Education-Robotics Symbiosis: An Evaluation of Challenges and Proposed Recommendations

Habib Ahmed* and Hung Manh La+
Advanced Robotics and Automation Lab
Department of Computer Science and Engineering
University of Nevada, Reno, USA
*Email: habib_ahmed@msn.com
+ Email: hla@unr.edu

***Abstract* - In the wake of technological innovation, integration between Robotics and Education is essential to promote the education and skill acquisition, which will lead to the training and development of the workforce of the future. This paper explores the two primary aspects related to Education and Robotics discussed in the relevant literature; one dealing with utilizing education of Robotics, primarily for Science, Technology, Engineering and Mathematics (STEM)-related courses, and the other discussing the usage of different robots in the broader context with the purpose of facilitating education and learning for students of all ages. At the same time, a model of Education-Robotics Symbiosis has also been highlighted, which discusses some of the critical components that can ensure that the vision of successful and sustainable Education-Robotics Symbiosis can be practically materialized at the various levels of the educational system. The proposed recommendations have implications for national-level policy-making in relation to STEM education, professional-level skill development as well as institutional-level Robotics education.**

Index Terms - Educational Robotics. Robotics Education. Robotic platforms. Social Robotics. STEM Education.

1. Introduction

Robotics and Artificial Intelligence (AI) have experienced some of the most important recent developments in the realm of science, technology and innovation, such that in the near future, robots are expected to play a central role in the daily lives of individuals, while performing different roles and responsibilities, ranging from educational tutoring and elderly assistance to industrial manufacturing, workplace collaborations and domestic social companionship [1-3]. Developments and advancements in the field of Robotics are expected to drastically impact the employment sector leading to changes in the skill requirements and expectations, while the effects of automation are already being felt by the workers and employees in various job markets around the world [4]. The importance of incorporating Robotics learning has been emphasized at different levels of educational system (ranging from pre-school and middle school to high-schools, colleges and uni-

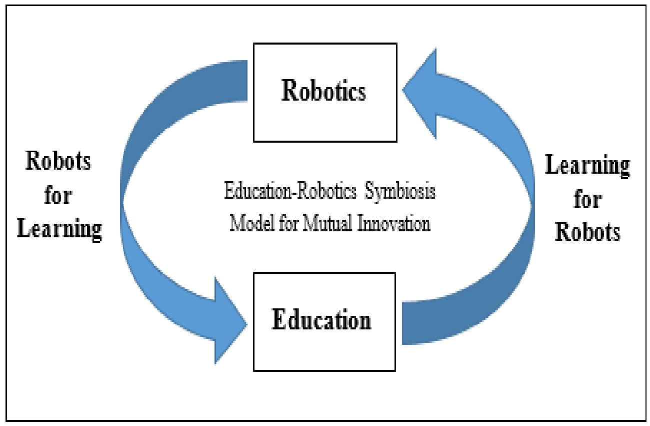

FIGURE I
PROPOSED MODEL FOR EDUCATION-ROBOTICS SYMBIOSIS

-versities), so that the workforce is able to meet the changing skillset demands of the workplaces in the future [4, 5]. However, there is a rising need for the education sector to evolve with changing demands and needs of the employment market, by incorporating technological innovations, such as Robotics applications within the curricula. With regards to the overlap between Robotics and Education, the following aspects have been highlighted: (i) incorporating learning related to the field of Robotics within the existing school curricula, and (ii) utilizing robots and AI-based applications for enhancing the learning experiences for students of all ages. For promoting learning within students, robots have been frequently employed in classroom settings to perform role of teaching assistant, tutoring for second language learning, teaching technical and non-technical courses and assisting in the social, cognitive and skill development of students [5-7]. However, most of the existing studies have focused on one aspect of the multi-faceted relationship between Robotics and Education. Therefore, this paper will provide a holistic perspective on Education-Robotics Symbiosis, in light of various underlying issues and propose a list of recommendations to improve students' learning and professional skill development, availability of skilled workforce and improved research and development with emphasis towards technological innovation. Figure 1 outlines the proposed model for Education-Robotics Symbiosis.

