Artificial Intelligence-based Totbot Application for Primary School Children

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Abstract

Artificial Intelligence (AI) is one of the fastest-booming technologies in the 21st century, which helps to enhance learning and development of early childhood education (ECE). Previous studies show that AI constantly improves children's skills such as computational thinking, creativity, collaborative inquiry, and so on. The main aim of this paper is to provide a critical analysis of robotics' role in early childhood development and emphasize the importance of STEM (Science, Technology, Engineering, and Mathematics) education. This study investigated (1) available platforms for children to learn AI concepts in a fun way,(2) programming for a young child and connecting with tangible blocks, (3) requirements for making a simple robot for early childhood education (4) finally, challenges and opportunities in the inculcation of AI for young children. For this study, the paper is selected from the past five years and child AI platform websites access are verified recently. From the analysis, these things concluded such as robots in early childhood creating an interest in STEM education, programming skills helping to analyze problem-solving abilities and hands-on training giving a real-life experience, and teamwork skills.

Keywords: Artificial Intelligence (AI), Early Childhood Education(ECE), STEM Education, Computational Thinking (CT), Tangible Blocks.

I. Introduction

In recent decades, AI plays a vital role in education by adapting human needs and innovative technologies, to ameliorate learning skills. The key factor behind AI is Smart work; it improvises the credentials of children to work with automated technology which leads to getting hands-on experience at a young age. For instance, voice assistant Alexa provides a colossal learning environment by transfiguring the learning process of children. Fig 1 shows the evolution of robotic education in early childhood education in the last three years. As a result of this paper, kids of age above 3 can understand the basic concepts of AI. AI in early childhood helps to enhance cognitive skills and improves critical thinking, computational thinking, and assertiveness skills. According to the world education forum, AI for children is based on a child-centric design that can prevent children from cyber risks. Education based on teaching AI concepts to children should be innovative and responsible. The main motive of this world economic forum is to responsibly help children to use AI [19]. According to National Educational Policy 2022, the recent system is based on an adaptable and strategic approach that focuses on basic learning, critical thinking, and social skills. This focus

on access, equity, quality, affordability, and accountability of AI curriculum help children to understand how it works and make decisions [23][24]. The key concepts involved in the curriculum are (1) Rule-based system- in which children and their robots interact in a play way method based on a set of rules, (2) Supervised machine learning makes children experience the classification and prediction concept from the given input data, (3) Generative AI learning makes task-based interaction between the children and the robot using the given data that can be image, text and much more, it can also be further developed through the creative skills of children[3]. This method effectively binds the children with robots to understand the AI concept.

STEM education is a coherent subject learning based on the hands-on learning approach in which Integrated learning concepts include Science, Technology, Education, and Mathematics[2]. STEM education in early childhood helps, enhance the hopefulness toward education. It aims at empowering children to utilize information and to make children engaged with learning which boosts curiosity in innovative learning and enhances the children's skills. Existing curriculum systems are insufficient to teach integrated subjects, teachers may face difficulty in teaching STEM education that's the limitation[6]. Some of the STEM educational robots like KIBO[2][7][17] is a hands-on robotic kits for young children to arouse children's interest in STEM education. Furthermore, Bee-Bot is a programming robot, which uses four-step movements to complete the problem[2]. These robots are accustomed for children from KG to 5 years as a collaborative activity in STEM. This enhances collaboration and creativity. The present stats of STEM in early childhood education are increasing from 17% to 35% for grades 4-6 but still, the research work on STEM is down the road to make it effective. This kind of robot enhances the technical mind by strengthening the children's logic skills.

Computational Thinking (CT) [2] is a lateral way of thinking and a problem-solving approach in a series of steps. Computational thinking in early childhood teaches to solve problems in multiple ways and enhances their learning capabilities. It gives ideal knowledge to children in logically breaking down the large problem and predicts the further process to reach the desired outcome. It enhances the “problem-solving ability” in early childhood [2]. For instance, the STEM-tastic Adventures app assists young children to learn and practice computational thinking skills with two different games: City walk-[2] Children develop a set of instructions to deliver gifts over the town; Better Building-[2] It is a game application, which helps robot friend to build a structure by allowing children to closely observe and arrange the objects by size, color, shape and label the object. In addition, Google launched a free app called Read Along (formerly the Bolo app)[20] is a fun speech-based tutoring app designed for children of age 5 and above. It helps to improve children's reading skills in English and other languages by letting them read stories aloud and it gives stars and badges with a build-in-reading assistant called ”Diya”. Google provides an AI-based platform to enrich their knowledge through AI experiments. Moreover, AI experiment [2] is an open-source collection of simple experiments to explore machine learning through pictures, drawing, language, music, and more. This has a bunch of experiments related to artificial intelligence, virtual reality, Android, etc [2]. Furthermore, PopBot[22] is an intelligent social robot that helps children to learn AI, which uniquely

helps children to learn about AI before they have started to learn complex math and provides a hands-on STEM platform for the AI generation. Provided that robotics in computational thinking is an effective way for children to systematically process the task and step-by-step commands to program a robot [8][11].

