Impact of 3D Model-Based Online STEM Activities on Skin Anatomy and Physiology Learning Among Pharmacy Students at MiCoST

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Abstract
The contemporary educational landscape is increasingly recognizing the importance of STEM (Science, Technology, Engineering, and Mathematics) education in fostering critical thinking, creativity and problem-solving skills. The aim of this study was to evaluate performance level between control and intervention group based on a 3D model of anatomy skin through online STEM activity (CLO3). The method involved comparing between control group (n=10) and intervention group (n=3). The control group was the MiCOST's students who did not participate in any STEM activities (non-STEM) whereby the intervention group involved the MiCOST's students involved in STEM activities. Among three students from the intervention group, all of them achieved 10 out of 10 marks for the 3D skin model video presentation whereby the minimum marks for the control group were 5.33 only. The result found that the STEM activity helped a lot of cognitive and affective domains for students to get higher marks compared to students who were not involved in STEM activity.

Keywords: 3D model, Online STEM Activity, Skin Anatomy, Physiology.

Introduction
There is a growing interest in integrating STEM activities into various educational curricula to enhance learning outcomes. The United Nations (UN) had launched several initiatives to promote the role of education in Sustainable Development Goals (SDGs) and set Goal 4 for quality education among other SDGs. It was believed that the integrated Science, Technology, Engineering, and Mathematics (STEM) approached was a promising educational framework for sustainable development that improved education quality Jamali et. al. (2022). A study conducted by Yang et. al. (2024) mentioned that the STEM education concept had changed the traditional way of education. It also stated that the combined use with project-based learning had provided new ideas for secondary school information technology education.

The subject's content for Diploma of Pharmacy, MiCOST is focusing on research in STEM (Science, Technology, Engineering, and Mathematics) education, which promoting the development of STEM education research as a distinct field. The course introduced foundational concepts and principles related to the anatomy and physiology of various body systems, including the cardiovascular, digestive, respiratory, renal, nervous, endocrine, immune, and integumentary systems. This subject had four learning outcomes and were focusing on one of the key learning outcomes which was the course learning outcome number three (CLO3). The CLO related the structure to the function for fundamental physiological processes (A4, PLO5) Affective Bloom Taxonomy, which were assessed through an assignment designed to explore these relationships in depth.

In general, Course Learning Outcome (CLO) is a written statement of what the student/learner is expected to be able to achieve at the end of the programme module/course unit or qualification. Learning outcomes are statements of what a learner is expected to know, understand and/or be able to demonstrate after completion of a process of learning. Through this comparative analysis, the research sought to determine whether participation in STEM activities enhanced students' cognitive and affective learning outcomes, as posited by Bloom's Taxonomy. By assessing the marks and skills demonstrated by both groups, this study aimed to provide insights into the effectiveness of STEM-based learning approaches in higher education, particularly within health sciences education.

STEM education has increasingly incorporated 3D models to enhance students' understanding of complex anatomical and physiological concepts. Research suggested that the used of 3D models in education, particularly in STEM fields, significantly improved students' spatial understanding and retention of complex structures and their functions. Eshaq (2024) found that integrating 3D models in STEM education provided students with practical applications and hands-on experiences that enhanced their learning outcomes. Similarly, Kağnıcı and Sadi (2023) demonstrated that STEM activities using 3D models in biology education improved students' understanding of biological structures and their functions, although changed in conceptions of learning were not observed.

The decline in students' interest in STEM-based streams can be attributed to factors such as student preferences, school infrastructure, and family support. Many students struggle to connect with theoretical STEM content and often prefer hands-on, object-oriented learning approaches that allow them to apply concepts in real-world scenarios. These practical methods are proven to be more engaging, fostering curiosity and a deeper understanding of STEM subjects. Without such opportunities, students may lose interest and fail to see the relevance of STEM in their lives (Idris et al., 2023).

In addition to teaching methods, school infrastructure and family support significantly impact students' engagement with STEM. Schools with outdated facilities and limited resources, such as insufficient science labs or technology tools, cannot provide the environment needed to spark innovation and experimentation. At the same time, families that lack awareness of the importance of STEM fields may fail to encourage their children to explore these areas. Idris et al. (2023) mentioned that by enhancing infrastructure and promoting family-focused awareness campaigns, educators and policymakers can create a more supportive ecosystem for fostering interest in STEM.

