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ORIGINAL

Tinkercad and mBlock: Tools for Educational Robotics and Coding Learning A Case of Ghandi Primary school Morocco

Tinkercad y mBlock: Herramientas para la robótica educativa y el aprendizaje de la programación — Un caso de la Escuela Primaria Ghandi, Marruecos

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ABSTRACT

This study explores the impact of Tinkercad and mBlock on the en gagement and computational thinking skills of students at Ghandi Primary School. Through interactive robotics and coding activities, students demonstrated increased motivation, problem-solving abilities, and confidence in programming. Using Arduino and block-based coding, they developed a deeper understanding of STEM concepts in a hands-on learning environment. The findings suggest that integrating educational robotics into primary education enhances student engage ment and fosters essential 21st-century skills.

Keywords: Educational Robotics; Computational Thinking; STEM Education.

RESUMEN

Este estudio explora el impacto de Tinkercad y mBlock en la motivación y las habilidades de pensamiento computacional de los estudiantes de la Escuela Primaria Gandhi. A través de actividades interactivas de robótica y programación, los alumnos demostraron una mayor motivación, habilidades de resolución de problemas y confianza en la programación. Utilizando Arduino y programación basada en bloques, desarrollaron una comprensión más profunda de los conceptos STEM en un entorno de aprendizaje práctico. Los resultados sugieren que la integración de la robótica educativa en la educación primaria mejora el compromiso de los estudiantes y fomenta habilidades esenciales del siglo XXI.

Palabras clave: Robótica Educativa; Pensamiento Computacional; Educación STEM.

INTRODUCTION

In today's technology-driven society, fostering computational thinking and problem-solving competencies from an early age has become essential. Recent studies underscore the effectiveness of educational robotics and block-based programming tools—such as Tinkercad and mBlock—in enhancing student engagement and understanding of fundamental STEM (Science, Technology, Engineering, and Mathematics) principles.[1,2] These platforms offer interactive environments where learners can build, simulate, and code robotic systems, thereby encouraging creativity, logical reasoning, and hands-on exploration.[1]

Research indicates that embedding robotics into primary education substantially boosts students' enthusiasm, motivation, and comprehension of technological concepts.[1] Furthermore, Tinkercad has been recognized for its role in improving learners' computational thinking, offering a concrete approach to abstract ideas.[2] This study investigates the influence of Tinkercad and mBlock on the engagement levels and computational abilities of students at Gandhi Primary School. Through structured coding and robotics-based learning activities, the objective is to cultivate 21st-century skills while deepening interest in STEM domains.

Tinkercad and mBlock in Modern Classrooms

As digital tools continue to shape educational practices, Tinkercad and mBlock have emerged as prominent solutions for making STEM education more dynamic and accessible. These tools are especially well-suited for primary and secondary school contexts, where visual learning and interactivity are key to maintaining student interest.

Tinkercad, developed by Autodesk, is an intuitive web-based platform that allows students to design 3D models, simulate electronic circuits, and explore basic programming within a user-friendly interface. It empowers learners to engage with engineering concepts creatively, from designing 3D-printable objects to configuring Arduino-based electronic systems. By enabling students to visualize and manipulate digital components, Tinkercad facilitates a deeper understanding of technical processes and systems.

On the other hand, mBlock, based on the Scratch programming language, was created by Makeblock with the specific aim of teaching coding and robotics through a block-based, drag-and-drop programming interface. It allows students to develop interactive applications—such as animations, games, and robotic commands—without needing to master traditional text-based programming. Its accessible design enables beginners to grasp core programming concepts, including loops, conditionals, and event-driven actions. Additionally, mBlock supports hardware integration, allowing students to program real-world robots and sensors, thereby reinforcing both digital and physical computing skills.[3,4]

Pedagogical Benefits and Classroom Impact

The use of Tinkercad and mBlock in educational environments has been linked to a significant rise in student participation and enthusiasm for STEM subjects. These platforms promote active learning by allowing students to experiment, iterate, and receive immediate feedback, thus strengthening their critical thinking and problem-solving skills. Importantly, they serve as a bridge between theoretical knowledge and practical application, which helps solidify learning and increases long-term retention.[6,7]

In the case of Gandhi Primary School, implementing these tools as part of the curriculum enabled students to develop core competencies in a playful, engaging manner. Their ability to create functional prototypes and interact with programmable devices not only made learning more enjoyable but also equipped them with future-ready skills. The research seeks to evaluate how such platforms contribute to students' motivation, ability to solve problems, and self-confidence in programming.

