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The Impact of Using Automated Robotics in Teaching and Learning College Courses: Skills, Infrastructures, and Learning Machines

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ABSTRACT

The introduction of automatic robotics in college courses has become an innovative force in higher education. However, while having all the potential, many colleges are facing serious obstacles in adopting this technology, such as high costs, inadequate infrastructure, and resistance from instructors. This study explores the impact of robotics on teaching and learning in college courses, with a focus on understanding the benefits, challenges, and real-world implications for both students and educators. Using a descriptive research methodology, the study analyses secondary data from academic journals, case studies, expert opinions, and industry reports to provide a comprehensive overview of the current state of robotics in education. Findings reveal that, though robotics expands more challenging education and facilitates creation of fundamental problem-solving and technological capabilities, still major barriers towards application exist. The future of higher education in robotics is envisioned to revolutionize learning with personalized learning, enhanced motivation, and collaborative experience. The study wraps up that colleges need to invest in low-cost, large-scale robot platforms, bring professional development training to teachers, and be ready to defy logistical and budget constraints.

Keywords: Automated robotics, College courses, Skills, Infrastructures, Learning machines

INTRODUCTION

The integration of robotics automation in the courses of a college is changing the age-old teaching and learning process. What was once an advanced topic being taught to those who pursued engineering and technical degrees only is now being infused in a variety of college courses starting from humanities and business to even more (Chandak, 2025). With advancements in artificial intelligence (AI), machine learning, and automation technologies, robots have the potential to make significant contributions to how students engage with learning content, engage with instructors, and gain key skills for the future job market. Automated robotics in education refers to the application of robots and AI-driven systems to assist various dimensions of the learning process (Al-Mutawah et al., 2021).They bring together one-to-one mentorship, simulation learning training, administrative support, and even live classrooms. They are not only being utilized to automate but it is building interactive, dynamic, and immersive learning environments which cannot be established in conventional classrooms (Kidd et al., 2025). Incorporating robotics in the university curriculum offers various advantages such as enhancing the interest of the students, thrilling critical thinking and problem-solving, and providing instant feedback. Apart from this, it also fosters a culture of learning in which students can get hands-on, practical experience of handling advanced technologies, getting them job-ready for an ever-evolving digital age (Mahmoud, 2014). However, as with any other technology in the pipeline, the application of robotics in schools is also with some problems. These problems are on the cost, technology awareness, ethics, and infrastructure requirement sides. It is of utmost importance that these problems be resolved responsibly so that conditions are created under which robotics is used to the greatest extent in education fairly, sustainably, and efficiently for all teachers and students (Al-Mutawah, 2022). Overall, the incorporation of robotic automation into higher education is not a trend, but a core change that is defining the future of education (Hung & Mahmoud, 2015). It opens up new avenues for learning, teaching, and collaboration, and equips students with knowledge and practice to thrive in an ever-growing automated and technology-driven world (De Souza Picanço et al., 2024).

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Robots can offer personalized learning based on the speed, need, and learning style of each individual student, allowing students to learn complex ideas better. With interactive robots in the classroom, students can interactively work with the subject matter, and learning becomes more experiential and enjoyable. Robots provide space for students to apply theoretical concepts to practical circumstances, which complements experiential learning (Hung et al., 2015). Colleges can apply distance learning via robots, where students with disabilities or students in other geographical locations can join classes without any form of restriction (Mahmoud & Taguines, 2025). Collaborative work using robots can foster team-building by assigning students to do group projects on robots and develop their communication and collaborative skills (Hussain et al., 2021). Automated grading systems and robotic assistants can handle repetitive tasks, freeing up educators to focus on teaching and student interaction. Robotics technologies are capable of recording and analyzing students' performance data in real time and presenting evidence-based information to educators to improve instructional practices (Mahmoud, 2023). Robots are also capable of assisting disabled students by helping them with personalized learning areas, such as voice-to-text functionality for physically disabled students. Robotics encourages learners to be science, technology, engineering, and mathematics (STEM) enthusiastic learners and encourages them to pursue careers in STEM fields. Robots could help automate office tasks such as attendance, marking, and timetabling so that teachers would have more time for teaching (Phokoye et al., 2024). Robotics can offer virtual classrooms where students and instructors can interact with robotic avatars, transcending geographical limitations in learning. Robots allow for direct transfer of theory in class to practical issues, enhancing problem-solving capacity in real life (Rojas et al., 2025). With robots, the pedagogy and instructional content can be standardized to more students, especially with online or blended learning. Robots are able to give real-time feedback and adjust lessons for learners' performances and thus make learning an interactive experience. Universities may offer lifelong learning opportunities through robot assistance so that professional workers or non-traditional students will be able to update their capabilities effectively (Mahmoud & Hamdi, 2009). Using robotics in the learning process drives students to create and innovate because they create and build robots as solutions to their specific problems, making it even more creative. Robots may also be used to facilitate peer-to-peer learning by allowing collaboration between students of different skill levels learning from each other. Robots can observe student activity, understanding, and interest and give immediate feedback to the instructors and learners (Lathifah et al., 2019). Although the initial financial outlays in robotics will be high, in the long term, they can cut costs on administrative processes, class scaling up, and improved learning. As automation widens its influence in the work environment, students who excel in working with automation systems and robots build a market competitive advantage. Such impacts reveal how college programs are able to transform teaching and learning with robotics using customized education, increased involvement, and workforce preparation for further technology (Mu et al., 2024).

