. 199-208.

Chevalier, M., Giang, C., Piatti, A., and Mondada, F., 2020. Fostering computational thinking through educational robotics: A model for creative computational problem solving. International Journal of STEM Education, 7 (1), Pp. 1-18.

Chidolue, O., and Iqbal, M.T., 2023. Design and Performance Analysis of an Oil Pump Powered by Solar for a Remote Site in Nigeria. European Journal of Electrical Engineering and Computer Science, 7 (1), Pp. 62-69.

Chidolue, O., and Iqbal, T., 2022. Solar Powered Pump for a Remote Oil Well in Nigeria.

Choi, H., Crump, C., Duriez, C., Elmquist, A., Hager, G., Han, D., Leve, F., 2021. On the use of simulation in robotics: Opportunities, challenges, and suggestions for moving forward. Proceedings of the National Academy of Sciences, 118 (1), Pp. e1907856118.

Dhiman, D.B., 2023. Education's Role in Empowering Women and Promoting Gender Inequality: A Critical Review. Available at SSRN 4556375.

Dulan, G., Rege, R.V., Hogg, D.C., Gilberg-Fisher, K.M., Arain, N.A., Tesfay, S.T., and Scott, D.J., 2012. Developing a comprehensive, proficiency-based training program for robotic surgery. Surgery, 152 (3), Pp. 477-488.

Eby, L.T., Durley, J.R., Evans, S.C., and Ragins, B.R., 2006. The relationship between short-term mentoring benefits and long-term mentor outcomes. Journal of Vocational Behavior, 69 (3), Pp. 424-444.

Estrada, M., Hernandez, P.R., and Schultz, P.W., 2018. A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. CBE—Life Sciences Education, 17 (1), Pp. ar9.

Ewim, D.R.E., 2023. Integrating Business Principles in STEM Education: Fostering Entrepreneurship in Students and Educators in the US and Nigeria. IJEBD (International Journal of Entrepreneurship and Business Development), 6 (4), Pp. 590-605.

Felten, P., and Lambert, L.M., 2020. Relationship-rich education: How human connections drive success in college: Jhu Press.

Forbes, M.H., and Roberts, C.A., 2021. Exploring a New Mentorship Model: From One-on-One to Flash Mentoring. Paper presented at the 2021 ASEE Virtual Annual Conference Content Access.

Fornari, A., Murray, T.S., Menzin, A.W., Woo, V.A., Clifton, M., Lombardi, M., and Shelov, S., 2014. Mentoring program design and implementation in new medical schools. Medical education online, 19 (1), Pp. 24570.

Forsbach-Rothman, T., 2007. The mentor role: Is training necessary? Journal of In-service Education, 33 (2), Pp. 245-247.

Gandhi, M., and Johnson, M., 2016. Creating more effective mentors: mentoring the mentor. AIDS and Behavior, 20, Pp. 294-303.

George, B., and Wooden, O., 2023. Managing the strategic transformation of higher education through artificial intelligence. Administrative Sciences, 13 (9), Pp. 196.

Goldenberg, M.G., Lee, J.Y., Kwong, J.C., Grantcharov, T.P., and Costello, A., 2018. Implementing assessments of robot-assisted technical skill in urological education: a systematic review and synthesis of the validity evidence. BJU international, 122 (3), Pp. 501-519.

Griffiths, P.M., 2019. Ecological Innovators: A Multiple Case Study Approach to Explore the Influencing Factors and Conditions Upon the Lives of Young People Who Innovate to Save the World: Lesley University.

Gubenko, A., Kirsch, C., Smilek, J.N., Lubart, T., and Houssemand, C., 2021. Educational robotics and robot creativity: An interdisciplinary dialogue. Frontiers in Robotics and AI, 8, Pp. 662030.

Hadad, S., Shamir-Inbal, T., Blau, I., and Leykin, E., 2021. Professional development of code and robotics teachers through small private online course (SPOC): Teacher centrality and pedagogical strategies for developing computational thinking of students. Journal of Educational Computing Research, 59 (4), Pp. 763-791.

Herro, D., Frady, K., and O'Hara, R., 2023. Exploring technical college student's collaborative problem solving and teamwork skills in multi-educational level engineering design teams. European Journal of Engineering Education, Pp. 1-21.

Hoffman, G., and Breazeal, C., 2004. Collaboration in human-robot teams. Paper presented at the AIAA 1st intelligent systems technical conference.

Holland, D.P., Park, E.J., Polygerinos, P., Bennett, G.J., and Walsh, C.J., 2014. The soft robotics toolkit: Shared resources for research and design. Soft Robotics, 1 (3), Pp. 224-230.