2. Why is Education-Robotics Symbiosis Important?

Maintaining a mutually-beneficial relationship between Education and Robotics is critical for a number of different reasons. Historically, the overall participation of women in STEM has been marginal (in US, less than 24% of the overall workforce in STEM is comprised of women), due to the masculine composition of technology-related career culture, lack of female role models in the STEM fields, negative stereotypes regarding women's abilities, insufficient self-efficacy and lack of positive early experiences to motivate women to pursue education in STEM [8, 9]. At the same time, the overall dropout rates in the STEM courses is also rising at an alarming rate, such that between 2003 and 2009, 69% of the students in associate degree programs and 48% of the students pursuing bachelor's degree left their respective degree programs [10, 11]. Some of the factors, which contribute to the rising dropout rates include lack of faculty involvement, unavailability of support from peers, and widening gap in expectations regarding quality of work between students and professors [12].

Based on the predictions of the US Bureau of Statistics [13] for the coming decade (2016-2026), careers related to STEM are expected to experience the highest growth, which will result in increased demand for skilled workforce in the near future. Therefore, at one end, the overall interest and participation towards pursuing STEM-related careers is dwindling. While, on the other end, rising innovation and technological revolution is expected to increase the overall demand for skilled labor with STEM-related qualification and expertise, which in turn will result in employment gap between the demand and supply of available labor workforce in the United States. The propagation of Robotics Education is being hailed as one of the ways in which the aforementioned issues can be rectified resulting in bridging the employment gap in the STEM-related jobs [10, 11]. The efforts by educational institutions at the different levels of education (covering early education, middle-school, high-school, colleges and undergraduate education) can enhance appeal and evoke interest of students (especially female students) at a young age towards pursuing careers in STEM-related fields.

Another important aspect of Robotics-Education symbiosis is related to utilizing technological advancements towards developing innovative practices for meeting the evolving educational needs of students. Robotics and the associated innovative educational tools have the potential to incorporate multi-disciplinary concepts related to Mathematics, Physics, Electronics, Computer Science, Programming, Engineering, Problem Solving and Troubleshooting [12]. At the same time, the usage of AI-based applications, social robots and robotic kits within educational settings have reported positive influences on the students' problem-solving abilities, skills improvements, social and cognitive development and motivation to pursue STEM-related courses and careers [13, 14]. Meanwhile, a host of different challenges inhibit the ability to maximize the potential for reaping benefits from Education-Robotics Symbiosis. Some of these challenges include high costs of robotic platforms, lack of teacher training and confidence, perceived inability to teach technology courses and significant gaps between students' age and technical knowledge requirements of learning exercises [15].

3. Robotics Education: Learning for Robots

In this section, the primary focus will be towards highlighting the importance of introducing learning opportunities with regards to physical and/or virtual robotic systems in the educational sectors. The importance of robots towards enhancing the learning outcomes of students has been previously highlighted [12], which further cement the importance of introducing robots in particular and AI-based systems in general within the educational context. At the same time, specific tools have also been developed in order to enhance the ease in learning technical concepts (e.g. programming, sensor integration, etc.) for students from technical as well as non-technical backgrounds [16]. Based on the philosophy of Constructionism, the hands-on learning approach has been widely utilized towards learning and skill development of students in STEM-related courses, leading to promising improvements in students' achievements and outcomes [16]. Therefore, programmable robotic kits constitute as an important element for Robotics education within the different educational environments ranging from class-based, individual-level and collaborative activities to international-level competitions (e.g. *Robocup Junior (RCJ), Robo Festa, First Robotics Competition and First Lego League (FLL)*) [17].

Some of the factors that impact the widespread utilization of Robotics kits in educational settings include *affordability*, *sensory modalities*, *processing power*, *modular design*, *software support* and *practical utility*. However, Robotic kits and related platforms alone are not sufficient for facilitating learning and education in STEM-related courses. In this regard, developing effective curricula is essential to foster interest in students and meet the future demands for skill development [18]. However, there is no established framework for the integration of Robotics in educational curricula. In order to facilitate integration between Robotics and Education, there is a need for a generalized framework for curricular development, which can cater to the diverging individual needs, technical limitations and varying professional skill requirements.