OBJECTIVES

Benefits of Automated Robotics in College Courses

Robotics automation is an immersive, interactive experience that learns demanding material in a way that's fun and compelling. The learners will learn better when they finally get to interact with robots in real life, see their projects materialize before their eyes, and work with real problems (Mahmoud, 2015). Robots have the ability to present individualized learning experiences based on the learning rate and style of each learner. This individualization can be particularly beneficial in massive classes, where immediate attention from the teacher can be beyond reach. Modified robots can be capable of providing personalized feedback such that no student is left out (Al-Mutawah et al., 2019). Robotics is capable of enabling remote learning and providing augmentation for students located in far away or remote areas. Robots may enable virtual classrooms and enable learners to access instruction that would otherwise be unavailable to them. This helps in providing access to good quality education to geographically remote students or disabled students. Robotics is directly related to science, technology, engineering, and mathematics (STEM) subjects. With the study of robotics, students gain excellent problem-solving, technical, and analytical skills that highly attract employers in the modern job market (Achmad et al., 2025). Robotics helps students appreciate the real-world applications of STEM concepts. Robots enable students to apply theoretical concepts to real-world problems, enabling them to experiment and gain their skills. By creating or programming robots to solve problems, students enhance their problem-solving skills, creativity, and critical thinking, which are essential in any career (Choi et al., 2024). Robotics activities are generally collaborative, and this provides the students with opportunities to work

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with other students on complex tasks. Robot design, programming, and debugging are activities that foster good communication, leadership, and team working skills. The skills benefit the increasingly teamwork-oriented work environment of today. Robots can provide immediate feedback to students while they are working, accelerating learning and enabling students to eliminate errors immediately (De La Hoz et al., 2024). Computerized testing, for example, quizzes or robot practical testing, gives immediate feedback to teachers on students' learning and at the same time on areas where they require improvement. Computerized robots can minimize clerical work, such as homework marking, attendance recording, and even answering routine student questions. With automation, teachers are able to save time and find it less challenging to instruct more and spend less time in clerical duties. The robots also have a capability of broadening class accessibility so that instructors can instruct hundreds of students proficiently (Eteokleous & Ktoridou, 2014). Robots can, for example, be used in vast auditoriums to monitor and interact with the students to make more personalized connections in large-class courses, improving learning in the process. With automation and robots increasingly becoming the standard in every sector, hands-on learners will be optimally positioned to address the future challenges (Al-Mutawah et al., 2022). Students learn practical skills in programming, engineering, artificial intelligence, and data analysis through interaction with robots while studying in college that are most relevant to today's workforce (Hung et al., 2012). These benefits depict how autonomous robots can transform college learning, delivering personalized, interactive, and efficient learning experiences and equipping students with the readiness for the challenges in the workplace (Karalekas et al., 2023).

Required Skills for Students and Educators in the Age of Automated Robotics

As robotics automation continues to revolutionize the education sector, students and teachers need to learn some skills to effectively take advantage of this technology. These skills are required to survive in a world where robotics will be more pivotal in education. Skills for students are very important for successful usage (Hunter et al., 2013). With robots becoming integral to learning, students must understand basic programming languages such as Python, Java, or C++ to interact with and control robots (Mahmoud & Taguines, 2025). Students need to be able to program robots to perform specific tasks, build custom applications, and solve problems in robotic systems. Robotics fosters a hand-on problem-solving method where students must be creative in their minds while designing, programming, or debugging robot systems. Students must be able to break down hard problems into elements that are feasible to handle and develop innovative solutions, skills fundamental in robotics as well as other fields (Lin, 2023). An understanding of sound science in Science, Technology, Engineering, and Mathematics (STEM) is necessary to study the algorithms and mechanics which enable robotics. Robotics is a multidisciplinary technology that makes use of techniques from a variety of STEM areas. The knowledge of such courses helps the students understand how the robots are structured, created, and programmed. The majority of robotics projects involve collaboration, which requires good communication and sharing of ideas (Mahmoud, 2009). Integration into groups to collaborate on complex robotic projects fosters teamwork, an important skill in academic and working environments because most robotics projects in real life are developed in teams. The robotics industry is ever-changing, with new technologies and methods emerging every other day. The students must be flexible in their learning approach and able to quickly adapt to new tools, technologies, and concepts in the ever-changing robotics world. Robotics involves collecting vast amounts of data from sensors, robots, and other systems (Al-Mutawah et al., 2018). Students need the ability to analyse data from robotics systems to evaluate performance, troubleshoot issues, and optimize robot functions. As robotics are increasingly used in various sectors, ethical questions surrounding their impact must be addressed. Students need to understand the ethical implications of robotics, including issues related to privacy, job displacement, and the responsible use of technology (Ali et al., 2023).