Hossain, K. Evaluation of Technological Breakthrough in Global Education and Future Employment Opportunity.

Howard, J., 2019. Artificial intelligence: Implications for the future of work. American journal of industrial medicine, 62 (11), Pp. 917-926.

Howell, W.L., McCaffrey, E.J., and Murphy, R.R., 2003. University mentoring for first lego league. Paper presented at the 33rd Annual Frontiers in Education, 2003. FIE 2003.

Huizing, R.L., 2012. Mentoring together: A literature review of group mentoring. Mentoring & tutoring: Partnership in learning, 20 (1), Pp. 27-55.

Hunt, D.M., and Michael, C., 1983. Mentorship: A career training and development tool. Academy of management Review, 8 (3), Pp. 475-485.

Ikwuagwu, C.V., Ajahb, S.A., Uchennab, N., Uzomab, N., Anutaa, U.J., Sa, O.C., and Emmanuela, O., 2020. Development of an Arduino-Controlled Convective Heat Dryer. Paper presented at the UNN International

Conference: Technological Innovation for Holistic Sustainable Development (TECHISD2020).

Jackson, A., Mentzer, N., and Kramer-Bottiglio, R., 2021. Increasing gender diversity in engineering using soft robotics. Journal of Engineering Education, 110 (1), Pp. 143-160.

Javaid, M., Haleem, A., Singh, R.P., and Suman, R., 2021. Substantial capabilities of robotics in enhancing industry 4.0 implementation. Cognitive Robotics, 1, Pp. 58-75.

Jawaid, I., Javed, M.Y., Jaffery, M.H., Akram, A., Safder, U., and Hassan, S., 2020. Robotic system education for young children by collaborative-project-based learning. Computer Applications in Engineering Education, 28 (1), Pp. 178-192.

Junn, J.C., Whitman, G.J., Wasnik, A.P., Wang, M.X., Guelfguat, M., Goodman, E.D., and Middlebrooks, E.H., 2023. Virtual mentoring: a guide to navigating a new age in mentorship. Academic radiology, 30 (4), Pp. 749-754.

Kaur, J., and Singh, H., 2021. Smart Learning Solutions for Combating COVID-19. In Explainable Artificial Intelligence for Smart Cities (pp. 135-166): CRC Press.

Keyser, D.J., Lakoski, J.M., Lara-Cinisomo, S., Schultz, D.J., Williams, V.L., Zellers, D.F., and Pincus, H.A., 2008. Advancing institutional efforts to support research mentorship: A conceptual framework and self-assessment tool. Academic Medicine, 83 (3), Pp. 217-225.

Kılıç, S., and Çakıroğlu, Ü., 2023. Design, Implementation, and Evaluation of a Professional Development Program for Teachers to Teach Computational Thinking via Robotics. Technology, Knowledge and Learning, 28 (4), Pp. 1539-1569.

Kitts, C., and Quinn, N., 2004. An interdisciplinary field robotics program for undergraduate computer science and engineering education. Journal on Educational Resources in Computing (JERIC), 4 (2), Pp. 3-es.

Kuo, H.C., Tseng, Y.C., and Yang, Y.T.C., 2019. Promoting college student's learning motivation and creativity through a STEM interdisciplinary PBL human-computer interaction system design and development course. Thinking Skills and Creativity, 31, Pp. 1-10.

Leeker, J.R., Maxey, K., Cardella, M.E., and Hynes, M.M., 2019. How to make pre-college STEM programs and industry partner relationships successful: a systematized literature review of industry mentoring. Paper presented at the 8th Research in Engineering Education Symposium (REES 2019).

Levy, R.G., 2003. A study of peer mentoring, multiple mentoring and other alternatives to traditional one-on-one mentoring: City University of New York.

Lezotte, S., 2021. Making sense of diversity and inclusion in engineering. Journal of Diversity in Higher Education.

Lin, P., Abney, K., and Bekey, G.A., 2014. Robot ethics: the ethical and social implications of robotics: MIT press.

Lin, V., and Chen, N.S., 2023. Interdisciplinary training on instructional design using robots and IoT objects: A case study on undergraduates from different disciplines. Computer Applications in Engineering Education.

Lorenzetti, D.L., Shipton, L., Nowell, L., Jacobsen, M., Lorenzetti, L., Clancy, T., and Paolucci, E.O., 2019. A systematic review of graduate student peer mentorship in academia. Mentoring & tutoring: Partnership in learning, 27 (5), Pp. 549-576.

Marcinkus, M.W., 2012. Reverse mentoring at work: Fostering cross-generational learning and developing millennial leaders. Human Resource Management, 51 (4), PP. 549-573.