4. Educational Robotics: Robots for Learning

In this section, the emphasis will be towards exploring the potential of social robots towards enhancing the quality of education in the future for students of all ages and study backgrounds. In the past few decades, the improvements in technological capabilities and reduced prices of social robots have facilitated their usage in educational settings [20, 21]. Traditional mode of classroom-based teaching (overall ratio between teachers and students is 1: N) prevent-

-s immersive learning experiences for children. While, the introduction of social robots within the educational settings reduces the barriers between students and instructors, where robots act as conduits to effectively impart necessary information and knowledge, while enhancing engagement within students and improving their learning outcomes [21, 22].

The role of robots in education has been classified by Mubin et al. [3] into the following three categories: *robots as tutors*, *robots as tools*, and *robots as peers*; where each aspect aids in the learning of children from different interactional perspectives. Some of the other studies have also tried to explore the 'Learning by Teaching' paradigm and care-taking robots (engaging in care-taking behavior towards robots, which result in learning gains) within the field of Educational Robotics in which the children improve their own learning by teaching robots and performing a particular activity (e.g. learning motor skills by performing specific actions) [23, 24]. In comparison to other educational technologies (e.g. virtual agents, on-screen applications, etc.), physically-embodied robots have the potential to promote task compliance towards maintaining long-term relationships, while resulting in greater learning achievements as well as improving learners' self-esteem and empathic feedback [25]. In order to promote long-term relationship and elicit engagement from students, the social robots in educational settings should be capable of effectively communicating as well as perceiving verbal communication and non-verbal cues involving hand gestures, head nods, eye gaze and body postures [26]. In order to improve the learning outcomes of the children, the learning activities and the robot behavior should adhere to the underlying socio-cultural context, as children's perception and interpretations are dependent on social acceptability of robots' verbal and non-verbal behavior [27].

5. Recommendations for Education-Robotics Symbiosis

In this section, the focus will be towards shedding light on the specific components of the holistic Education-Robotics symbiosis model, which can enable the researchers to tailor Robotic applications to Education and at the same time, mold Educational practices for teaching STEM and non-STEM-related courses. Education-Robotics Symbiosis is essential, as it will enable educators to impart necessary STEM-related knowledge and skills for students at different levels of technical and non-technical fields of study, which can enable them to gain necessary skill sets required to actively participate in the global workforce of the future. Figure 2 outlines a hierarchical model for propagating Education-Robotics Symbiosis at the different levels of the society. It can be seen in figure 2 that different initiatives are required to ensure that foundation can be laid towards integration between Education and Robotics within each of the different levels of the education system. In order to accomplish this, different stakeholders at different levels of the education system are required to play their due roles.

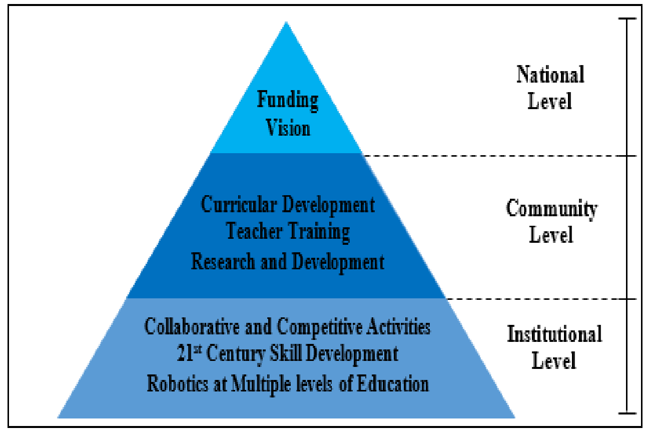

FIGURE II
IDENTIFYING FACTORS AT DIFFERENT HIERARCHICAL LEVELS TOWARDS SUSTAINABLE EDUCATION-ROBOTICS SYMBIOSIS

5.1 Vision for Sustainable Education-Robotics Symbiosis

At a national-level, two primary aspects have been highlighted, which can assist in the successful and sustainable development for promoting Education-Robotics Symbiosis. The primary purpose of this research is not to shed light on the economic and financial aspects of the Robotics and Education. Therefore, this section will briefly outline the importance of national and international cooperation and collaborations towards promoting Education-Robotics Symbiosis. In order to facilitate the widespread utilization of different robotic platforms in Education, the national-level government agencies are required to collaborate and partner with various national and international-level technology firms. In this regard, African Robotics Network's (AFRON) initiative "Ultra Affordable Educational Robot" is an example of partnership between educational institutions in developed and developing countries for promoting Robotics education in under-developed countries in Africa [17].