On the contrary, there are various skills to be learned for the teachers so that they could successfully adopt robotics. Teachers have to be conversant with managing robotics tools, how they operate, and their integration into lesson plans. While increasingly more robots get incorporated in the classroom, teachers must also become comfortable dealing with robotics platforms, managing software associated with it, and troubleshoot any issues that may surface (Podobnik et al., 2024). Instructors must be trained on how to design effective curricula incorporating robotics and other technologies so that students can acquire the needed knowledge and skills. Robotics brings new pedagogical methods, and instructors must adapt their teaching practices to ensure they are using robotics effectively to achieve learning outcomes (Torres & Inga, 2025). As robots are to be found on campus, the instructors must have skills to

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successfully troubleshoot and repair issues in robot operation, programming bugs, and technical problems. Instructors will need to work as a facilitator and troubleshooter regularly in helping students navigate through hurdles in real time. Computer science and engineering faculty members and other departmental faculty will be employed by the majority of institutions to teach the students robotics as part of multidisciplinary personnel. The instructors should be qualified enough to serve in multidisciplinary teams to provide the students with a comprehensive education in robotics (Ramankulov & Shyndaliyev, 2024).

Robotics technology is evolving rapidly, and teachers need to stay current with the latest trends, equipment, and best practices. Ongoing professional development enables teachers to keep their skills sharp and incorporate the latest robotics advances into their teaching, providing students with the most current and suitable education. Teachers must be capable of explaining complicated robot ideas in plain terms and provide support for various levels of students' ability (Huda et al., 2021). Proper communication enables students to comprehend complex ideas and implement them in practical applications. Teachers must provide individual support to help students solve robotics project issues. Teachers ought to develop assessment plans that gauge the understanding of robot concepts and applying robotic systems among students (Ahlgren & Verner, 2012). Because robots are used in learning, the teachers have to provide timely and constructive criticism as well as implement innovative methods of evaluating students' progress (Chandak, 2025). As robotics more and more determines the future of education, the skills demanded by students and teachers alike will shift. For students, focus will be on gaining technical skills, problem-solving skills, and teamworking skills that are aligned with the demands of a more automated industry (Al-Mutawah et al., 2021). For educators, staying current with technology updates, learning new pedagogy competencies, and continuity of learning support will be the most critical component of being effective with robotics in education. Last but not least, both students and educators must develop the practice of lifetime learning if they are to thrive in the robot era of automation (Mahmoud, 2023).

Challenges and Solutions in Implementing Robotics in College Education

Robotics hardware, equipment, and facilities may be expensive, and schools do not have the means of purchasing equipment. Schools and institutions may try to raise funds in the form of government grants, cooperative partnerships with technology firms, or the use of low-cost open-source robotics platforms as a cost-saving strategy. Schools can also share resources or partner with other schools in order to pool resources and reduce costs. The majority of the students and teachers may lack the necessary technological literacy to effectively use robotics in the classroom (De Souza Picanço et al., 2024). Offer professional development workshops for teachers to acquaint themselves with robotic pedagogies and tools. Offer introductory robotics training and tutorials to students to build confidence in using robotic technologies. Robotics might be resisted by some teachers for fear of its complexity, reliability, or that it will replace their jobs (Hussain et al., 2021). Assure teachers that robotics is meant to augment their teaching and not replace them. Offer proper training and illustrate how robotics can be used to automate tasks such as grading or administrative tasks so that teachers will have more time to focus on high-value interactions with students. Use of robotics in education, especially with AI integration, raises ethical concerns of privacy, data security, and robots replacing human jobs (Rojas et al., 2025). Develop clear ethical guidelines and adhere to privacy laws like GDPR. Tackle ethics issues, privacy issues, and robotics use in education and inform students and teachers of risks. Integrating robotics into existing curricula may prove difficult, especially if robotics is handled as a niche or independent course rather than an interdisciplinary approach (Mu et al., 2024). Create interdisciplinary curricula where robotics is infused within courses like computer science, engineering, mathematics, and even business or arts. This allows students to see the applicability of robotics to their other studies, and it is part of their overall learning experience. Not every school has the required resources, e.g., high-speed internet, special rooms, or devices, to implement robotics. Schools can invest in common resources or join hands with nearby technology firms, non-profits, or universities with access to sophisticated robotics kits and resources. The use of low-cost or open-source robotics platforms can also enable schools with minimal budgets to get involved (Al-Mutawah et al., 2019). Robotics machinery is prone to technical issues such as breakdown, system malfunctioning, or becoming outdated software, and it will become a point of frustration for the students as well as teachers. Plan periodic preventive maintenance in such a way as to keep robotics hardware in best condition of operation at all times. Install planned periodical preventive maintenance so as to keep robotics hardware in best possible mode of operation at all times. Conduct fault