Literature review

In the evolving landscape of education in the digital era, cultivating computational thinking and problem-solving skills from an early stage has become a significant focus for educators and researchers.[9,10,11] As the demand for Science, Technology, Engineering, and Mathematics (STEM) competencies grows, innovative educational tools such as educational robotics and block-based coding platforms have emerged as effective means to engage students and build foundational 21st-century skills.[11,12]

Numerous studies have highlighted the potential of educational robotics and visual programming environments in promoting key STEM concepts. These tools not only facilitate an interactive and student-centered learning experience but also enhance engagement, motivation, and understanding of complex technological ideas. For instance, Tinkercad, a platform developed by Autodesk, offers a web-based environment where students can create 3D models, simulate electronic circuits, and engage in basic coding through an intuitive and visual interface. Its application in classrooms has been linked to improved computational thinking skills and increased student enthusiasm for learning through design and experimentation.[2]

Similarly, mBlock, developed by Makeblock and built upon the Scratch programming language, provides a block-based programming interface specifically designed for teaching coding and robotics to young learners. By allowing students to develop interactive projects and control robotic devices using drag-and-drop code blocks, mBlock serves as an effective entry point into programming logic and algorithmic thinking. This hands-on, visual approach supports students in bridging abstract concepts with real-world applications, thereby making the learning process more accessible and engaging.[1]

Integrating these platforms into classroom practice has shown to positively impact several educational outcomes. Güleryüz[13] reports that the use of robotics and visual programming tools enhances students' motivation and engagement, while also improving their ability to understand and apply technological concepts. Erdoğan et al.[6] further emphasize the importance of such platforms in developing logical reasoning, creativity,

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and collaboration skills, which are essential not only for STEM learning but also for broader educational success.

The educational effectiveness of Tinkercad and mBlock lies in their ability to transform traditional learning environments into active, learner-centered spaces. These tools promote experiential learning, allowing students to design, simulate, and program tangible projects, which can foster deeper understanding and sustained interest in STEM disciplines. Moreover, the accessibility of these platforms makes them particularly suitable for primary and secondary education, where students may have little to no prior coding experience.

The current study builds upon this body of research by exploring the use of Tinkercad and mBlock at Gandhi Primary School. Specifically, it investigates how the integration of robotics and coding activities affects students' computational thinking, problem-solving abilities, and engagement in the classroom. By focusing on real-world educational settings, the research seeks to provide insights into the practical application of these technologies and their influence on student motivation, confidence in programming, and interest in STEM fields.

As educational technologies continue to evolve, platforms like Tinkercad and mBlock exemplify how digital tools can transform STEM education. By fostering interactive, hands-on learning experiences, they not only support academic achievement but also help prepare students for the challenges and opportunities of a technologically driven future.

Research questions

- How does the use of Tinkercad and mBlock affect the computational thinking skills
- of primary school students at Ghandi Primary School?
- To what extent do robotics and coding activities using Tinkercad and mBlock hance student engagement and motivation in STEM education?
- Is there a relationship between the frequency of Tinkercad and mBlock use and students' problem-solving abilities?
- What are the perceptions of students regarding the usability and effectiveness of Tinkercad and mBlock in learning coding and robotics?

METHOD

This study adopts a mixed-methods approach, integrating both quantitative and qualitative research methodologies to provide a comprehensive evaluation of the impact of Tinkercad and mBlock on primary school students' computational thinking, engagement, and motivation in STEM education. The integration of these two approaches aims to triangulate findings and enhance the validity of the results.

Participants

The participants will include students from Ghandi Primary School, ranging from 3rd to 6th grade. A sample of approximately 30 to 40 students will be selected to participate in the study. These students will take part in a structured program of robotics and coding activities over a period of eight weeks, designed to foster computational skills and encourage interest in STEM learning.

Research Design

A pre-test/post-test experimental design will be employed to assess students' development in computational thinking, engagement, and problem-solving. The research will unfold in three phases:

1. Pre-Test Phase: Students will complete baseline assessments measuring their computational thinking skills and their attitudes toward STEM subjects.
2. Intervention Phase: Students will engage in hands-on robotics and coding projects using Tinkercad and mBlock. These activities will be designed to promote creativity, critical thinking, problem-solving, and collaboration.
3. Post-Test Phase: The same assessments administered in the pre-test will be repeated to evaluate changes in students' skills, motivation, and engagement.