However, there is a need for involvement and participation of policy-makers and educators at the highest level to provide a vision, planning and allocate funding to promote Education-Robotics Symbiosis. At the same time, a framework for collaboration between the education sector, research and development and industrial sector is essential for practical implementation and sustainability of the vision for effective integration between Robotics and Education sectors [28]. In order to substantially improve funding for facilitating and propagating the vision of Education-Robotics Symbiosis, there is also a need to rely on a number of different public and private funding options, such as venture capitalists, as well as facilitate innovative education-centric robotics services and products through incubators, accelerators and joint workspace solutions [28]. Therefore, efforts towards sustainable Education-Robotics Symbiosis have the potential to revolutionize the regional Educational and Robotics sectors, which can lead to growth of the educational innovation firms, thereby increasing competition and reducing the overall costs of robots in the long-run.

5.2 ROBOTS AT MULTIPLE-LEVELS OF EDUCATIONAL SYSTEM

It has been established by existing researches that the current efforts are primarily focused towards imparting knowledge and skill development activities for students belonging to STEM-related courses [20, 21]. However, it has been reported that robotics concepts can be successfully integrated within the existing curricula [29], which means that activities using robotic kits can be incorporated within the existing curricula for students from different background. Therefore, the *STEM pipeline* (framework for enhancing mentorship and collaboration between students at different stages of educational attainment, ranging from pre-school to high school) [29] should be extended to incorporate students from different specializations, courses and learning preferences. Research into Early Childhood Education has revealed that introduction of new technology within the Montessori classrooms resulted in fostering digital literacy and learning through technological integration [5]. Meanwhile, studies investigating the benefits of early exposure to STEM-related concepts have reported reduced perception of gender specificity of STEM courses in students, increased motivation and improved social and technical skill development within early childhood classrooms [30]. Due to the multi-disciplinary, technically intensive and complex nature of concepts related to Robotics, the initial exposure to Robots in Early Childhood Education should be facilitated with the usage of different interactive, social robots in different basic-level learning activities [31].

A holistic approach towards Education-Robotics Symbiosis would require the utilization of myriad of different robotic systems for performing different tasks. Ideally, some of the robotic systems used within the educational sector should include the following: physically-embodied anthropomorphic robots (e.g. Nao, Pepper), non-anthropomorphic robots (e.g. robotics kits, service robots, industrial robot platforms), virtual agents, and other AI-based applications (e.g. laptop, mobile, and tablet based applications). A number of studies have focused towards increasing the reach and affordability of robotic platforms for improving learning of robots [17]. The early approaches towards integrating Robotics in Education have relied on 'robots as tools' perspective alone [32]; this has severely limited the opportunities towards holistic integration to promote Education-Robotics Symbiosis. There is a need to extend the scope of activities from using simple robotic kits alone to placing Robotics as an integral part of the overall learning and education process through repeated interaction between students and different educational robots, starting