The purpose of this paper is as follows:

- Identifying the significance of using educational robots in early childhood education.
- Find out the challenges and opportunities of using AI and educational robots as learning aid.
- Present the synthesis of ideas to bind the children in AI concept-based learning.

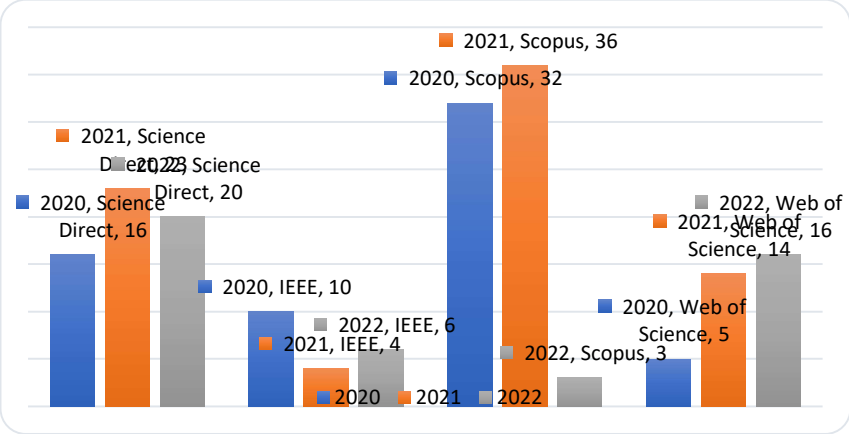


Fig 1. Robotics in Early Childhood Education

This paper is organized as follows: Section 2 describes AI sites for children to learn AI concepts, Section 3 summaries the visual programming language for young children, Section 4 describes the requirements for designing robotic kits for children, section 5 describes the challenges and opportunities in AI robotic curriculum, and finally section 6 summaries the overall analysis of robotics in early childhood education.

II. AI for Children

AI plays a vital role in developing children's skill levels to adapt to the rapidly changing digital world. Most children are growing with AI around them, from learning platforms to gaming platforms. Teaching AI to children from a young age can help them to develop their problem-solving skills, and critical thinking, and adapt to changes in the environment[2]. This increases concentration and boosts the imagination. Learning AI at a young age broadens their thoughts in a proper way.

Computational Thinking is also known as algorithmic thinking which works based on constructivist learning theory and allows children to develop their learning skills through interaction and experience in a social environment. The key concepts in the Computational Thinking process are (1) Decomposition: which breaks down an enormous problem into smaller parts, (2) Pattern Recognition: which finds the regularities in the problem, (3) Abstraction: which helps to extract the useful key points and (4) Algorithms: is used in solving the problems in a step-by-step method to solve the problem. Those concepts root for the children to solve the problem by simplifying it. Fig 2 shows the computational thinking process flow.

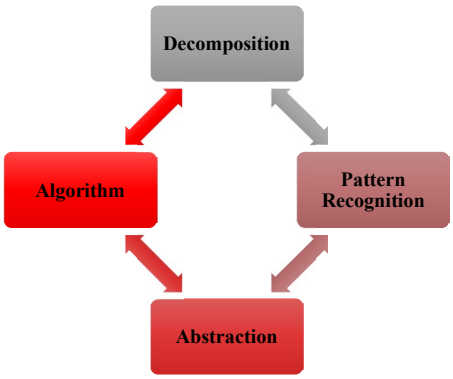


Fig 2. Computational Thinking Process

The following websites help to develop the children's skills and the basic AI concept in a fun way. **Machine learning for kids** [12] is an online platform, which works by providing Hands on experience on simple machine learning concepts. Machine learning in early childhood displays essential challenges such as what, why, and how? [3] This makes children secure essential machine learning concepts. These sites consist of three basic blocks used to train learn and test and make a project. Moreover, the worksheet includes several Al project concepts and contains pre-trained models to make real-world projects. The objective of Machine Learning for Kids is to assist young children to learn about artificial intelligence and machine learning concepts.