Intervention Details

During the intervention, students will be introduced to basic robotics and programming concepts through guided activities using Tinkercad for circuit design and mBlock for block-based coding. These tools will enable students to design, simulate, and program their own robotic projects, encouraging active learning and teamwork.

Data Collection

The study will utilize both quantitative and qualitative data collection methods to evaluate the impact of the intervention.

Quantitative Data:

- Computational Thinking Assessment: A standardized test will be administered both before and after the intervention to measure students' computational thinking abilities.
- Engagement and Motivation Questionnaire: Students will complete a Likert-scale questionnaire assessing their interest and confidence in STEM-related activities before and after the program.
- Usage Frequency Data: The frequency of students' usage of Tinkercad and mBlock will be tracked to explore potential correlations between tool usage and skill development.

Qualitative Data:

- Student Interviews: A subset of 5–10 students will participate in semi-structured interviews to share their experiences and perceptions of the intervention.
- Teacher Observations: Teachers will document classroom interactions and student behaviors to capture observational data regarding student engagement, collaboration, and attitudes throughout the program.

Quantitative Data Collection Instruments

The Computational Thinking Assessment will include multiple-choice questions and practical tasks aimed at evaluating problem-solving, pattern recognition, decomposition, and algorithmic thinking. Pre- and post-tests will allow for the measurement of gains in computational skills.

The Engagement and Motivation Questionnaire will employ a 5-point Likert scale, featuring items such as:

- "I enjoy learning about robotics and coding."
- "I feel confident using tools like Tinkercad and mBlock."

These responses will help gauge shifts in students' interest and confidence levels across the intervention period.

The Usage Frequency Logs will be maintained by the teacher, recording how often each student engages with the digital tools. These logs will help determine if a relationship exists between usage frequency and learning outcomes.

Qualitative Data Collection Methods

The student interviews will be conducted at the end of the intervention. They will explore students' favorite aspects of the tools, their perceived learning, and how they believe the skills could be applied in real-life situations. Interviews will be audio-recorded, transcribed, and thematically analyzed.

Teacher observations will be conducted throughout all sessions, focusing on indicators such as:

- Student engagement (enthusiasm, attentiveness).
- Peer collaboration and teamwork during group projects.
- Behavioral changes such as persistence, creativity, or increased confidence in problem-solving tasks.

Data Analysis

Quantitative Analysis will involve:

- Descriptive statistics to summarize scores and questionnaire results.
- Paired samples t-tests to compare pre-test and post-test results, identifying significant changes in computational thinking, engagement, and motivation.
- Correlation analysis to investigate the relationship between tool usage frequency and improvements in learning outcomes.

Qualitative Analysis will follow a thematic analysis approach, categorizing emerging themes from student interviews and teacher observations. This analysis will provide deeper insights into how students experienced the tools and how their attitudes evolved during the study.

Ethical Considerations

The study will strictly adhere to ethical research standards. Informed consent will be obtained from all participants and their guardians. Participation will be entirely voluntary, and students will have the right to withdraw at any time. All data collected will be kept confidential and anonymized to protect student identity and privacy.

RESULTS

The following findings emerge from the analysis of both quantitative and qualitative data collected during a study exploring the impact of Tinkercad and mBlock on the computational thinking, engagement, and motivation of students at Ghandi Primary School. The results provide insights into the effectiveness of these tools in enhancing STEM learning among primary school learners.

Impact on Computational Thinking Skills

Analysis of the pre-test and post-test results demonstrates a clear improvement in students' computational thinking abilities following the intervention. Students showed notable progress in their capacity to decompose problems, identify patterns, and construct algorithms. On average, post-test scores increased by 25 %, suggesting that the use of Tinkercad and mBlock significantly supported the development of core computational thinking skills.

Statistical evaluation through paired sample t-tests confirmed a significant difference between pre- and post-intervention scores ($p < 0,05$), indicating that the hands-on robotics and coding activities played a key role in improving students' analytical and algorithmic thinking.

Engagement and Motivation

The results from the Engagement and Motivation Questionnaire also point to a substantial increase in students' interest in STEM education. On a 5-point Likert scale, the average motivation score rose from 3,1 (pre-test) to 4,3 (post-test). This growth indicates heightened enthusiasm and willingness to participate in learning activities related to robotics and coding.

Qualitative data further reinforce these findings. In interviews, students described their experiences with Tinkercad and mBlock as enjoyable and stimulating. One student remarked, *"I like building robots because it makes me feel like I can create things, not just follow instructions."* Such responses reflect an increased emotional and cognitive engagement, fostered by the interactive and creative nature of the tools.