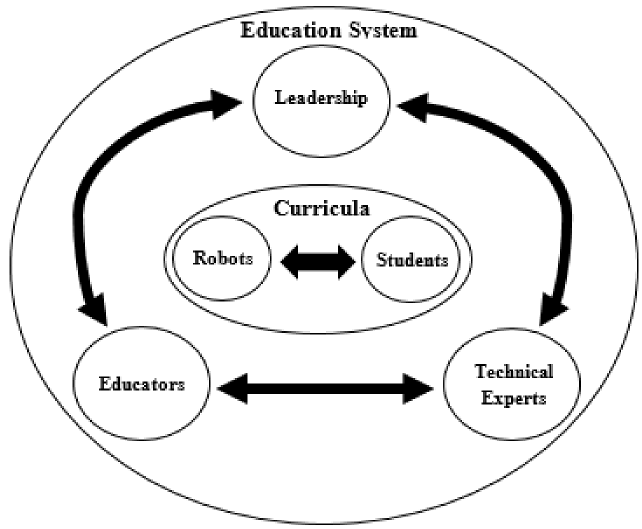

FIGURE III
MODEL OF THE EDUCATION SYSTEM WITH INTEGRATION OF ROBOTICS AT THE CENTER OF LEARNING

from Early Montessori education to Higher Education. Through holistic integration of Robotics in Education, as shown in figure 3, the different stakeholders will be able to play their due role towards facilitating, managing, formulating and designing activities, teaching, learning and skill attainment, quantifying performance as well as developing an educational framework, which caters to the evolving personal, professional and technological demands and needs.

5.3 CURRICULAR DEVELOPMENT: FOCUSING ON INCLUSIVE PARTICIPATION

For the curricular development to further the vision of Education-Robotics Symbiosis, an inclusive, rather than exclusive approach should be taken into consideration, which initiates at the level of Early Childhood Education to Higher Education. In this regard, a number of varying curricular development approaches have been proposed in the past, which include *theme-based* (the curricula is divided based on specific topics or focus of learning, which students learn at varying individual levels through problem identification, collaboration and communication), *goal-based* (activities focusing on the accomplishment of pre-defined objectives) and *project-based* (investigating practical challenges through collaboration) curricula approaches [21]. By examining the aforementioned curricula, it can be seen that the different approaches highlighted in previous studies are applicable to specific type of activities being covered by the particular curricula. There is a need for developing a generalized framework for designing curricula and proposing different activities, which can be molded based on the diverging skill development needs of different group of students, technical and instructional limitations of instructors as well as the availability of robotic platforms. Relevant studies have also

TABLE I
A TENTATIVE OUTLINE OF THE DIFFERENT ACTIVITIES TO FOSTER EDUCATION-ROBOTICS SYMBIOSIS

Student	**Activities**	**Activity Type**	**Goal**
All	Exhibitions	Extra-curricular	Enhance engagement in STEM-related courses
All	One-on-one robot counselling	Co-curricular	Monitor academic progress, assess behavioral changes, etc.
Pre-K to K-3	One-on-one robot learning	Curricular	Language learning, and basic-level skills development
Pre-K to K-8	Summer Camp	Extra-curricular	Promoting hands-on experience using Robotic kits and platforms
K-8 onwards	Lab sessions	Curricular	Skill development and hands-on experience
Higher Ed.	Workshops	Co-curricular	Skill development for successful inclusion in workforce

noted that existing emphasis on Robotics-related activities is extra-curricular in nature [20], which limits its efficacy and participation to students already affiliated with STEM-related courses, while neglecting students from other backgrounds, who can benefit from the direct participation and hands-on experience on different robotic platforms. By providing a combination of co-curricular and extra-curricular activities focusing on a broad-range of activities and targeting a number of different participants, students from diverging backgrounds can improve their technical (mathematical knowledge, scientific investigation and technology fluency) as well as non-technical (communication, collaboration, critical thinking and cooperation) skills [21]. The details of the various activities targeting students at different levels of education has been highlighted in table 1.

5.4 TWENTY-FIRST CENTURY SKILLS' DEVELOPMENT AND ATTAINMENT

Statistical evidences have repeatedly highlighted concerns regarding gaps between demand and supply of technical workforce with necessary STEM-related knowledge, skills and competencies in the US [32]. Technological advancements in the workplace environment has shifted the role of workers from relying on rote memorization of different processes to skills related to problem solving in an unstructured, complex workplace [33]. In order to stay relevant within a rapidly changing global employment sector, educators as well as students need to remain in touch with the changes in the skill requirements. Some of the necessary skills for propagating a successful career within the labor workforce of the future include creativity, critical thinking, problem solving, communication, collaboration (collectively referred as 4Cs), problem-solving, decision-making, Information and Communication Technology (ICT) and information literacy [21]. Meanwhile, earlier studies have highlighted the benefits of Robotics Education and associated STEM-related concepts towards imparting necessary skills, which include creative thinking, problem-solving, logic and reasoning, collaboration, and communication [34]. Based on the Bloom's Taxonomy, the activities should emphasize on analytical thinking, evaluation and creation through hands-on interaction and 'tinkering' with the help of available robotic kits [35]. Following are some of the proposed strategies for developing engaging activities for skill development: (i) emphasis on theme-based activities, (ii) amalgamation of arts and engineering-related concepts to cater to diverging interests of wide-range of participants, (iii) utilizing storytelling activities, and (iv) activities should foster cooperation, rather than competition between different participants [38]. The skill development of students is one aspect of the effort towards 21st century skill attainment, as teachers, educators and managers are also required to remain up-to-date in terms of awareness and skill development to ensure that they have the necessary skills, knowledge and insights towards mentoring students and impacting policy-making in the future. As, prior studies have stressed upon the need for development of technical capabilities and knowledge of teachers regarding Robotics, Engineering and Programming-related concepts [39].

