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# The Bloom's Taxonomy Proposed: Teaching Educational Robotics at the Elementary and Secondary Levels

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## ABSTRACT

Learning is a complex and vital process that involves not only memorizing knowledge, but also the ability to identify and understand patterns. Educators engage a range of instructional strategies to facilitate the process, including visual aids, hands-on activities, and collaborative learning experiences. Bloom's research significantly contributed to the understanding of teaching methodology by focusing on such questions: What do students need to know? How can it be taught effectively? And at what stage should this knowledge be imparted? This approach emphasized the importance of cognitive processes over basic content, education methods. It is essential to focus on Bloom's Taxonomy for teaching Educational Robotics (ER). The study aims to highlight this comprehensive taxonomy grounded in learning outcomes. This taxonomy seeks to categorize knowledge and skills essential for students engaged. It also outlines the stage of learning that can enhance learning abilities. The study findings are expected to make a valuable contribution to existing research and enrich both theoretical and practical dimensions. It also emphasizes that Bloom's Taxonomy can aid in understanding how it can be effectively taught and assessed among elementary and secondary school students.
**Keywords**: Educational robotics; bloom's taxonomy; school education; learning

## INTRODUCTION

Learning is a complex and vital process that involves not only memorizing knowledge, but also the ability to identify and understand patterns. Educators engage a range of instructional strategies to facilitate the process, including visual aids, hands-on activities, and collaborative learning experiences. There is a strong emphasis on facilitating learners' accurate identification of existing knowledge and supporting acquisition of new information (Sisson & Mazzuchi, 2019). The learning is crucial for the development of individuals, communities, and societies. However, this pursuit has its share of potential opportunities and challenges, often exacerbated by frequent disruptions. The increased prevalence of digitalization has significantly broadened and presented new possibilities in the field of education (Jauhiainen & Guerra, 2023).

Several educational institutions use a passive approach for learning. Educators should use an active learning strategy to provide a more in-depth and meaningful learning experience. This technique aims to engage students at higher which can increase their interest and engagement with comprehension of the course material. In contrast, critical pedagogy has focused on empowering students to become agents of social change for greater equity and justice (Tabrizi & Rideout, 2017). It is common to tailor teaching methods based on students' learning styles, usually categorized as auditory, visual, and kinesthetic. This approach believed to enhance learning outcomes. For instance, it is generally thought that learners remember information better when it is represented visually. However, its widespread acceptance and effectiveness. Many studies have raised questions about its validity, and there is a lack of empirical evidence to support it. (Ali et al., 2022).

Ability to ask questions fueled by curiosity significantly enhances learning processes. Curiosity is the desire to know, see, or experience that stimulates exploratory behavior aimed at new information. This curiosity is a fundamental aspect of positive influence in learning experiences and ultimately contributing to favorable outcomes (Abdelghani et al., 2024). Learning activities can enhance students' cognitive ability, problem-solving skills, and creativity. Such activities cultivate a dynamic and captivating learning atmosphere that enables students to advance throughout most of the levels of Bloom's taxonomy. Experimental learning activities provide a distinctive opportunity for students to learn and develop (Waheed et al., 2021). Bloom's research determined, what students need to learn, how to teach them effectively, and when it should be taught, rather than focusing solely on the content, methods, and timing of teaching. The curriculum's objectives should dictate what, how, and when to teach. In several educational areas, accomplishing a goal necessitates understanding it first and striving to achieve it. The approach prioritizes results (Rule & Lord, 2003). Many young learners struggling with effectively use learning strategies, particularly ones that require prior knowledge. They may have trouble applying these strategies independently because the lack of basic knowledge. This problem is known as mediation deficit. Also, younger children may not benefit as much as older children or adults from using effective learning strategies independently, which is called utilization deficiency (Brod, 2021).