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diagnosis workshops for teachers and students and utilize technical support or IT personnel for proper troubleshooting (Mahmoud, 2015). Excessive use of robotics and AI by the teachers and students may cause damage and thus avoid humane, imaginative, and critical thinking while learning. Exercise caution to maintain a balance by utilizing the robotics as an addition to the traditional method and not as its total substitution or replacement. Encourage activities with human collaboration and problem-solving without the use of technology to ensure that students continue to gain cognitive and social skills (Achmad et al., 2025).

Additionally, there are certain students who will not be interested in robotics or won't be able to grasp the technology and therefore disengage and demonstrate low participation levels. Engage students with interactive, innovative projects in which they have an opportunity to interact face-to-face with robots to problem-solve or create innovations. Incorporate gamification elements or robotics competitions to engender active, competitive, and rewarding learning. In addition, demonstrate how robotics is applied to address real-life issues to continue to stimulate students. Access differences to robotics education by different regions, socioeconomical level, or subgroups of students can restrict chances for some students (Hung et al., 2012). To narrow the equity gap, offer virtual robot lessons, open-source software, and low-cost kits so that all students can access robotics education. Schools and universities can collaborate with local community organizations to reach the under-served communities and offer mobile learning laboratories for taking robotics to rural or underprivileged communities (Karalekas et al., 2023). These are common issues, however, in incorporating robotics into the curriculum, and with careful solutions and commitments from all involved, robotics can be a powerful addition to the learning experience for students and teachers (Podobnik et al., 2024).

Statement of the Problem

Increased use of robot machines in learning has encouraged a paradigm shift toward pedagogy and learning, particularly in the realm of higher learning. Due to the pace with which robotics and automation technologies are changing, higher learning institutions have begun investigating their use for the improvement of the learning process, particularly in the context of STEM education (Al-Mutawah et al., 2021). Robotics has the potential to come with enormous benefits, such as greater student engagement, experiential learning, and transferring to students' essential skills that the job market is seeking (Torres & Inga, 2025). Introducing robotics to the college classroom comes with enormous challenges, such as high initial costs, lack of technological infrastructure, and educator and student resistance to the technology. Despite the growing interest and early success of robotics education, a comprehensive understanding of its real impact on student learning and on institutional practice remains limited (Lin, 2023). There is a need for research that evaluates the efficacy of robotics for student learning outcomes, transcends the barriers to successful implementation, and investigates the real-world benefits and limitations from both educators' and students' perspectives (Torres & Inga, 2025). This study is significant because it tries to explore the potential of applying robots to redefine pedagogy and sketch some of the challenges to be addressed if robotics is to be employed effectively. All this data will illuminate the way the adoption of robotics as a technology can change education, increase access to learning, and equip individuals better to cope with a more dynamic working environment. The value of this study lies in its potential to guide the eventual integration of robotics into collegiate course work. With automation becoming more prevalent in the workplace across industries, schools must prepare students for this shift by familiarizing them with and exposing them to advanced technological equipment. Through an examination of the impacts, challenges, and benefits of robotics in learning, the study will give crucial information to guide educators, administrators, and policymakers in making sound decisions on adopting robotics in higher education institutions. Furthermore, realization of challenges to institutions will enable one to come up with mitigation measures, in the process providing equal opportunity for all students to access robotics learning. Therefore, this study aims to provide appropriate answers to the following 3 research questions: 1) In what ways does the integration of robots in collegiate-level classes influence learning, skill acquisition, and student engagement? 2) What are the main challenges faced by colleges in integrating automatic robotics into their curriculum, and how can one overcome these challenges? 3) What are the advantages and the constraints that both students and teachers have found in using computerized robotics in college courses, and to what extent do they influence the diffusion of robotics into higher education?

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By answering these research questions, this study will contribute to current knowledge about robotics in education and provide practical recommendations that can be implemented to inform the shaping of the future of teaching and learning in higher education through the utilization of automated robotics.