5.5 EDUCATION-ROBOTICS SYMBIOSIS AND STEM GENDER GAP

The Education-Robotics symbiosis can be used as a vehicle for spearheading strategies for bridging the wide gender gap in STEM-related fields, which has remained as one of the central themes of the STEM-related literature in the past few decades [40-43]. In order to provide equal opportunities towards gaining essential skills to become active members of the STEM communities in the future, academics at the individual, institutional and national levels should devise strategies that aim towards fixing the 'leaky pipeline' at the different stages of the education sector, all the way from childhood and college to decisions related to selection of STEM-related professions [44, 45]. In order to systematically fix the various issues within the STEM pipeline, there would be a need to devise tailored strategies at the different sections of the pipeline. At the school, college and university-levels, girls and women should be encouraged to pursue STEM education and learning by dedicated mentors, along with the availability of scholarship opportunities and ability to take advanced STEM-related courses before entering college-level education [46]. In order to facilitate the retention and minimize the attrition of women from STEM-related careers, efforts should also be made towards dispelling cultural stigma and stereotypes, along with policy-making to minimize and effectively handle harassment-related issues [46]. In order to dispel cultural stigma and stereotypes, educational institutions should leverage positive media representations as well as real-life and media-based female role models to enhance relatability between STEM and women leaders, which can lead to increased interest of girls and women towards pursuing careers in STEM-related fields [45]. The activities related highlighted in table 1 should be designed with focus towards the inclusion of minority individuals (ethnic minorities, persons with disabilities, immigrants and members of Lesbian, Gay, Bisexual, Trans-sexual, Queer and Allies (LGBTQA) communities) as well as promotion of gender-balanced participation within activities designed to facilitate Education-Robotics symbiosis at the different levels of the education system.

Apart from developing strategies to promote retention of women and minority individuals, efforts should also be devoted towards developing a better understanding of the different factors that inhibit these communities from actively pursuing STEM-related careers. Some of these factors include stereotypical portrayal of gender roles, family circumstances, cultural stigma associated with STEM careers, gender bias in pay scale and stunted career growth in STEM and personal factors (e.g. self-belief, motivation and perceived intrinsic and extrinsic value) [40, 42, 44, 47, 48]. Another interesting finding reveals that gender gap in STEM is wider in countries with the highest overall gender equality (e.g. Finland, Sweden, Norway) [49-51], which points to the fact that phenomenon of STEM gender gap is considerably complex in nature. Therefore, it is important not only to devise strategies to bridge the gender gap in STEM-related careers, but also to differentiate between the effective and non-effective strategies being employed in existing educational settings. As presently, despite the different strategies employed by developed countries in the world (e.g. United States), the gender gap in STEM has persisted [52]; this points to failure towards adequately understanding the underlying nature of the STEM gender gap. Therefore, within the context of Education-Robotics symbiosis, there will be a need for understanding the various factors that can facilitate the influx of minority individuals and women towards acquiring STEM skills at the different stages of the pipeline as well as professionally participating and pursuing long-term STEM-related careers.