Robot-assisted STEM teaching has been beneficial in a variety of scenarios. The scenarios-based approach involves creating associated curriculum objectives or promoting the development of 21st-century skills such as collaboration, creativity, critical thinking, and computational thinking skills. In Scenario-Based Learning (SBL), students take on additional responsibility during the learning process. It is suggested that such robotics applications can help students develop cognitive and psychomotor traits such as creativity, multidimensional thinking, acritical thinking, and analytical thinking (DEMİR KAÇAN & KAÇAN, 2022). Robotics education is a Project-Based Learning (PBL) activity that combines math, science, and technology, providing significant benefits across all levels of education. Many studies have discussed the advantages of using robots in education. (Binugroho et al., 2014). It is a valuable framework used for categorizing educational goals. It helps students to understand multidisciplinary concepts, apply knowledge in real-life scenarios, and enhance their confidence in the classroom environment (Gummineni, 2020).

The study highlights the potential of research in ER, offering valuable insights for researchers and teachers and guiding future directions in this field. The study suggests that Bloom's taxonomy is worthy for teaching ER to elementary and secondary school students. Furthermore, future research should include a more comprehensive analysis of this field.

## LITERATURE REVIEW

Technological revolution that began in the early 20th century. This revolution has influenced diverse fields, for instance, business, social, health, and education. The information technologies fusion in education has led significant changes in teaching and learning processes. Teachers must embrace new tools to facilitate creative, collaborative, and active learning. different approaches and tools such as robotics, can modernize daily teaching and learning practice (López-Belmonte et al., 2021). Integration of ER robotics encompasses many elements that contribute to students' development, such as fostering logical thinking, enhancing psychomotor skills, and improving spatial perception. Additionally, it promotes students' autonomy through Project-Based Learning (PBL), fostering creativity, encouraging research, and facilitating a better understanding of the digital world (Munzenmaier & Rubin, 2013).

The conceptual framework is based on important educational theories and ideas, that integrate knowledge across multi disciplines to enhance learning outcomes. This framework is centered around situated cognition, which suggests that learning is most successful in real-world contexts. This concept advocates for an interdisciplinary approach, asserting that students understand and apply STEM principles in more appropriate way, when they engage in relevant activities that simulate real-world situations. This multidisciplinary education combines science, technology, engineering, and mathematics strength to offer a comprehensive learning experience. By integrating these disciplines, educators aim to equip students with the skills and knowledge necessary to address complex challenges that often require a multifaceted approach (Olatunbosun Bartholomew Joseph & Nwankwo Charles Uzondu, 2024).

In many classrooms, most students are physically present but mentally absent. About 40% of students do not put sufficient effort and pay attention to their studies, schools often use education tailored to students' learning styles, focusing on auditory, visual, and kinesthetic learning. The theories of multiple intelligences, Vygotsky's social learning, the zone of proximal development, and brain research all support differentiated instruction and assessment (Ali et al., 2022).

A game inspired by Kolb's learning model, that integrates angles (math), Blocky (visual programming), to engage primary and secondary school students.it can help to achieve the curriculum through hands-on activities, and align with games (Zainal et al., 2018). It is important to recognize learning styles to teach effectively. Different learning styles lead to different outcomes for learners. In this study, researchers investigated how teaching methods, learning styles, and students' achievements relate to the first three levels (Knowledge, Comprehension, and Application) of Bloom's taxonomy. They also incorporated unique differentiated teaching interventions and examined Kolb's learning style (Ali et al., 2022). Educational robots and block programming both significantly aiding learners in enhancing their STEM skills (Karaahmetoğlu & Korkmaz, 2019).