AI adventures and AI creators: is an online program for students of 2nd to 5th grade or any elementary school children intrigued in learning and exploring the essential logic of AI. This online program carries 10 sessions divided into several modules which consist of mindset development exercises, creative paper-based coding, fun block-based programming, project-based team, and hack-a-thons. The main objectives of AI adventures and AI creators are to develop computational and algorithmic thinking. The AI creators' program is for students from 5th to 7th grade. This is a 25-hour online program. Students build AI apps using Block based programming tools like Scratch and Thinkable, and machine learning tools like Google's Teachable Machine.

Experiments with Google [21] are a collection of amazing experiments using Chrome, Android, AI, AR, etc; this site collects projects along with tools and resources, to arouse others to create innovative projects. The main objective is to create children's own experiments and explore the resources. In addition, Google has put together tons of exercises and resources to help kids learn about AI. Some of the examples are(1) A teachable Machine is an easy way to create machine learning models,(2) Quickdraw helps with machine learning research, and (3)Sketch-RNN Demos make you draw along with the neural network.

Cognimates: An AI education platform for building games, programming robots, and training AI models. The most objective of the Cognimates platform is to elongate coding to AI education and literacy. This consists of three phases: (1)play with a pre-Trained Model (2)train your own Text Model (3) use your Text Model in a Project. Additionally, it includes sample projects to make children arouse their own projects. This also includes research projects (e.g.:Envisioning AI for K-12 - What should every child know about AI?).

AI 4 children: is introduced to teach kids artificial intelligence using a widely used programming language from scratch with AI machine learning teaching tools from Dalton Learning Lab, which gives learning opportunities for the children to interact and understand AI concepts [1].

These kinds of online learning platforms help young children to learn with already trained data and project-based

learning on the children's age and the capability of knowledge consumption. The main goal of this platform is to enrich the children's cognitive skills by means of learning multitudinous programming skills.

III. Coding in Early Childhood

Programming is a momentous skill that every child remains aware of in the recent era. Children begin to code using simple visual programming tools that allow them to construct programs with pre-build blocks of code. Educational coding programs are particularly designed to educate programming skills to young children in a fun and lively way. Coding in early childhood helps to develop a healthy expression of creativity and abstract thinking, which gives children a multi-dimensional view of solving problems. Programming education for children believes make progress in multitudinous skills, this contributes to their future accomplishments (See Fig 3).

ScratchJr[2] is a visual programming language developed to offer programming skills to children of ages 5-7. Children can program their own interactive stories and games, and learn to illuminate problems, design, and express themselves imaginatively on the computer. On the other hand, Code.org is an eponymous website that points to empowering children to learn computer science. To start a new project, this website provides various tips and demo projects to engage children effectively in learning and also the Hands-on training. Blocky[2] is a visual code editor, which consists of interlocking, graphical blocks to describe the code concepts like variables, logical expressions, loops, and more. The resources provided to the developers are plug-ins- a detached piece of code to add fields, define themes, and more; In addition Codelabs- is a step-by-step instruction on how to utilize and customize Blocky. The main motive of these websites is to "build the logical skills of children in a play way method based interaction ".

(a) Scratch Jr (b) Code.org

Fig 3. Visual programming Language Blocks

Coding with an object is an effective way to enhance skill-based learning (See Fig 4). This makes STEM education simple and fun to learn. Coding with an object simply implies the coding robots, which brings up the IQ level of little children to a predominant level. This offers the most advanced individual learning opportunities but still shows up to be a fun contraption for children.

Some of the fascinating robots used in education like KIBO-[16][17] KinderLab Robotics is a block-based tool that helps to

teach STEM, basic coding, and building robotics to children of age 4 to 7. It offers a creative coding and robotic system that effectively arouses interest in children for physical control of objects. The key ideas used to teach by adding and subtracting blocks and commands to make activities. Next, Bee-Bot[16] is a Bee-shaped robot, which is used for children above the age of 3. It teaches kids to learn about controls, directions, sequences, and algorithms with basic programming tools, then wonder Workshop works with Dash to design the behaviors and interactions and Dot used for coding. This is used by children of age above 6. Children can effortlessly make their own real-world gadgets and robots, by giving a stepwise advancement to the world of robotics. LEGO-WeDo 2.0-[2] is a Hand on STEM solution, which is a combination of a LEGO brick classroom-friendly computer program, it motivates standard-based projects and a discovery-based approach. Cubetto- is a robot that teaches a kid to code, this is used by children aged 3 years to 9 years. In the coding block on the control board, kids coordinate Cubetto's movements. The main goal is to enhance creative skills. Max and Tobo – is a combination of robotics and coding with storytelling and game mechanics. This is accessed by children aged 6 years to 9 years. The robot moves and interacts based on the children's creativity which makes children explore their creativity. Cubelets are used by children above the age of 4 years, and work on three basic categories namely Sense; Think; Act. It provides a friendly environment, and these are the building blocks for better thinkers. These blocks are mainly used to enhance creative thinking. Edison – Robot designed to enhance STEM teaching resources. This is for kids the age of 6 to 16 years. Edison is based on simple barcode programs. Children can learn different programming languages as their skill improves. Cubelets provide an engaging and enjoyable coding education.