Project-based learning (PBL) has become a very effective teaching method in recent years due to its capacity to improve students learning outcomes and engagement. Yang et al. (2024) highlighted how revolutionary this strategy can be. Their study demonstrated that the implementation of PBL not only increases students' comprehension and mastery of knowledge but also greatly enhances their motivation in studying and utilizing information technology. All of these elements work together to boost students' motivation and create a more engaging and dynamic learning environment.

Their findings are consistent with the larger goals of modern education, which are to get students ready for a world that is changing quickly. Teachers urge students to interact with real-world issues, apply critical thinking skills and collaborate effectively with peers. This experiential approach to learning allows students to bridge the gap between theoretical knowledge and practical application, thereby deepening their understanding and retention of key concepts. Furthermore, the integration of technology within PBL further enriches the learning experience, equipping students with essential digital literacy skills that are increasingly vital in the 21st century.

Research by Jamali et al. (2022) has illuminated new trends and focus areas in STEM (science, technology, engineering, and mathematics) education in tandem with PBL's achievements. According to their research, "early childhood education", "computer education", and "environmental education" are the three key hotspots in the field of STEM and educational excellence. These results demonstrate the increasing awareness of basic and interdisciplinary subjects that are essential to determining the direction of STEM education in the future.

Therefore, this research project focuses on evaluating the impact of online STEM activities based on a 3D model of anatomy skin to relate the structure to the function for fundamental physiological processes (CLO3). This study evaluated students' understanding and performance in Basic Anatomy and Physiology course between control and intervention group among students of Diploma of Pharmacy, Melaka International College of Science and Technology, MiCoST.

Methodology

The methodology involved comparing the performance of two groups of students which were a control group that did not participate in any STEM activities and an intervention group that engaged in specific STEM activities. The control group focused on explaining the anatomy and function of various organs through video presentations, while the intervention group was tasked with constructing a 3D model of the skin and presenting it, integrating hands-on learning with theoretical knowledge.

Based on the research, the assignment method involved comparing between control group (n=10) and intervention group (n=3). The control group was the MiCOST's students who did not involve in any STEM activities (non-STEM) whereby the intervention group involve the MiCOST's students involve in STEM activities.

Table 1 showed the comparison of assignment methods between control and intervention group based on CLO3 which related the structure to the function for fundamental physiological processes (A4, PLO5). Bloom Taxonomy: Affective (A4).

Table 1: Comparison Assignment Method between Control and Intervention Group.

	CONTROL (n=10)	**INTERVENTION (n=3)**
TASK	For this assignment, students will explain the anatomy and the function of various organs: 1. Heart 2. Blood vessels 3. Gastrointestinal tract 4. Skin 5. Bone tissues 6. Endocrine glands 7. Lung and Alveolus 8. Nervous system 9. Eye 10. Ear	For this assignment, students will construct a model of the skin using any appropriate material as a structural template. On each of the four side, students need to include information regarding the different aspects of the integumentary system. Students should have 3D elements as well. Students may use any arts and craft that deem appropriate. i) Side 1: Construct, draw and label correctly the anatomical structure of the skin that includes epidermis, dermis and hypodermis. ii) Side 2: Construct, draw and label accessory structure such as hair, gland, receptor, nerve and blood vessels. iii) Side 3: Draw 1 types of skin cancer (Squamous Carcinoma, Basal Cell Carcinoma or Melanoma). iv) Side 4: Identify the keratinocytes and melanin pigment.
GUIDELINES	Video presentation only without 3D model construct and focusing to various body system.	**SIZE 3D MODEL: NO LIMITS** **Choose any suitable materials to construct the skin 3D model.** The items can come from anywhere but must represent a specific part of the skin's anatomy. For example: ● Pick the bristles of a toothbrush for the hairs in the skin. ● Gummy bear material (or firm Jell-O) could be used as the fat layer in skin. ● Plasticine ● Sponge ● Tissue box ● Sketch tools (paper, colour pencil) (any arts and craft.