Project-Based Learning (PBL) and Problem-Based Learning (PBL) are commonly recognized effective teaching approaches for science education. These methods enhance students' skills, including independent learning, problem-solving, creativity, metacognition, and teamwork. In a PBL environment, students actively engage in real-world assignments through design and problem-solving while applying their mathematics, physics, and programming knowledge (Barak & Assal, 2018). Even though traditional programming languages like Basic or Pascal are challenging for young learners. The NXT-G environment makes programming easy to understand with its drag-and-drop Block design. Numerous robotics studies have aimed to evaluate the impact of these hands-on activities on young learners. The coaching provides hints, and feedback, redirects students. Without coaching, the path ahead is unclear. Challenges in these activities keep things interesting and spark the urge to find solutions (Ucgul & Cagiltay, 2014).

It is important to improve coaching strategies that effectively support students' learning. The FIRST Lego League (FLL) challenges promote a project-based learning approach. This approach encourages students to tackle real-world problems and motivates teamwork, critical thinking, and creativity. Research on the influence of coaches' skills and pedagogical experiences on students' learning and skills development in the FLL challenge is an area that may be underrepresented (Graffin et al., 2022). If the problems given to learners are too well-structured, closed-ended, simple, abstract, or unrealistic, then little learning is obtained. Students may be busy with only a small assignment. The concept of a roof without walls is used to characterize the desire to acquire higher-order thinking skills according to Bloom's taxonomy in youngsters who have not studied facts or obtained substantive knowledge in a certain subject (Barak & Assal, 2018).

**Bloom's Taxonomy**

The Bloom educational taxonomy created by Benjamin Bloom, contains six levels, knowledge, comprehension, application, analysis, synthesis, and evaluation. Each level is explicitly defined and organized hierarchically based on cognitive complexity. Bloom's revised taxonomy of Educational Objectives can serve as a model for elementary school knowledge management education and other educational requirements, such as STEM. Regarding knowledge management, we can enhance the objective-based approach to education by adding competencies for those objectives. We can utilize a pedagogical framework, which includes planning, scheduling, preparation, teaching strategies, content knowledge, problem-solving, classroom management, questioning, implementation, assessment, and feedback (Sisson & Mazzuchi, 2019).

**Revised Bloom's Taxonomy**

The original taxonomy revised to refine the levels as Remember, Understand, Apply, Analyze, Evaluate and Create. This updated structure better aligns with current educational practices and highlights the importance of various cognitive levels to foster deeper learning, critical thinking, and problem-solving (Waheed et al., 2021). This modern taxonomy responds to emerging educational needs, such as digital literacy, collaborative learning, and creative problem-solving, which are increasingly important. It shifts the focus from static knowledge acquisition to dynamic skill development, emphasizing adaptability, and innovation in learning. These changes aim to better equip educators in designing curricula and assessments that promote real-world readiness and lifelong learning (Aripin et al., 2020).