METHODS

In this study, the descriptive study method was employed to explore and analyse the use of automated robotics in college courses. The primary goal of using this methodology was to provide a comprehensive and detailed account of how robotics is integrated into teaching and learning, highlighting its benefits, challenges, and implications in higher education. The descriptive design was used because it allows close examination of current practices and experiences with no experimental control or control groups. The qualitative descriptive design was used in the research, which is designed to provide an accurate, detailed description of a phenomenon. It was meant to gather the current status of robotics integration into university curricula, issues that were faced, and benefits realized. The research does not include a population sample or the collection of data from any specific individuals but synthesizes evidence from literature, case studies, expert opinions, and industry reports on the use of robotics in education. Since this is descriptive research and there are no samples of studies, the collection of data was the collection of secondary data from different sources. Academic journals and research articles with papers comprising articles from academic journals and publications relative to robotics and higher education were reviewed. Data collected from the identified sources were processed using a descriptive data analysis. This is a type of analysis that seeks to describe and report data in significant patterns, as well as findings, without inferring causality or generalizability. In this context, the analysis focused on establishing prevailing trends and recurrent themes regarding robots' application in college classrooms. The descriptive data analysis findings show that the integration of robotics in college courses is beneficial and challenging. On the positive side, it offers great benefits in terms of students' engagement and skill acquisition. On the negative side, it has drawbacks such as being costly and demanding better infrastructure. With the advancement in technology, naturally it could be anticipated that these issues would be eased and hence more utilization of robotics in tertiary education. By way of conclusion, this research utilizing the descriptive study method provides a comprehensive description of the current state of robotics in education, with significant trends, benefits, and issues surfacing while throwing glimpses on the future of robotics as an educational game-changer.

RESULTS AND DISCUSSION

This study found that there are some specific infrastructures that are required for robotics integration in college education. High-speed internet and reliable internet connections are essential for cloud-based robotics control and communication. This study revealed that robotics labs and dedicated spaces with equipment and resources for hands-on robotics learning (Mahmoud, 2009). AI software programs and educational platforms with built-in AI to simulate and control robotics are important. This study emphasized on the need of 3D printing facilities for creating and modifying robotic components and prototypes (Al-Mutawah et al., 2018). Virtual reality (VR) or augmented reality (AR) support and environments to simulate robotics in action are essentials. This study highlighted the need for interactive whiteboards for immediate interaction among students, robots, and instructors. Computing hardware is required to access personal devices or computer terminals to code robots. Sensor and motion capture technology are necessary for gathering real-time data and feedback from robots, as per this study (Huda et al., 2021). Cloud computing is required to store large data generated by robotic and AI systems. It was strongly concentrated on the security systems' need to protect information and control the accessibility to robotics sensitive devices. It found and uncovered in more detail five examples of robotics learning machines in college education, as shown in Figure1. These robots have extensive use in college education, for instance, the best college courses to use them and the factors that led to their selection (Chandak, 2025; Kidd et al., 2025; Phokoye et al., 2024).

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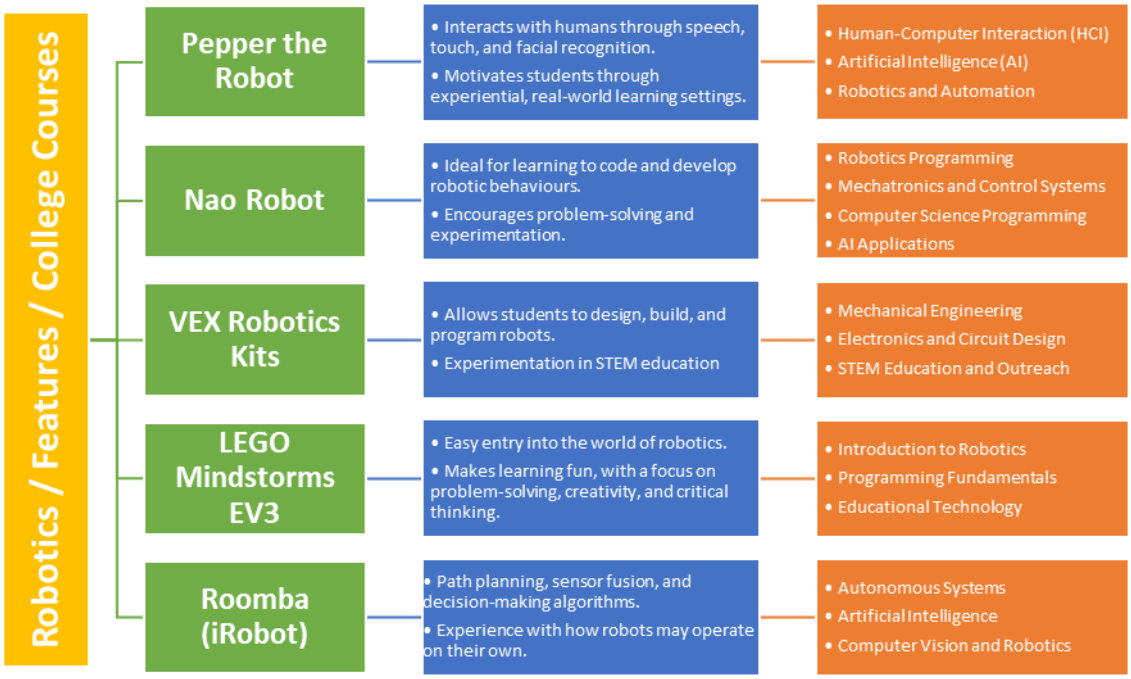
Figure 1. Examples of robotics learning machines in college education.