Mayer, A.P., Blair, J.E., Ko, M.G., Patel, S.I., and Files, J.A., 2014. Long-term follow-up of a facilitated peer mentoring program. Medical Teacher, 36 (3), Pp. 260-266.

Melo dos Santos, G., 2023. Adaptive Human-Chatbot Interactions: Contextual Factors, Variability Design and Levels of Automation.

Miller, D.P., and Nourbakhsh, I., 2016. Robotics for education. In Springer handbook of robotics (pp. 2115-2134): Springer.

Mubin, O., Stevens, C.J., Shahid, S., Al Mahmud, A., and Dong, J.J., 2013. A review of the applicability of robots in education. Journal of Technology in Education and Learning, 1(209-0015), Pp. 13.

Munn, C., 2019. Bring Life to Your Classroom with Robots & Empower Your Students to Engage in Innovative Thinking. Paper presented at the Society for Information Technology & Teacher Education International Conference.

Nakanjako, D., Byakika-Kibwika, P., Kintu, K., Aizire, J., Nakwagala, F., Luzige, S., Kamya, M.R., 2011. Mentorship needs at academic institutions in resource-limited settings: a survey at Makerere University College of Health Sciences. BMC medical education, 11, Pp. 1-6.

Ninassi, C., and Burrell, D., 2023. Teaching business leadership skills to professionals in healthcare cybersecurity, biodefense and biotechnology through experiential learning methods.

Nostrand, B., 2000. Autonomous robotics projects for learning software engineering. Paper presented at the Smc 2000 conference proceedings. 2000 ieee international conference on systems, man and cybernetics.'cybernetics evolving to systems, humans, organizations, and their complex interactions'(cat. no. 0.

Nwaokorie, F., 2022. Knowledge And Approach To Career Mentoring Among Senior Secondary School Students In Owerri Metropolis. Nigerian Online Journal of Educational Sciences and Technology, 4 (2), Pp. 56-70.

Oke, A., and Fernandes, F.A.P., 2020. Innovations in teaching and learning: Exploring the perceptions of the education sector on the 4th industrial revolution (4IR). Journal of Open Innovation: Technology, Market, and Complexity, 6 (2), Pp. 31.

Olanike, S.A., Asogwa, C.N., Njideka M.O., RE, E.D., and Temiloluwa, O.S., 2023. A Comparison of Perceptions of Assessment Practices in Higher Institutions between Academic Staff and Students: A Case Study of Federal College of Education, Yola. International Journal of Social Sciences & Educational Studies, 10 (3).

Osborne, R.B., Thomas, A.J., and Forbes, J.R., 2010. Teaching with robots: a service-learning approach to mentor training. Paper presented at the Proceedings of the 41st ACM technical symposium on Computer science education.

Osman, N.Y., and Gottlieb, B., 2018. Mentoring across differences. MedEdPORTAL, 14, Pp. 10743.

Ozkazanc-Pan, B., 2021. Diversity and future of work: inequality abound or opportunities for all? Management Decision, 59 (11), Pp. 2645-2659.

Pannier, C., Berry, C., Morris, M., and Zhao, X., 2020. Diversity and Inclusion in Mechatronics and Robotics Engineering Education. Paper presented at the ASEE annual conference exposition proceedings.

Papadakis, S., and Kalogiannakis, M., 2020. Handbook of research on using educational robotics to facilitate student learning: IGI Global.

Papadakis, S., Vaiopoulou, J., Sifaki, E., Stamovlasis, D., Kalogiannakis, M., and Vassilakis, K., 2021. Factors That Hinder in-Service Teachers from Incorporating Educational Robotics into Their Daily or Future Teaching Practice. Paper presented at the CSEDU (2).

Phan, M.H., and Ngo, H.Q.T., 2020. A multidisciplinary mechatronics program: From project-based learning to a community-based approach on an open platform. Electronics, 9 (6), Pp. 954.

Reich-Stiebert, N., and Eyssel, F., 2017. (Ir) relevance of gender? On the influence of gender stereotypes on learning with a robot. Paper presented at the Proceedings of the 2017 ACM/IEEE international conference on human-robot interaction.

Rekha, K., and Ganesh, M., 2012. Do mentors learn by mentoring others? International Journal of Mentoring and Coaching in Education, 1 (3), Pp. 205-217.

Rhodes, J.E., Schwartz, S.E., Willis, M.M., and Wu, M.B., 2017. Validating a mentoring relationship quality scale: Does match strength predict match length? Youth and Society, 49 (4), Pp. 415-437.