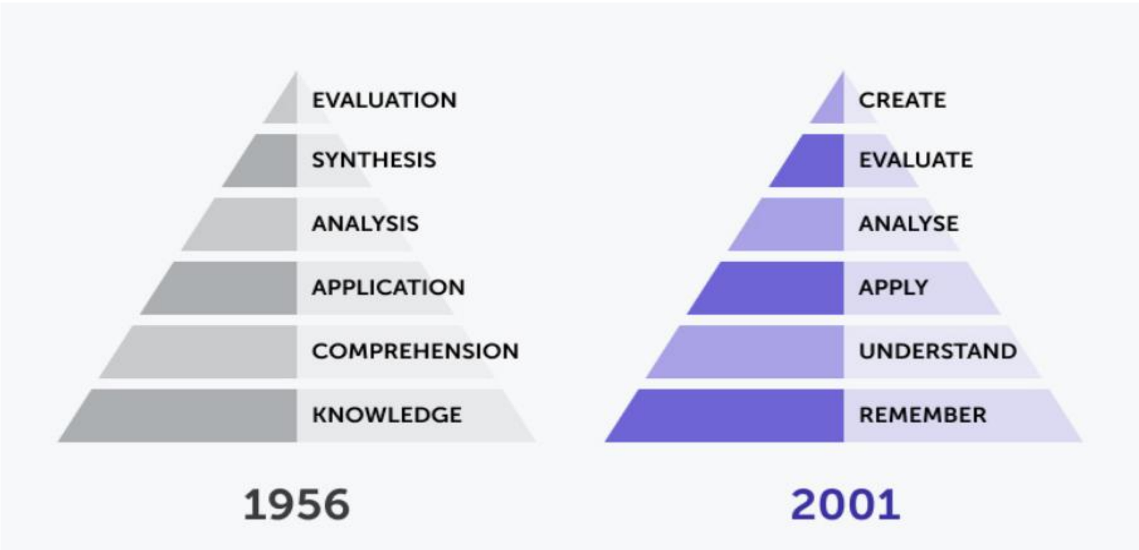


Figure 1 *The Bloom Taxonomy and Revised Bloom Taxonomy*

**Changes in Bloom Taxonomy**

There is a significant difference between the original version and the revised. The original taxonomy included levels of Knowledge, Comprehension, Application, Analysis, Synthesis, and evaluation. The revised draft, these levels have been transformed into Remembering, Understanding, Applying, Analyzing, Evaluation, and Creating (Munzenmaier & Rubin, 2013). This change is depicted in Figure 1, demonstrating the differences between Bloom's original taxonomy and the revised Bloom's taxonomy. The source of the figure is **https://www.valamis.com/hub/bloom-taxonomy**

## METHODOLOGY

**Study Objective and Material**

The objective of the study is to highlight the importance of Bloom's taxonomy for the instructions of ER at both elementary and secondary education level. For this, we selected relevant articles published between 2014 to 2024. Additionally, we will demonstrate how Bloom's Taxonomy effectively serves as a framework for enhancing the educational outcomes associated with teaching and learning ER. To collect related material, we employed Google Scholar. This approach enables to us obtain a diverse selection of scholarly articles. We carefully crafted a set of keywords ("Bloom Taxonomy" AND "Educational Robots" OR "robots" AND "learning" AND elementary and secondary education" OR "school education") to conduct a thorough search on this topic.

## RESULTS AND DISCUSSIONS

Elementary and secondary school students can enhance their technology proficiency, subject area knowledge, problem-solving abilities, and computational thinking skills with ER. Integration of ER into the curriculum can positively impact students by fostering a learner-centered approach. It offers unique learning experiences. ER improves students' technological skills. It enhances the educational environment, making more engaging and effective. The robotics in education has numerous benefits, outweighing any potential drawbacks, and plays a significant role in shaping learning experiences. It significantly enhances experiences and skills across various subject areas. In science, ER helps to conduct experiments, demonstrate scientific concepts, and engage students in hands-on learning experiences related to different scientific fields. For instance, students can build robots to explore scientific principles and phenomena, enhancing their learning in science (Cooper, 2023).

Young learners can engage in interactive activities that involve designing, constructing, and programming a robot to complete physical tasks such as navigating, an obstacle course, picking up objects, or following a designed path. This task requires students to manipulate the robot's physical components, such as motors and sensors, to achieve the desired results. This process enhances psychomotor and logical skills through practical application and experimentation (López-Belmonte et al., 2021). The Bloom Taxonomy, categorized educational objectives into three domains: 1. Cognitive (knowledge-based), 2. Affective (attitude or emotional-based), and 3. Psychomotor (skill-based). This taxonomy was developed to promote higher forms of thinking in education, such as analyzing, evaluating, and creating rather than just remembering facts. It was the result of collaborative work and has a significant impact on learning and teaching practice. Educators widely accepted and embraced Bloom's taxonomy and its positive effect on student learning (Sisson & Mazzuchi, 2019).