Pepper the Robot is suitable for using in teaching and learning many college courses, like: Human-Computer Interaction (HCI), Artificial Intelligence (AI) and Robotics and Automation for many reasons. Social and interactive learning as Pepper is a humanoid robot designed to interact with humans through speech, touch, and facial recognition. It is particularly convenient for courses like HCI, where students can be taught human-machine interaction and communication. It is also a platform on which one can study concepts in AI, particularly for courses like machine learning, natural language processing, and emotion detection. Motivation and engagement since Pepper can be used to encourage students through experiential, real-world learning settings that emphasize human-robot interaction. It can be used to demonstrate topics like chatbots and machine learning, hence making it a great way of enabling interaction with advanced systems in more relatable and interesting terms (Mahmoud, 2023). Nao Robot is great for teaching several college courses, such as: Robotics Programming, Mechatronics and Control Systems and Computer Science Programming and AI Applications as Nao is a smaller, programmable humanoid robot ideal for learning to code and develop robotic behaviours. It is normally covered in class in Robotics Programming to make the students learn programming the behaviour of a robot in programming languages like Python and C++. In subjects like Mechatronics and Control Systems, Nao is a great place for learning movement, sensors, and real-time control systems. Working with Nao is a tangible way for the students to turn their code into action in a real, flesh-and-blood robot. It encourages problem-solving and experimentation, and for this reason, it can be utilized best to include students in computer science and engineering courses in which real-time control and programming are major components ((Rojas et al., 2025).

VEX Robotics Kits is preferred when teaching many college courses, like: Mechanical Engineering, Electronics and Circuit Design and STEM Education and Outreach. Hands-on engineering and design as VEX Robotics Kits are modular systems that allow students to design, build, and program robots. They are very suitable for Mechanical Engineering and Electronics courses, where students are able to convert theory into practice to design robotic systems through controllers, sensors, and motors. The kits also offer an experimental platform in STEM education with the potential of further practical methods of educating students on engineering and technology. Scalability and Versatility because VEX kits are versatile and scalable, they support beginner and advanced projects. They offer individual and group project offerings that promote critical thinking and teamwork skills ((Mu et al., 2024). LEGO Mindstorms EV3 is suitable for a number of college courses, including: Introduction to Robotics, Programming Fundamentals and Educational Technology. Accessible and modular design as LEGO Mindstorms EV3 is an ideal learning platform for Introduction to Robotics courses, especially for students new to the field. It offers an easy entry into the world of robotics with a simple, modular design that is easy to program and control. Educational value

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because the platform is designed in a manner that makes learning enjoyable, with a focus on problem-solving, creativity, and critical thinking. It is routinely used in Educational Technology classes to demonstrate how robotics can be used as a learning tool. Furthermore, the user-friendliness of LEGO Mindstorms makes it the perfect vehicle for introducing programming concepts, particularly to students who are less technologically inclined (Choi et al., 2024).

Roomba (iRobot) is very helpful when teaching a wide range of college courses, like: Autonomous Systems, Artificial Intelligence and Computer Vision and Robotics. Autonomous navigation and AI as Roomba, while primarily a consumer product, is an excellent educational tool for courses related to Autonomous Systems. Students can learn real-life applications of path planning, sensor fusion, and decision-making algorithms used in autonomous robots. Autonomous navigation and room sweeping of Roomba make it ideal to learn about AI, machine learning, and computer vision algorithms that govern its movement. Real-world applications, as Roomba is a genuine, consumer-grade model of autonomous robots that could be learned from students. It's a very good representation of AI and robotics use in the real world and is a way of getting experience with how robots may operate on their own to complete some jobs. It's of value for students of AI and robotics interested in autonomous navigation, mapping, and real-time decision-making (De La Hoz et al., 2024). Each of these education robots offers unique education benefits that can be traced to a variety of college courses in robotics and engineering. Incorporating these robots into classes will enable educators to provide students with interactive, hands-on learning experiences that can potentially propel programming, engineering, AI, and other essential skills. Whether it's the interactive humanoid capabilities of Pepper, the coding and control skills gained through Nao, or the engineering challenges of VEX and LEGO systems, each robot supports a distinct learning goal, fostering critical thinking, collaboration, and innovation in the classroom (Karalekas et al., 2023).