		Students have to start the project by drawing a 3D model of anatomy skin. Students have to start to construct the 3D model of skin. Students have to take the photo of each side of the skin **OR** may record the video of the 3D model of the skin. Students have to present the module and perform the experiment during the presentation. Students have to teach a group of school student using the module proposed. The material involved must be informed to school students one week before the class for their preparation. Since the medium of conducting class is online, students have to record the online class with the school students and upload to google classroom.
AUDIENCE	Lecturer (MiCOST)	Community (Students of secondary school in Malaysia)

Identifying the assessment marks.

The following rubric were used to assess the marks for student's assessment.

1. Information Gathering, included all required structures and had appearance of skin diagram.
2. Key/Labels Key accurately labelled with correct functions of all required structures.
3. Construction - Care Taken Construction clean, neat, colorful, easy to read and understand, creative, 3D.
4. Organization- The type of presentation was appropriate for the topic and audience
5. Presentation Good language skills and pronunciation were used. Visual aids were well prepared, informative, effective and not distracting.

Results and Discussion

In this section, the findings were reported corresponding to the two groups studied, the control group of non-involvement in STEM activity and the intervention group which was involved in STEM activity.

i) Control group of individuals with non-involvement in STEM activity.

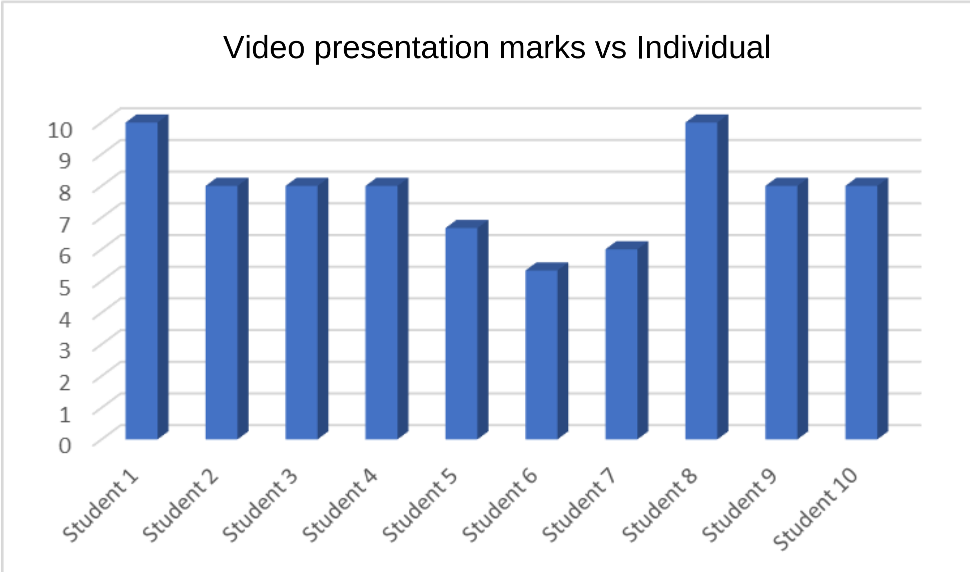

Figure 1: The distribution of Video Presentation Marks for control group (non-involvement in STEM activity) related between cognitive and affective domain.

The control group consisted of ten participants (n=10). Figure 1 shows the distribution of Video Presentation Marks for Basic Anatomy and Physiology Course. It demonstrated that the marks obtained ranged from 5 to 10, with two participants achieving the maximum score of 10, while one participant received the lowest score of 5.33. The distribution of marks highlights the variation in performance within the group, suggesting differences in participants' understanding and skills related to the assignment criteria.

The results reveal a connection between the cognitive and affective domains as defined by Bloom's Taxonomy. The cognitive domain involves knowledge and comprehension, while the affective domain focuses on attitudes and emotional engagement. Participants who performed better likely demonstrated stronger integration of these domains, indicating a balanced understanding and motivation. Conversely, those with lower scores may have struggled to connect their knowledge with the presentation's practical and emotional aspects.