(a) KIBO (b) Bee-bot (c) LEGO WeDo 2.0 (d) Cubetto (e) Cubelets

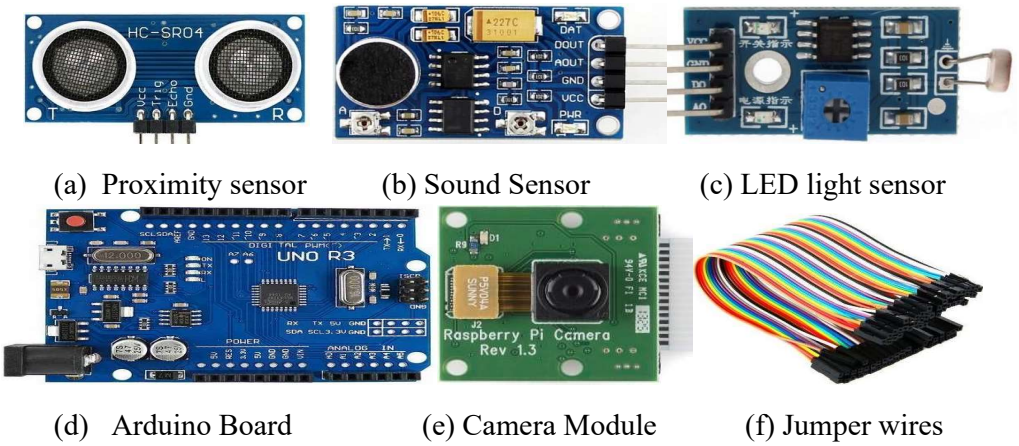
Fig 4. Tangible coding robotic kit for Early Childhood Education

IV. Robot construction for Children

A. Hardware

The sensors used in educational robotics stimulate curiosity in new learning environments and hands-on practices for children. Using sensors in robots, it is easy to make movements and indulge the children in lively interaction. Sensors within the robot work based on the human sensory organ [9]. Robotics requires necessary sensors to control themselves in the learning environment. Some of the sensors mentioned [10] (See Fig 5), (1) Proximity sensor module: It detects the object using ultrasonic waves, and helps in obstacle avoidance; (2) Sound sensor: It is an acoustic sensor that helps in detecting sound signals like voice, clap, etc; (3) LED light sensor: It detects the light and the robot's vision system has a computer-controlled camera, helps the robot to make adjustments in movements; (4) Arduino Board: It helps to read the inputs based on the sensor and to control the electronic devices used; (5) Camera module

is used to take High-definition video and the photographs; (6) Jumper wires: It is used to connect the two points without soldering, easy to reconfigure the connections.



