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**Research Article**

# Creating a Virtual Community in the Course 'Implementations of STEM in Business for SDGs': A Case Study on Sharing Engineering and Technology Concepts

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**ABSTRACT**

The United Nations' Sustainable Development Goals (SDGs) aim to foster global sustainability, with engineering and digital technologies playing a crucial role in achieving these objectives. The course "Implementations of STEM in Business for SDGs" integrates Science, Technology, Engineering, and Mathematics (STEM) knowledge, focusing on how engineering principles can be applied to develop business concepts that support the SDGs. This study evaluates the use of a Metaverse-based virtual environment, where 139 undergraduate students across five semesters, from 2022 to 2024, presented and discussed their projects in a virtual exhibition. Analysis of the students' projects showed that SDG9 (Industry, Innovation, and Infrastructure) was the most selected goal at 16.23%, followed by SDG11 (Sustainable Cities and Communities), SDG13 (Climate Action), and SDG7 (Affordable and Clean Energy) at 13.91%, 13.62%, and 13.33%, respectively. Many students selected multiple SDGs for their projects, offering valuable insights into their business development trends. From the evaluation of the 35 current students who tested the Metaverse platform, the average satisfaction rate was 81.5%. These findings suggest that the Metaverse can be an effective tool for enhancing online learning environments and promoting interaction and knowledge exchange between students and instructors.

**Keywords:** Sustainable Development Goals (SDGs), Science Technology Engineering and Mathematics (STEM), Metaverse, Virtual Community, 21st Century Skills.

## 1) INTRODUCTION

### (a) Sustainable Development Goals (SDGs)

The Sustainable Development Goals (SDGs) comprise 17 interconnected global objectives established by the United Nations General Assembly in 2015, aimed at addressing the most pressing challenges faced by humanity. These objectives address a diverse array of social, economic, and environmental challenges, including the elimination of poverty (1) in all its forms everywhere, ensuring food security (2) while enhancing nutrition and promoting sustainable agriculture. Additionally, they focus on ensuring good health and well-being (3) for all individuals, providing quality education (4) and offering lifelong learning opportunities, while striving for gender equality (5) and empowering all women and girls. The SDGs also highlight the need for clean water and sanitation (6) for all, affordable and clean energy (7), decent work and economic growth (8), and the building of resilient infrastructure (9) to support sustainable industrialization and encourage innovation. Reducing inequalities (10) both within and among countries, making cities and communities (11) inclusive, safe, resilient, and sustainable, and ensuring responsible consumption and production patterns (12) are also essential elements. Moreover, taking urgent action to combat climate change (13) and its repercussions, conserving and utilizing the oceans, seas, and marine resources (14) sustainably, and protecting life on land (15) through sustainable management of ecosystems are vital goals. Furthermore, promoting peace, justice, and strong institutions (16) and strengthening global partnerships (17) for sustainable development are key aspects emphasized by the SDGs. The primary objective of the SDGs is to establish a more sustainable and equitable world by the year 2030, and they serve as a framework for countries to align their policies and actions towards achieving this vision. Each goal is accompanied by specific targets and indicators, enabling nations and organizations to measure progress and effectiveness while fostering partnerships and collaborative efforts to tackle global challenges. The SDGs emphasize the importance of integration; they acknowledge that progress in one area can significantly affect outcomes in others, promoting a holistic approach to sustainable development.

### (b) Metaverse in Education

The Metaverse is a collective virtual space formed by the merging of enhanced physical reality and persistent virtual reality. It has emerged as a transformative digital ecosystem that represents the next evolution of the internet, facilitating immersive experiences through virtual and augmented reality. The Metaverse enables users to engage with a computer-generated environment and interact with other users in real-time, thereby creating opportunities for social engagement, education, and commerce. As businesses and educational institutions investigate the possibilities offered by the Metaverse, its impact on various sectors becomes increasingly evident, particularly in enhancing collaborative efforts, improving learning experiences, and fostering innovation. Furthermore, the Metaverse aligns with the Sustainable Development Goals (SDGs) by promoting accessibility to education and training resources, providing platforms for sustainable business practices, and fostering global partnerships. Understanding the intersection of the SDGs and the Metaverse is crucial for leveraging these technologies to drive meaningful progress towards sustainable development.