This study identifies and assists in defining the future of teaching and learning college courses using robotics. The future of teaching and learning college courses using robotics is very promising, with it ushering in revolutionary changes in the teaching and learning of education. With further development of artificial intelligence (AI), machine learning, and automation, the future of using robotics to teach and learn college courses will broaden and progress (Achmad et al., 2025). Consequently, there are some trends and future expectations of the future of robotics in higher education. Universality across subjects as in the coming years, robotics will spread beyond the typical engineering and computer science degrees and become a subject of an augmented set of college courses like business, humanities, social sciences, and healthcare (Eteokleous & Ktoridou, 2014). Robots' capability to model reality and experiential learning will be useful across the spectrum in areas of study from business students learning via robot-simulated teaching on logistics to nursing students learning patient care via the application of robots (Lin, 2023).

Personalized and adaptive learning one of the most prospective breakthroughs of robots in the future is personalized learning by robots. The robot with AI capability will be able to assess individual students' learning capacity and educational needs and then deliver personalized study materials, guidance, and comments (Hunter et al., 2013). This computer program will give adequate challenge and direction to each student, either according to his or her ability or learning style, to realize maximum potential. Increased use of collaborative robots (Cobots) as robots to assist human students, also referred to as collaborative robots (Cobots), will be a standard in the classroom. These robots can offer group projects, not-so-complex problem-solving, and even peer-like interaction. For example, engineering or robotics students can work together with Cobots in programming or robot designing, mimicking actual industrial settings. This kind of collaboration will improve teamwork as well as allow students to develop important skills like leadership, communication, and problem-solving (Torres & Inga, 2025). Robots as teaching assistants because robots are likely to serve as teaching assistants in the classroom, helping instructors with grading, answering student queries, providing real-time feedback, and facilitating repetitive tasks. These robots could act as tutors for students, assisting with basic questions or even offering individualized one-on-one learning sessions, thus allowing instructors to focus on more complex educational tasks (Huda et al., 2021). Simulations and virtual learning environments as robots will be a significant component in creating immersive simulations and virtual learning environments. Students will be able to engage with virtual robots in simulations that replicate actual complex problems, such as emergency response scenarios, mechanical diagnostic scenarios, or environmental simulations (Al-Mutawah et al., 2019). Virtual robots will provide students with an opportunity to try and practice without having to employ expensive physical equipment or materials.

More learning of soft skills as robots will become more used to learn soft skills, such as emotional intelligence, communication, and teamwork. Social robots capable of simulating human interaction will allow students to practice

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these essential skills in a virtual world, equipping them for an increasingly emotional-intelligence-and-communication-intensive workforce (Lathifah et al., 2019). International and distance learning experiences, with the expansion of distance and hybrid learning environments, will have robotics at the forefront to deliver interactive and dynamic learning experiences to learners around the globe. Telepresence robots can enable students to attend class remotely, conduct laboratory work, and interact with instructors or classmates as if physically present (Mahmoud, 2015). This technology will also grant disabled or rural students access to quality education. Ongoing feedback and real-time analysis by robots, made easy by AI, will enable ongoing, real-time feedback on students' performance. With student data collection using robots, organizations will be able to have insightful information regarding learning behaviour, challenges, and strengths. This evidence-based practice will allow educators to make better-informed decisions about course content, teaching strategies, and student support plans that will all lead to enhanced teaching and learning (Lin, 2023). Ethics and issues of fairness as more robotics become integrated into higher education, ethics and fairness issues will be highlighted more. Equitable access of robotics technology for all students and applying the technology in ethical means will be of primary concern (Ali et al., 2023). As robots join the learning process, universities will also have to contend with matters such as data privacy, the potential for technology to replace human teachers, and the impact of robotics on the labor market. Robot design and functionality in the case of future robots, for example, will be more varied and able to carry out more forms of educational functions. Robots in the future will not only be capable of directly instructing but also monitor students' welfare and offer emotional support or adjust the pace of the course based on a student's cognitive or emotional status. Robots will be more intuitive, intelligent, and responsive, thus making it simpler to interact with teachers and students (Torres & Inga, 2025). The scope of robotics in teaching and learning at the higher education level is enormous. As the technology continues to change, the role of robotics will become more pivotal in university education, embracing both technical and nontechnical fields. From personalized education to communication in virtual space, students will be exposed to excellent opportunities to feel their education differently with robots (Ramankulov & Shyndaliyev, 2024). Even if some problems in terms of expense, infrastructure, and ethics must be overcome, the potential that robotics holds out for educational advancement cannot be excluded, in the light of a thrilling, effective, and available learning process.