A notable observation is the substantial gap between the lowest and highest marks in this group, with scores distributed in a roughly normal pattern. This gap may be attributed to the participants' lack of exposure to online STEM activities, which could have enhanced their ability to complete the assignment effectively. The absence of such preparatory activities likely impacted their readiness to engage with the assignment's requirements, leading to discrepancies in performance outcomes.

ii) Results for intervention group (n=3) involved in STEM activity.

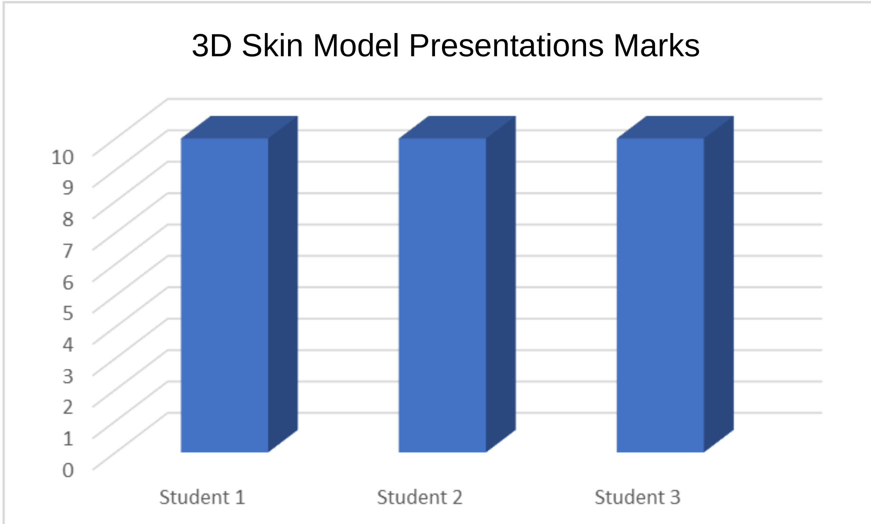

Figure 2: The Distribution of 3D Skin Model Presentation Marks for Intervention Group (involved in STEM Activity) Related between Cognitive and Affective Domain.

The intervention group comprised three students (n=3), who participated in a specially designed online STEM activity as part of the study. Figure 2 presents the distribution of marks for the 3D skin model presentations assessed in this group. Remarkably, all three students achieved full marks (10/10) in their evaluations, reflecting a consistent level of excellence in their performance. This uniform achievement highlights the students' commitment and the effectiveness of the teaching and learning strategies employed in the activity.

The results further underscore the capability of the online STEM activity to meet its intended educational objectives. Specifically, it successfully facilitated the achievement of the targeted Course Learning Outcome (CLO3), which emphasizes the ability to relate structural features to their functional roles in fundamental physiological processes. This outcome indicates that integrating innovative, hands-on digital activities into the curriculum can significantly enhance student understanding and engagement in complex scientific concepts, aligning with the findings of Idris et al. (2023) and Dewi et al. (2024).

iii) Comparison between minimum marks of the control and intervention groups.