(a) Proximity sensor (b) Sound Sensor (c) LED light sensor

(d) Arduino Board (e) Camera Module (f) Jumper wires

Fig 5. Common hardware parts inside the robotic kit

B. Educational Robots

Educational robots help to develop problem-solving skills and teach to look up the problem from many perspectives. Some of the educational robots are mentioned [14][2](See fig 6): (a) Keepon is a simple social robot designed to help children with Autism. It primarily plays a vital role in aiding children with Autism. This comprises two factors: attentive action and emotive action. Keepon is designed with audio, visual, motion, and force sensors to effectively process the rhythmic information from the environment. It is integrated with a beat detection algorithm to isolate rhythms in music. Keepon's simple appearance proved to be adaptable enough to grasp mentally its emotions and interactions easily. (b) Kasper is a child-sized humanoid bot that helps to enhance the lives of children with autism. Kasper has the least facial expressions so as not to overwhelm the children on the autistic spectrum. It acts as a social mediator for aiding the children to communicate and express their emotions [5]. It helps to prevent children from social isolation. Enhances collaborative skills by tactic interaction in the environment and also develops an immense understanding of social cues [13]. (c) Zeno is a humanoid robot, having advanced facial expressions in comparison with the Kasper bot. It is ideally used for therapies focused on emotion and social interaction. Zeno robot speaks 26 languages and has a touch display to control the robotic movements. It enhances concentration and cognitive skills by means of more social interaction with Zeno. Reduces stress and helps autistic children to aid and learn social skills. (d) NaO [15][16] robots lend a hand as a teaching aid for children for the betterment of knowledge. It makes children connect with hands-on projects, and integrated works and encourages problem-solving capability. This is also called "Multipurpose Robot ", and acts as a classroom companion and the autism spectrum disorder (ASD) therapy assistant. (e) Jibo Robot is a social robot designed to engage with interactively play scenarios to help children learn fundamental social cognitive skills. It acts as an intelligent personal assistant and is able to perform fascinating movements, interact with people and easily recognize faces. This enhances the creation and character-rich skills.

(a) Keepon (b) Kasper (c) Zeno (d) Nao (e) Jibo

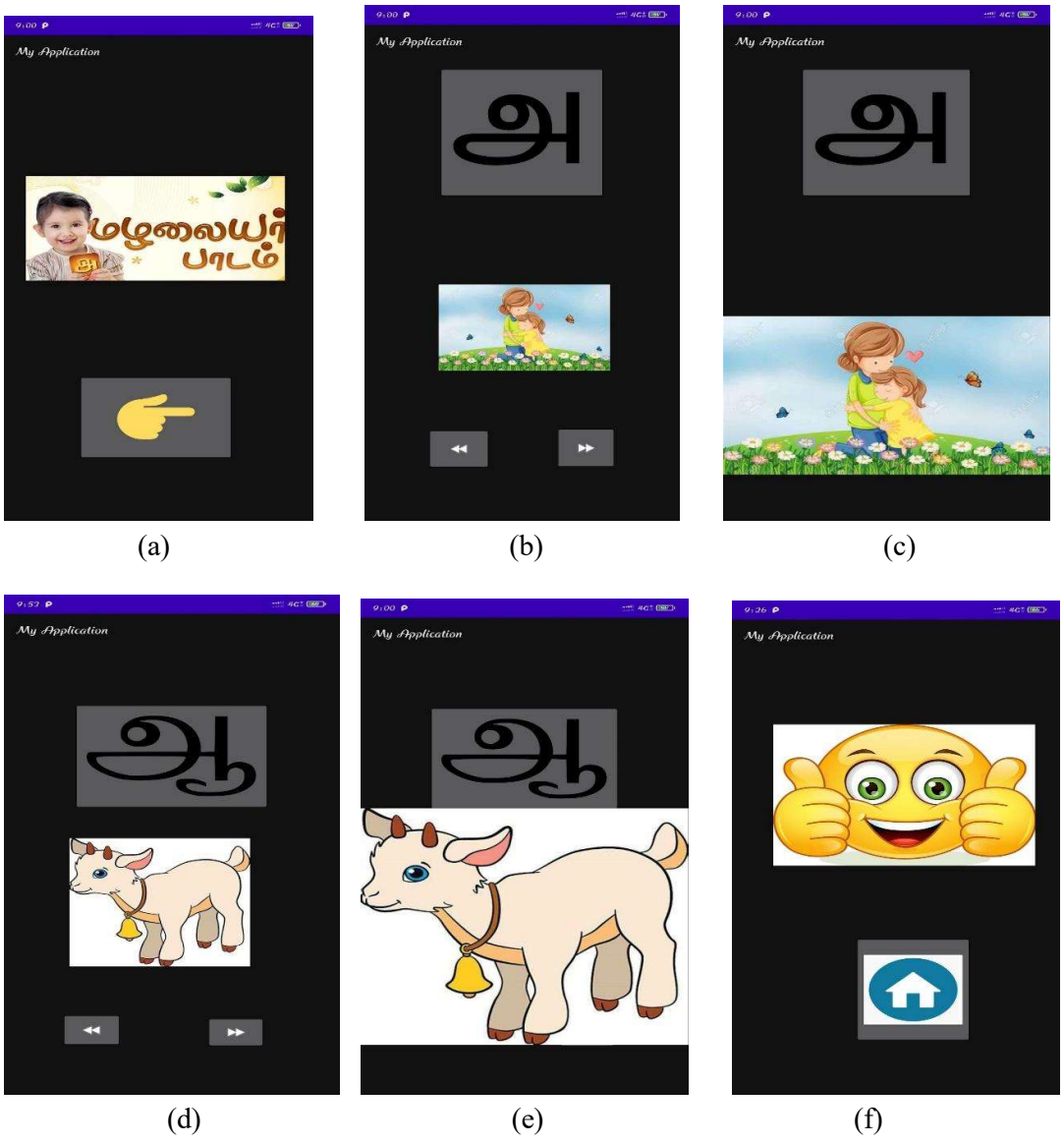
Fig 6. Educational robot for Early Childhood Children