CONCLUSION

Addition of robotics automation to college curriculum is a giant leap of historical magnitude in education and learning that holds phenomenal potential to increase the volume of students' engagement, acquirement of their talent, and future employability. While there are self-evident benefits to the application of robotics in education, such as: sparking innovation, problem-solving capacity building, and experiential learning through practices, there are also some humongous disadvantages like enormous expenses, infrastructural needs, and skill in teachers' training. This study has recommended the incorporation of robotics into the mainstream content of the dominant curriculum in order to ensure robotics is used as an extension of the curriculum with the purpose of enriching it rather than acting as a replacement for conventional methods of teaching. It must be utilized to balance theoretical applications with practical, experiential applications. The current research proposed offering teacher training and providing extensive professional development for teachers so that teachers are familiar with robots and aware of how to integrate these technologies in education. This study highlighted the interdisciplinary learning emphasis to invoke interdepartmental cooperation (e.g., engineering, computer science, business) to develop interdepartmental courses where students can see how robotics affects different disciplines. This study proposed starting with basic concepts in robotics to introduce students to introductory concepts in robotics before venturing into advanced systems. Begin with easy-to-understand platforms such as LEGO Mindstorms or VEX Robotics. This study suggested to create problem-based learning (PBL) scenarios to design courses where students use robots to solve real-world problems. Problem-based learning encourages critical thinking and enhances the practical application of knowledge.

This study recommended that experiential learning be promoted so that students spend significant amounts of time working with the robots, as opposed to learning about them. The more hands-on they are with the robots, the more they will learn. The current study recommended that in order to encourage teamwork because robotics projects are often team-based. Encourage cooperative learning in which students of different backgrounds (e.g., design, programming, engineering) collaborate, simulating the real dynamics of robotics development. This study suggested implementing robotics to enhance STEM skills. Robotics can potentially serve as an effective learning tool for science, technology, engineering, and mathematics (STEM) skills. Ensure students gain technical skills, problem-solving

skills, and critical skills. This study highlighted the importance of integrating coding and programming knowledge while learning how to program robots is important. Offer coding classes and workshops where students learn and apply programming languages such as Python, Java, or C++. This study suggested setting specific learning objectives to create clear, measurable learning goals for robotics projects and assignments. Clear objectives will allow students and teachers to track progress effectively. The current research aimed at encouraging experimentation through the provision of students with a chance to experiment with different robotic designs, software, and configurations. Permissible failure and iterative processes enhance innovation and creativity. The current research proposed setting protocols for safety as an effort towards setting and adopting safety protocols in the use of robotics in schools. Robots may have moving parts that pose risks, so it's important to educate students on safe operation. This study highlighted the need to incorporate AI and machine learning and to teach students how AI and machine learning can be used to enhance robotic systems, allowing them to understand the relationship between robotics and other emerging technologies. The current study suggested to provide access to online resources to offer access to online tutorials, coding platforms, and robotics kits to support students in learning outside of the classroom.

This study placed great emphasis on combining ethics considerations and making a case for the ethics implications of automation and robotics into educational, business, and societal points of view. Request students to reflect carefully on the final implications of such technology for the future. This study proposed the implementation of virtual and augmented reality (VR/AR) to enable the learning of robotics through VR/AR simulation of robots so that students could be able to view and engage with robots virtually in digital virtual environments. This study proposed offering robotics competitions to design or participate in robotics competitions to offer students a hands-on, goal-oriented experience. Competitions foster teamwork, problem-solving, and time management. This study suggested the use of robotic helpers to introduce robotic helpers into the classroom to aid in paper tasks like grading, attendance, or helping students through technical problems, allowing teachers more time to teach. This study recommended to ensure access for all students to make sure that robotics is accessible to all students, including those with disabilities. Consider adaptive technologies or inclusive design features to ensure equitable access. The current study suggested to keep abreast of technological advancements and to stay updated on the latest developments in robotics and AI. The technology itself changes rapidly, so it is crucial to update course content regularly and adjust the teaching methods accordingly. The suggestions here are all aimed at establishing an inclusive, practical, and efficient learning environment using robotics that will allow the students to reap the complete advantages of this technology while acquiring skills that are needed in the future. Additional research will be needed to measure the long-term effects of robotics on student learning and to offer solutions on how to break down barriers to its use in higher education.

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