Robotics is an of technology. It creates programming skills, hardware comprehension, and the creation of robotic systems. It can improve digital literacy and prepare students for upcoming technological challenges. Educational robots provide a practical platform to apply engineering principles. It can help to design and build robots for solving engineering challenges and understand the design process. It is a valuable tool for teaching mathematical concepts such as geometry, algebra, and trigonometry. By programming robots, students can learn to solve equations, perform calculations, and visualize mathematical problems more effectively (Xia & Zhong, 2018). Additionally, ER offers a practical experience to learning computer science concepts such as coding and computational thinking. Students can write code to control robots, develop algorithms, and troubleshoot programming errors, enhancing problem-solving skills. Integrating ER into various subject areas can also create interdisciplinary learning experiences that foster creativity, and collaboration among students.

In this modern world, classrooms have an increasingly diverse student population, including individuals from various language, cultural, geographical, and socioeconomic backgrounds. This diversity underscores the need, to shift toward more learner-centered education, supported by adequate resources. A learner-centered education system necessitates that educator draw upon their expertise and available resources to understand how each student learns and actively participates in diverse cultural settings.

STEM evolved into a global movement, transcending local boundaries. There is a pressing need to revolutionize STEM education in Schools by integrating it into mainstream curricula and leveraging innovative teaching techniques. This shift aims to transform traditional instructional approaches, fostering a more interactive and engaging learning environment. Educators, policymakers, business and industry leaders emphasize the importance of STEM skills to address present and future societal and economic challenges (Bidita, 2024).

STEM education combines knowledge from multiple disciplines. This approach enables students to develop various skills. It is highly regarded globally as a way for countries to showcase their commitment to educational reform. However, a significant challenge in implementing STEM education is the shortage of highly qualified STEM teachers. This stage presents a novel theoretical framework from the perspective of teachers' identity transformation and development. A dynamic and progressive process, created through the interaction of personal and professional characteristics with new educational experiences, the identity of a teacher (Mao et al., 2024).

Encouraging teachers of STEM-related subjects to transition into integrated STEM education is a crucial strategy for increasing the number of STEM teachers. Considerable research has been conducted on this topic, primarily by providing professional development programs for STEM educators, however, it remains a point of contention whether short-term programs for training teachers can successfully furnish long-term support, for their development. The complexity of teachers' professional abilities, including educational beliefs, professional knowledge, and teaching skills, among other factors, is the main reason for this issue. This poses a challenge for short-term training programs, which may struggle to address all aspects adequately.

Bloom created opportunities for educators and curricula developers to clear it further by explaining its stages, he did not set any restricted criteria (e.eg., age, gender, or any specific subject) for learning. Bloom's taxonomy is neither a single person's work nor a small teamwork outcome; it is the participation of a huge group (more than one thousand) of educators and teachers. Initially, it was used for teaching. Bloom is widely recognized as a founder of the taxonomy, it is important to note that the framework's significance lies in its support of cognitive skill development, which is fundamental to the learning process. Without cognitive engagement, learners would struggle, to effectively utilize the psychomotor domain and implement practical skills. Teachers used this taxonomy for teaching, assigning tasks, and defining learning objectives: what to teach, how to educate, and what should be outcomes. But Bloom is most famous not just as a founder, there is also a reason that cognitive skill is basic for learning. If the learner is not engaged in cognition, how does he/she utilize effective domain and implement Psychomotor skills?

ER is a tool for understanding STEM discipline and enhancing 21st-century skill-set (Bano et al, 2024). Bloom's taxonomy is appropriate for implementing ER activities. For example, Bloom has 3 domains:1. Cognitive (knowledge-based), 2. Affective (attitude, or emotional-based), and 3. Psychomotor (skills-based). There is a need to consider these 3 main key points working together. Robotics requires three domains to be involved in this field, cognitive memory knowledge, motivation needed after failure to analyze to make it better, and, attitude improvement for learning more, working in a team helps to find many solutions and divide them into parts, and this process enhances communication skills, teamwork and social skills. Hands-on activities also overcome diversity and build attitudes towards learning technology on equity. The Cognitive and Affective domains have handbooks to guide and understand, but the third domain psychomotor needs more attention, for adapting hands-on learning patterns, because there was no handbook for this domain till 1970 (Munzenmaier & Rubin, 2013). Educators and researchers should consider the importance of this domain.