Rice, M.K., Hodges, J.C., Bellon, J., Borrebach, J., Al Abbas, A.I., Hamad, A., Zeh, H.J., 2020. Association of mentorship and a formal robotic proficiency skills curriculum with subsequent generations' learning curve and safety for robotic pancreaticoduodenectomy. JAMA surgery, 155 (7), Pp. 607-615.

Roy, M., and Roy, A., 2021. The rise of interdisciplinarity in engineering education in the era of industry 4.0: implications for management practice. IEEE Engineering Management Review, 49 (3), Pp. 56-70.

Rusk, N., Resnick, M., Berg, R., and Pezalla-Granlund, M., 2008. New pathways into robotics: Strategies for broadening participation. Journal of science education and technology, 17, Pp. 59-69.

Saba, F., and Shearer, R.L., 2017. Transactional distance and adaptive learning: Planning for the future of higher education: Routledge.

Sanyal, C., 2017. The effective mentor, mentee and mentoring relationship. The SAGE handbook of mentoring, Pp. 143-155.

Serholt, S., and Barendregt, W., 2014. Students' attitudes towards ethical dilemmas in the possible future of social robots in education. Paper presented at the Proceedings of the 23rd international symposium on robot and human interactive communication. IEEE Press.

Shmatko, N., and Volkova, G., 2020. Bridging the skill gap in robotics: Global and national environment. Sage Open, 10 (3), Pp. 2158244020958736.

Sivaraj, R., Ellis, J.A., Wieselmann, J.R., and Roehrig, G.H., 2020. Computational participation and the learner-technology pairing in K-12 STEM education. Human Behavior and Emerging Technologies, 2 (4), Pp. 387-400.

Smakman, M., Vogt, P., and Konijn, E.A., 2021. Moral considerations on social robots in education: A multi-stakeholder perspective. Computers & Education, 174, Pp. 104317.

Spencer, R., Pryce, J., Barry, J., Walsh, J., and Basualdo-Delmonico, A., 2020. Deconstructing empathy: A qualitative examination of mentor perspective-taking and adaptability in youth mentoring relationships. Children and Youth Services Review, 114, Pp. 105043.

Sullivan, A.A., 2019. Breaking the STEM stereotype: Reaching girls in early childhood: Rowman & Littlefield Publishers.

Susilo, E., Liu, J., Rayo, Y.A., Peck, A.M., Montenegro, J., Gonyea, M., and Valdastri, P., 2016. STORMLab for STEM education: An affordable modular robotic kit for integrated science, technology, engineering, and math education. IEEE Robotics & Automation Magazine, 23 (2), Pp. 47-55.

Tan, C., and Ng, C.S., 2021. Cultivating creativity in a high-performing education system: The example of Singapore. Journal of Curriculum and Pedagogy, 18 (3), Pp. 253-272.

Taylor, K., 2016. Collaborative robotics, more than just working in groups: Effects of student collaboration on learning motivation, collaborative problem solving, and science process skills in robotic activities.

Tocháček, D., Lapeš, J., and Fuglík, V., 2016. Developing technological knowledge and programming skills of secondary schools students through the educational robotics projects. Procedia-Social and Behavioral Sciences, 217, Pp. 377-381.

Vandevelde, C., Wyffels, F., Ciocci, M.C., Vanderborght, B., and Saldien, J., 2016. Design and evaluation of a DIY construction system for educational robot kits. International Journal of Technology and Design Education, 26, Pp. 521-540.

Wallace, K.J.V., 2014. Development of workforce skills: Student perceptions of mentoring in FIRST robotics: The University of Southern Mississippi.

Wang, W., and Siau, K., 2019. Artificial intelligence, machine learning, automation, robotics, future of work and future of humanity: A review and research agenda. Journal of Database Management (JDM), 30 (1), Pp. 61-79.

Weise, M., Hanson, A., Sentz, R., and Saleh, Y., 2018. Robot-ready: human+ skills for the future of work.

Winter, J., and Boudreau, J., 2018. Supporting self-determined indigenous innovations: Rethinking the digital divide in Canada. Technology Innovation Management Review, 8 (2).

Xia, L., and Zhong, B., 2018. A systematic review on teaching and learning robotics content knowledge in K-12. Computers & Education, 127, Pp. 267-282.

You, H.S., Chacko, S.M., and Kapila, V., 2021. Examining the effectiveness of a professional development program: integration of educational robotics into science and mathematics curricula. Journal of science education and technology, 30, Pp. 567-581.

Zachary, L.J., and Fain, L.Z., 2022. The mentor's guide: Facilitating effective learning relationships: John Wiley & Sons.

Zhao, H., Coombs, S., and Zhou, X., 2010. Developing professional knowledge about teachers through metaphor research: Facilitating a process of change. Teacher Development, 14 (3), Pp. 381-395.