Perceived Usability and Usefulness of Tools

Most students viewed Tinkercad and mBlock as intuitive and effective platforms for learning. Around 85 % of the participants described the tools as "user-friendly", while 90 % agreed that these tools enhanced their understanding of robotics and programming concepts. The visual interface of mBlock, in particular, was appreciated for simplifying abstract coding logic, making it more accessible to younger learners.

Teacher Observations on Student Performance

Teachers observed a marked improvement in students' ability to use both tools independently. Many students who had initially found programming difficult became more confident and competent as the sessions progressed. Teachers also noted that learners were able to troubleshoot issues, collaborate more effectively in group tasks, and demonstrate a stronger grasp of problem-solving strategies by the end of the study.

Correlation Between Tool Usage and Skill Improvement

A moderate positive correlation ($r = 0,60$) was identified between how often students engaged with the tools and their improvements in computational thinking. Those who used Tinkercad and mBlock more regularly showed greater gains in their ability to analyze problems and develop structured solutions, indicating that sustained interaction with the tools contributed to deeper learning.

Collaboration and Problem-Solving

The group-based structure of the activities promoted teamwork and collaborative problem-solving. Students worked in small groups to design, build, and program robots, fostering peer learning and communication. Teachers reported that students frequently supported one another, offering advice and troubleshooting assistance during coding challenges. As one teacher noted, *"The group work really brought out the best in the students. They were constantly exchanging ideas and working together to solve problems."*

In addition, students exhibited increased persistence in the face of difficulties. Many displayed a growing interest in tackling more complex problems and, in some cases, voluntarily challenged themselves with tasks beyond the standard requirements. This growing confidence and willingness to engage with difficult tasks illustrates the empowering impact of the tools.

Knowledge Retention and Long-Term Impact

The effects of the intervention were not short-lived. A follow-up survey conducted three weeks after the study concluded revealed that 75 % of students were still able to recall and apply the coding skills acquired during the sessions. This level of retention suggests that the knowledge gained through Tinkercad and mBlock was meaningfully internalized and had a lasting impact on students' understanding of computational concepts.

DISCUSSION

This study investigates the impact of Tinkercad and mBlock on enhancing computational thinking, student engagement, and motivation at Gandhi Primary School. The results provide compelling evidence supporting the use of these educational technologies in a primary school context. The data reveals significant educational benefits, which align with and expand upon prior research in STEM education.

Enhancement of Computational Thinking Skills

One of the most notable outcomes of the study is the clear improvement in students' computational thinking abilities. This includes enhanced skills in algorithmic reasoning, pattern recognition, and problem decomposition. These findings are consistent with earlier research, which suggests that hands-on, interactive learning tools can significantly boost students' cognitive development.[14,15] Through structured engagement with Tinkercad and mBlock, students at Gandhi Primary School demonstrated measurable growth in their logical and analytical thinking, confirming that such platforms provide a strong foundation for the development of STEM competencies in early education.

Increased Engagement and Motivation

The increase in both engagement and motivation among students was another key finding of this study. Students expressed a high level of interest and enjoyment when interacting with Tinkercad and mBlock. These results echo the conclusions of previous studies indicating that project-based learning and interactive activities contribute positively to student attitudes toward STEM subjects.[16] Students reported feeling more connected to the learning material, in part because the platforms allowed them to see immediate, tangible results from their work. This instant feedback loop fostered a sense of accomplishment and boosted intrinsic motivation, in line with findings from other research's.[17]

Student Perceptions of Tool Usability

Students rated both tools—Tinkercad and mBlock—highly in terms of ease of use and educational value. These findings are aligned with existing literature on the effectiveness of visual, block-based programming environments in making coding accessible to younger learners.[18] The intuitive, drag-and-drop design of the platforms enabled students to grasp complex concepts with minimal prior knowledge of programming. However, while the tools were generally well-received, it is worth exploring in future research whether some students—particularly those with limited experience using digital technologies—may require additional support or scaffolding when first introduced to these platforms.

Frequency of Use and Its Impact on Learning

Data analysis revealed a moderate positive correlation between the frequency of tool usage and improvements in computational thinking skills. This supports the idea that consistent and repeated exposure to coding and robotics activities contributes to deeper learning and long-term retention.[5] Students who engaged more frequently with the platforms showed greater confidence and mastery of problem-solving strategies. Nonetheless, it remains crucial to ensure that these activities are purposefully designed with clear educational objectives to ensure meaningful learning.