The current curricula concepts, such as Project-Based Learning, Problem-Based Learning (PBL), and Inquiry-Based Learning (IBL), prioritize real-world applicability and student interaction. Effective design methods like hands-on activities, cross-disciplinary collaboration, and technical integration improve learning outcomes. The study found number of institutional difficulties, including resistance to change, limited resources, and the need of professional development (Olatunbosun Bartholomew Joseph & Nwankwo Charles Uzondu, 2024).

In STEM education, pedagogy in engaging students through IBL and PBL play a crucial role. Teachers need to receive professional development to ensure the effective implementation of these pedagogical approaches. Students' diverse backgrounds and experiences, including cultural and linguistic diversity, which is crucial for fostering inclusively and equity in STEM education (Riduan & Othman, 2024). Educational robotic kits help learners to learn computational thinking, problem-solving, programming, and engineering skills. This teaching style is gaining popularity in many school curricula worldwide. STEM educators believe that teaching robotics, building, and programming is excellent for teaching robotics, engineering, and computational thinking. It also helps students develop many skills such as teamwork, collaboration, creativity, and project management (Chaudhary et al., 2016).

Children learn ER by building and programming robots using sensors, motors, and other components through play, group challenges, and hands-on activities. ER has its origins in both constructivist and constructionist learning theories. It is a multidisciplinary approach that includes designing algorithms, and mechanical structures, building and operating robots and robotics kits, and application engineering, mathematics, physics principles, and other science subjects(Papadakis, 2020). Scenario-based learning (SBL) brings real-world situations into the classroom, allowing students to consider a problem, and apply their knowledge and skills. Students engaged in SBL are involved in higher-level thinking processes such as analysis, synthesis, and assessment. This approach emphasizes the analysis, synthesis, and application processes in Bloom's Taxonomy. Teaching STEM subjects by using robots have been successful in various settings. Incorporating robotics into education can improve students' cognitive and psychomotor skills, including creativity, multidimensional thinking, critical thinking, analytical thinking, problem-solving, and 21st-century skills (DEMİR KAÇAN & KAÇAN, 2022).

One effective way to develop and refine the psychomotor skills of their students is through the introduction of hands-on activities with physical robots in classroom. The experimental learning approach helps build practical skills and knowledge and fosters creativity (Binugroho et al., 2014; Waheed et al., 2021).

## CONCLUSION

The study results concluded that participating in experimental learning activities effectively targets the psychomotor level in Bloom's Taxonomy. These activities involve hands-on experiences that allow learners to apply their knowledge, skills, and abilities in real-world scenarios and acquire practical knowledge. By doing so, learners can develop skills, such as accreditation and perception. Therefore, incorporating hands-on activities in educational programs can promote the acquisition of psychomotor skills. After reviewing various studies, we highlight three key stages of learning. This Bloom's taxonomy can enhance ER outcomes at elementary and secondary levels by effectively integrating the principles of experiential learning. It is necessary for educators to plan carefully for executing such strategies. It is important to acknowledge that Bloom's taxonomy is a foundational framework in contemporary experiential learning practices.

**Recommendations**

The study brought attention to several other significant points for educators and researchers. Bloom's taxonomy three stages are most beneficial to teach ER at elementary and secondary school levels. This learning taxonomy help to teach ER in more effective way in schools. The study also provided insight into the significance of Bloom's three key stages in learning digital skills. It is anticipated that Bloom's taxonomy may contribute to teach ER for skills required in future. Educators and stakeholders are actively considering potential of ER, so further investigation is necessary to understand the impact of this Bloom's taxonomy in learning practices. The study aims to offer valuable guidance to educators and researchers in educational field.

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