5.6 Collaborative Training and Partnerships

From the educators' perspective, a number of different challenges and reservations have been highlighted, which include inaccessibility of innovative educational robots in schools, considerable time and effort required towards teacher training, reluctance to follow and adopt changing technological trends as well as widespread perception and synonymy of Robotic tool usage, construction and programming as activities reserved for boys [17]. Despite rising interest and usage of robots within the global education sector [20, 21], it has been reported that schools remain technologically-deficient and deprived [38], which reduces the level of technical skills and technology literacy imparted by the schooling systems to the workforce of the future. Although, there is considerable level of skepticism regarding the adoption of technology in the educational context [53]. However, it is important to understand that robots, albeit innovative in nature, are very different from typical educational innovations (e.g. laptops, e-learning, etc.), as there is a social and interactional perspective to robots [54], which require different metrics for measuring performance improvement.

The role of educators is paramount within the educational sector towards successful integration of Robotics [55], as they are directly tasked with designing relevant activities, which, ideally, should be based on hands-on experience, involving problem-solving and practical utilization of technical STEM-related concepts [32]. Meanwhile, the limited exposure to technology in the educational settings can be partly attributed to the lack of confidence and motivation developed by educators towards learning and adopting new technology [15]. In cases when technology is incorporated in the education, the primitive pedagogical methodologies with structured and pre-planned activities are used, which are unable to fully leverage the benefits of technology-enabled education [21]. However, educators alone cannot be realistically expected to bring the technology revolution, as training and partnership is essential to equip them with necessary skills to effectively utilize technology as well as leadership-level initiatives, which enable a culture of innovative practices in the education sector [56]. Adoption of technology, in particular, the robotics-related technology will allow the educators and students, in collaboration and support of the leadership and technology experts, to enhance their own skills, which can aid in the integration of appropriate Robotics-related activities within the existing curricula.

6. Conclusion and Future Works

The previous sections have highlighted the need for an integrated approach between the fields of Education and Robotics, as the existing researches have failed to provide an adequate overview of the necessary components required for the sustainable symbiosis between Robotics and Education. In this respect, a number of different factors have been discussed in the previous sections of the paper. Individually, there are gaps in existing research areas and collectively, there is a need to shed light on the different factors for facilitating Education-Robotics Symbiosis. The relevant literature focus on the development of cost-effective Robotic kits for facilitating education related to Robotics and STEM-related courses and skills development (e.g. programming, mechanical engineering, mathematical knowledge) only [17]. These studies focus on STEM-related courses and their associated students alone [20, 21], while neglecting other non-STEM-related students, who could potentially improve their skills for professional development. Meanwhile, another separate aspect of the literature aim towards utilizing Social Robotics for facilitating education and learning, specifically in young children [22, 26]. However, all of the existing studies are limited in scope (focusing on specific courses or topics in a course) and duration (studies undertaken for a limited time duration). In this respect, this research has provided an outline for a novel model for promoting Education-Robotics symbiosis. A number of essential components have been highlighted, along with their benefits towards facilitating symbiosis between Robotics and Education at the different levels of the education sector. Within this model, the role of the different stakeholders (e.g. state-level and national-level policy-makers, local-level educational leadership, class-level teachers, educators and mentors, professional-level technical experts and students) has also been highlighted, which can stress on their varying roles and responsibilities towards enabling and facilitating symbiosis between Education and Robotics.

Since, this research is in its early stages, it is difficult to examine the practical efficacy (in terms of wide-ranging benefits at the individual levels for students and teachers as well as collective-level benefits at the level of educational institutions and the overall education system) of the proposed models and internal components towards promoting merger between Robotics and education at the multiple levels of education system. There will be a need for future studies to examine the effectiveness of interacting and engaging social robots in actual educational settings to evaluate their efficacy and long-term improvements on students' learning outcomes. Due to the wide-ranging national-level variations (for example, schools in Third-World countries cannot afford to acquire social robots such as *Nao* and *Pepper* within their classroom settings) in the level of development of Robotics and STEM-related programs at the different levels of the education systems, there will be a need for modification of the Education-Robotics symbiosis model to provide the maximum benefit to the different stakeholders within the varying regional, cultural, legal, economic, linguistic and educational contexts. Therefore, the future researchers will need to further explore and extend the various aspects of the Education-Robotics symbiosis outlined in this research. In this regard, empirical evidences will be collected and analyzed to reveal the practical effectiveness of the different proposed strategies, which will enable the validation of the different aspects of the proposed model in actual educational settings.

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