C. Testbed

The paper proposes a sample test application called Totbot App, which is developed using the Android app. This software can be easily installed on any operating system (Windows, Linux, and Mac). The combination of education with the digital platform effectively preoccupies children with developing skills. In most cases, the children would lack interest in a bookish learning environment; to overcome the challenge the "Totbot App" is developed. Totbot is a human-centered computing app, which is a tactile-based and voice-based learning app for children in grades K-3

Fig.7 Tamil Vowels

Typically, a technology-based approach is used to enhance the children's cognitive skills, which is a simple and effective app for the children to easily upgrade their learning skills. Fig 7 shows the Tamil vowels(uyir eluthukkal). As a pilot study, a learning mobile application is designed and developed for primary school children. It is a Tamil language voice-based app consisting of an image button and an image view. Additionally, the two buttons are designed to go to the next page and the previous page. The sample results are illustrated in Fig 8. Fig 8. (a) shows the homepage of the app, Fig. 8 (b)shows the Tamil vowels(uyir eluthukkal) first letter with the corresponding word, Fig.8 (c) shows the toasted image of the word with voice, Fig.8 (d) shows the second letter with an image view, Fig.8 (e) shows the toasted image of the second letter with the voice and Fig 8. (f) shows the end page with a button to go to the homepage. This pilot study used a few Tamil letters and their corresponding word with voice. As a result, Tamil vowels(Uyir eluthukkal) are illustrated by setting up the toasted image and the vowel sound, when the image button is clicked.



(a) (b) (c)

(d) (e) (f)

Fig.8 Sample test App

V. Challenges and opportunities

The way people teach and learn continuously changes in the developing digital world. AI can give a run to bind with developing technologies. Artificial intelligence (AI) for early childhood brings a number of significance and also limitations [6]. This brings colossal growth on both sides by providing the unities and also the risk. The existing curricula focus on implying bookish knowledge and giving less importance to the practical part and the implementation of concepts, which leads to the nullification of children's abilities and creativity. In addition, effective software design for children's education is a major challenge. The benefits of AI and robotics in early childhood improvise the educational outcome of a child. It helps to explore and analyze the kid's creative capability and problem-solving capacity[2]. This enhances the confidence in learning concepts based on their preferences, leading to a boost in the level of education [4]. AI in early childhood also improvises the

children's cognitive skills and ideally accelerates the learning speed. Early childhood education can help in STEM education by means of adaptive learning and encourages facing the future with courage [18].

The use of AI in early childhood education may reduce human interaction and the information collected can be hacked by hackers. Children exploring the various third parties for learning would lead to malicious parties threatening the child's privacy[19]. AI education comes with a high cost, and students in the poverty line cannot access it. Teachers with no prior knowledge of STEM education would feel difficulty in teaching the children. In order to overcome these limitations, designing safe open source websites with advanced technology and introducing educators to the right curriculum to use STEM education effectively for the children.

VI. Conclusion and Future works

Artificial Intelligence and robotics in early childhood education play a salient role in the recent era. This paper intensely reviewed the significance of critical thinking, cognitive skills, programming robotics, kids, and the good practice of STEM education.

The hands-on practice with the Tangible blocks and the visual block-based coding essentially enhances the children's basic programming skills and leads to strengthening their problem-solving capability. The analysis of the recent five years paper for Artificial intelligence and robotics in early childhood concluded that AI in early childhood mounts with the research work towards enhancing the educational robots and rooting the children to learn basic artificial intelligence concepts by mainly focusing on their cognitive thinking and project-based learning. There is emerging research needed for engaging children in learning based on their native language. The existing apps used for early childhood education are not in the native language, which makes children nonchalant with learning. In the future, to overcome this difficulty, developing a native language-based app can effectively bind the children in learning and make betterment for understanding.

Acknowledgment

The presented study has conducted with the support of the Centre for Machine Learning and Intelligence (CMLI) funded by the Department of Science and Technology (DST)-CURIE-AI.

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