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MineLab 360: Safe Science, Infinite Discovery

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ABSTRACT

MineLab 360: Safe Science, Infinite Discovery is an educational innovation that leverages the immersive potential of Minecraft Education Edition to transform the way science is taught in schools. Designed as a multidisciplinary virtual lab, MineLab 360 enables students to explore hazardous experiments in Biology, Chemistry, and Physics within a safe, engaging, and gamified environment. The innovation addresses key challenges in science education, including limited access to functional laboratories, safety restrictions on physical experiments, and low student engagement with abstract scientific concepts. By simulating real-life experiments—such as virtual dissections, compound synthesis, pH testing, circuit construction, and motion analysis, students develop scientific inquiry skills without the risks associated with traditional lab settings. Unique features of MineLab 360 include curriculum-aligned virtual worlds, built-in lab safety training, interactive NPC guides, and in-game journals for student documentation and reflection. This approach supports both in-person and remote learning, making it accessible to schools with limited infrastructure or during disruptions such as pandemics. The innovation promotes equitable STEM education, enhances digital fluency, and supports the integration of 21st-century skills into science instruction. MineLab 360 has been implemented in science teacher education programs has received positive feedback from both educators and learners. MineLab360 is in the process of intellectual property registration under MyIPO as a digital instructional module and immersive science teaching kit. MineLab 360 represents a sustainable, scalable solution for safe, inquiry-driven, and future-ready science education.

Keywords: Virtual Laboratory; Minecraft Education Edition; Science Education Innovation; Laboratory Safety; Gamified Learning

INTRODUCTION

Practical experimentation is fundamental to effective science learning, yet access to well-equipped

laboratories remains a significant challenge, particularly in underfunded schools or during crisis situations such as pandemics. Safety concerns further restrict students from engaging in hands-on exploration of scientific phenomena (Dewitt et al., 2021). In response to these pressing issues, MineLab 360: Safe Science, Infinite Discovery was conceptualized as an immersive digital learning innovation using Minecraft Education Edition. This multidisciplinary virtual laboratory redefines how science is taught by transforming traditionally risky or inaccessible experiments into safe, engaging, and inquiry-based simulations. MineLab 360 allows students to conduct simulated experiments in Biology, Chemistry, and Physics, thereby making abstract scientific concepts tangible and accessible. By embedding virtual environments with interactive non-playable characters (NPCs), curriculum-aligned tasks, and real-world laboratory protocols, MineLab 360 bridges the gap between theoretical knowledge and experiential learning. The tool enhances students' scientific inquiry skills and digital fluency while fostering a culture of curiosity and experimentation. The aim of this innovation is to support safe, equitable, and scalable science education across diverse educational contexts.

METHODS

MineLab 360 was developed using a design-based research (DBR) methodology that integrates iterative development, implementation, and refinement based on stakeholder feedback. The innovation is grounded in constructivist learning theory and the principles of gamified learning, emphasizing active knowledge construction, exploration, and reflection (Papert, 1980; Hamari et al., 2014).. The development process included four main phases. During the first phase, a needs analysis was conducted through surveys and interviews with science teachers and students to identify the challenges in current lab-based science instruction. Concurrently, the national STEM curricula were reviewed to ensure that the virtual lab activities aligned with the expected learning outcomes (Ministry of Education Malaysia, 2017).. In the second phase, modular virtual labs for Biology, Chemistry, and Physics were designed and developed within Minecraft Education Edition. This included creating interactive NPCs that guide students through the experiments, integrating in-game journals for documentation and reflection, and incorporating built-in lab safety tutorials and gamified tasks to maintain engagement (Dewitt et al., 2021). The third phase involved the implementation and pilot testing of the innovation with 42 pre-service science teachers across three universities. Data were collected through classroom observations, user activity analytics, surveys, and focus group interviews. In the final phase, the gathered feedback was used to refine the virtual lab environments. Improvements were made to the learning pathways, NPC instructions, and difficulty levels of the tasks. Throughout the process, the biology lab featured simulations such as frog dissections, osmosis experiments, and microorganism cultures. The chemistry lab included virtual activities like compound synthesis, pH testing, and distillation, while the physics lab involved circuit construction, force and motion analysis, and energy transformation simulations. Pedagogically, all tasks were closely aligned with the Malaysian KSSM syllabus and were designed to be adaptable for use in other curricula. The system also emphasized real-world laboratory protocols, formative assessments, gamified progress tracking, and reflection tools

RESULTS AND DISCUSSION

Findings from the pilot implementation revealed several key outcomes. Firstly, student engagement and motivation significantly increased. Surveys and interviews showed that learners found science lessons more enjoyable and exploratory due to the gamified elements and narrative-driven tasks in MineLab 360. This increased engagement fostered a greater sense of ownership and agency in learning. Secondly, there was a notable improvement in students' conceptual understanding and scientific inquiry skills. Pre- and post-tests demonstrated statistically significant gains in content knowledge and problem-solving abilities. Observation records supported these findings, showing improved student capabilities in forming hypotheses, analyzing results, and deriving conclusions. The use of digital tools further enhanced students' digital literacy, 3D navigation, and familiarity with collaborative virtual environments. Additionally, the innovation promoted accessibility and inclusivity by enabling practical science learning in environments lacking physical laboratories or during periods of remote instruction. Teachers recognized the platform's potential to level the playing field by providing all students, regardless of geographic or economic limitations, with meaningful lab experiences. Educators also responded positively to the system's alignment with their curriculum and ease of use. They reported that the built-in training modules and intuitive interface helped them integrate MineLab 360 seamlessly into their teaching practices. Furthermore, the scalability and sustainability of the innovation were evident. As a modular system, MineLab 360 can be expanded to include more disciplines or tailored to meet different curriculum standards. It is also undergoing intellectual property registration with MyIPO as a digital instructional module and immersive teaching kit. Its digital nature, compatibility with widely available devices, and potential for use in both in-person and remote settings make it a long-term solution for modern science education challenges.

CONCLUSION

MineLab 360 represents a transformative approach to science education that addresses the pressing need for safe, engaging, and accessible laboratory experiences. By leveraging the immersive environment of Minecraft Education Edition, it empowers students to engage with scientific concepts through exploration, experimentation, and critical reflection. Its curriculum-aligned and gamified design fosters inquiry-based learning and digital fluency while providing inclusive access to high-quality science instruction. The pilot study confirmed that MineLab 360 enhances student engagement, inquiry skills, and conceptual understanding, while also increasing teacher readiness for digital pedagogies. As schools move toward blended and hybrid learning environments, MineLab 360 offers a scalable and sustainable model for delivering effective science education in both well-equipped and resource-constrained settings.

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and refinement process. The innovation is currently in the process of intellectual property registration under MyIPO (Malaysia) as a digital instructional module and immersive science teaching kit.

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