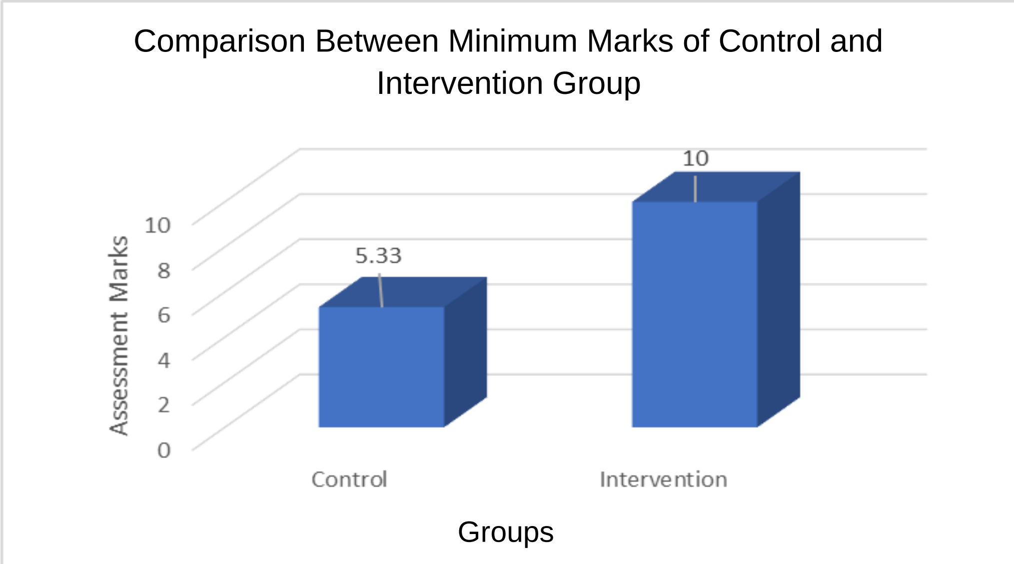

Figure 3: Comparison between Minimum Marks of Control and Intervention Groups

Figure 3 showed the comparison between minimum marks of control and intervention groups. Among three students from the intervention group, all of them achieved 10 out of 10 marks for the 3D skin model video presentation whereby the minimum marks for the control group were 5.33 only.

The result found that the STEM activity helped a lot of cognitive and affective domains for students to get higher marks compared to students who did not involve in STEM activity. Besides that, STEM activity improved presentation and critical thinking skills of the students during the presentation. It was proved by this online STEM activity that it helped students to achieve excellent marks due to the learning outcome being clearly specified and also improved the development of communication skill.

It was also supported by a study conducted by Jamali et. al. (2022), which mentioned that STEM education can improve the quality of education and future works in this area were really recommended and supported. Computing education has also become a crucial part of STEM due to the growing significance of digital technology in daily life. Artificial intelligence, data analysis, and coding are now fundamental talents that students need to succeed in a technologically advanced environment rather than specialized ones. Including computing education in the curriculum helps students become informed citizens who can assess the ethical and sociological ramifications of technological breakthroughs in addition to preparing them for future employment.

The pressing need to address global sustainability concerns is reflected in environmental education, another important hotspot that Jamali et al. (2022) discovered. Teachers can foster a feeling of environmental stewardship and motivate action by including students in projects pertaining to conservation, climate change, and renewable energy. In this situation, project-based learning is a useful method for incorporating environmental issues into the curriculum. Teachers can build a more impactful, inclusive, and engaging learning environment that equips students to succeed in a world that is changing all the time by adopting these trends (Yang et al., 2024 and Jamali *et al.*, 2022). Through cooperative projects that examine regional environmental problems, suggest fixes, and carry out initiatives, students can get a greater comprehension of ecological systems and how they relate to human activity.

Implementing STEM (Science, Technology, Engineering, and Mathematics) approaches in education has shown remarkable success in enhancing student engagement. Dewi et al. (2024) highlighted that by emphasizing hands-on learning, inquiry-based exploration, and interdisciplinary connections, STEM methodologies make the learning process more dynamic and interactive. These approaches encourage students to tackle real-world problems, fostering critical thinking, creativity, and collaboration. For instance, integrating technology and engineering principles into science or math lessons allows students to see practical applications of theoretical concepts, making the material more relevant and engaging.

Moreover, STEM approaches create opportunities for students to develop essential 21st-century skills such as problem-solving, adaptability, and teamwork. These strategies often involve project-based learning, which immerses students in tasks that mimic professional scenarios, promoting deeper understanding and retention of knowledge. By shifting the focus from passive absorption of information to active participation, STEM education not only improves academic outcomes but also inspires a passion for learning, preparing students for future challenges in an increasingly technological and interconnected world.

Conclusion

As a conclusion, the STEM education is categorized as a comprehensive and interdisciplinary education which consists of four disciplines. It involves science, technology, engineering and mathematics that emphasizes the cross-fertilization of multiple disciplines and striving to improve the overall quality of students. Creative teaching strategies and changing educational highlights the significance priorities in influencing how people learn in the future. With its focus on active participation and real-world application, project-based learning fits very well with STEM's increasing emphasis on early childhood, computer, and environmental education. In this study, online STEM activity based on 3D models of anatomy skin proved that the performance level of students among intervention group provided a positive impact. Students were able to relate the structure to the function for fundamental physiological processes based on the assignment method. Hence, suggestion for future research to be conducted in a larger group of students' samples.

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