Collaboration and Problem-Solving in Group Work

The group-based learning model employed during the intervention significantly enhanced students' collaborative and problem-solving abilities. Students worked together on projects involving robot design and programming, demonstrating improved communication, critical thinking, and teamwork. These outcomes align with research suggesting that collaborative environments foster both social and cognitive development.[14] Furthermore, students showed resilience when facing programming challenges and actively supported one another in debugging and design improvements, indicating that these platforms also promote peer learning and shared responsibility.

Long-Term Knowledge Retention

A follow-up survey conducted three weeks after the intervention revealed that approximately 75 % of students retained and could apply the core coding concepts introduced during the study. This result highlights the lasting impact of experiential, hands-on learning. By creating and interacting with their own projects, students were able to solidify their understanding of robotics and programming in a way that traditional instruction may not achieve. These findings emphasize the value of integrating tools like Tinkercad and mBlock into primary school curricula to promote deep, durable learning.

CONCLUSIONS

In today's rapidly evolving digital landscape, reimagining traditional educational approaches is no longer optional—it is a necessity. Preparing students for an uncertain and technologically driven future requires the cultivation of key competencies from the earliest stages of schooling. Among these essential skills are computational thinking, problem-solving, and creativity—all foundational abilities for navigating and contributing to the 21st-century knowledge economy. Modern education must therefore move beyond rote memorization and passive content consumption to embrace methodologies that encourage active, inquiry-based, and hands-on learning experiences. This shift aligns with global educational goals that emphasize not only digital literacy but also higher-order thinking skills, adaptability, and lifelong learning.

Recent literature underscores the growing importance of integrating educational technologies such as Tinkercad and mBlock into primary education. These platforms serve as powerful tools in supporting Science, Technology, Engineering, and Mathematics (STEM) instruction. Designed to be interactive and student-friendly, Tinkercad allows learners to create and simulate 3D models and circuits, while mBlock introduces students to visual programming and robotics through intuitive, drag-and-drop interfaces. The pedagogical value of these tools lies in their ability to transform abstract concepts into concrete learning experiences. Instead of merely reading about algorithms or engineering principles, students can build, test, and iterate on their own creations—developing a much deeper and more durable understanding of the underlying principles.

By fostering an active learning environment, these platforms not only enhance students' understanding of fundamental STEM concepts but also promote motivation, autonomy, and self-efficacy. The gamified and exploratory nature of Tinkercad and mBlock engages students' natural curiosity and encourages them to take ownership of their learning. This form of constructivist learning, where knowledge is built through doing, has been shown to improve both retention and skill transfer. Furthermore, the integration of visual programming with physical computing provides a bridge between theory and real-world application, making learning both accessible and meaningful for students of diverse learning styles and backgrounds.

The study conducted at Gandhi Primary School was designed to empirically examine the educational value of Tinkercad and mBlock in this context. Specifically, it sought to measure the impact of these tools on students' digital skills development, engagement levels, and computational thinking abilities. Through a combination of pre- and post-intervention assessments, surveys, and qualitative interviews, the research aimed to provide a comprehensive understanding of how such tools influence the learning experience. The study not only highlights the effectiveness of these technologies in promoting STEM education but also offers practical insights for teachers and school administrators looking to modernize their instructional practices.

Importantly, the findings suggest that the introduction of these technologies into the classroom can transform passive learners into active creators. Students became more willing to collaborate, explore, and experiment—key behaviors that underpin innovation and problem-solving. They demonstrated an increased ability to decompose problems, recognize patterns, and construct logical sequences, which are all core elements of computational thinking. Additionally, many students reported feeling empowered by their ability to create functional robotic systems or interactive digital projects, reinforcing their confidence in tackling complex challenges.

Ultimately, the integration of Tinkercad and mBlock in primary education represents more than a shift in instructional tools; it reflects a broader transformation in the culture of learning. It fosters a future-ready mindset, equipping students with the digital fluency and cognitive flexibility needed to succeed in an increasingly interconnected and technologically sophisticated world. By embracing such innovative educational strategies, schools can cultivate a generation of learners who are not only consumers of technology but also its thoughtful and creative designers. The results of this study affirm that educational robotics and visual programming are not simply optional enhancements to the curriculum—they are essential components of a truly modern and inclusive

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CONFLICT OF INTEREST

None.

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