### (c) Course on Implementation of STEM in Business for Sustainable Development Goals

Course 888350: Implementation of STEM in Business for Sustainable Development Goals is a major elective course in the Bachelor of Science (B.S.) in Digital Innovation (International Program) offered by the International College of Digital Innovation, Chiang Mai University, Thailand. This course enables students to learn about implementing Sciences, Technology, Engineering, and Mathematics (STEM) in businesses to contribute to the 17 Sustainable Development Goals (SDGs). The course emphasizes the integration of digital technologies with other scientific fields to create innovations that support business operations and sustainable development. Among the topics covered, Engineering Technology plays a vital role in helping students apply its principles to initiate business ventures.

The course content incorporates STEM and other knowledge domains, including Mathematics, Chemistry, Computer Science, Biology, Physics, and Engineering. Engineering accounts for 20% of the total course content. It explores how engineering technology can contribute to various SDGs, the trends of its application in starting businesses, and real-world examples of startups in this area.

Students are assigned an individual task where they select an existing startup business related to engineering technology, explain their interest in it, and propose ideas or solutions to improve the business using engineering technology. Students must then align their new business idea with relevant SDGs by specifying which of the 17 SDGs their idea can help achieve. Finally, they prepare a report using tools like PowerPoint or Canva and present their ideas in class.

After the class presentations, students submit their presentation files to the instructor. These files are then compiled and shared with other students as learning resources. However, sharing these resources through traditional online drives or cloud platforms may lack engagement and appeal. Therefore, there is a proposal to showcase students' work on Metaverse platforms, which offer interactive and visually attractive features. This new approach is expected to enhance students' interest and engagement in learning.

## 2) LITERATURE REVIEW AND RESEARCH METHODOLOGY:

The exploration of metaverse technology in higher education has gained significant traction in recent years, highlighting its potential to transform learning environments [1]. A study examined the factors influencing students' intentions to utilize metaverse-based learning environments. By analyzing data from a sample of 226 higher education students, the study identified that Perceived Ease of Use (PEU), Perceived Usefulness (PU), and Perceived Enjoyment (PE) significantly impact students' Intentions to Use (IU) such environments. This research contributes valuable insights into understanding the users' experiences with digital tools, highlighting how satisfaction within virtual environments can enhance active learning engagement.

In a study conducted in 2023 [2], the interconnectedness between Education 4.0 and Classroom 4.0 was explored, emphasizing the importance of integrating innovative technologies for effective learning experiences. Data collected from students and educators revealed that utilizing advanced technologies significantly boosts student engagement and decision-making. Additionally, establishing collaborative learning communities was identified as a crucial factor in fostering innovative learning approaches, enabling educational practices to adapt to emerging challenges.

In 2023, a study found that the metaverse significantly enhances students' learning experiences, even though it may not directly correlate with improved academic outcomes [3]. Experimental activities demonstrated that students exhibited heightened levels of engagement and creativity, which expanded their ability to learn through innovative methods. These findings suggest that employing the metaverse as an educational tool can foster deeper content engagement and comprehension of subject matter.

Moreover, a narrative review conducted in 2023 provides valuable insights into the application of existing literature to learning in the metaverse [4]. The study analyzes essential issues related to effective design, interaction creation, and management of learning experiences. By drawing on relevant research, it aims to establish a framework for developing learning environments that stimulate student interest and cater to the needs of contemporary learners through engaging experiences.

Finally, a systematic literature review conducted in 2024 reveals that the integration of technology in educational settings can advance educational development, despite challenges posed by rapid technological changes [5]. The findings suggest that students can create stimulating learning experiences that effectively enhance educational outcomes. This review provides insightful recommendations for improving curriculum delivery in higher education, addressing the challenges and demands faced by learners in the digital age.

Therefore, metaverse technology is essential for improving the effectiveness of teaching and learning processes. This research will focus on the dissemination of student works through the metaverse platform, involving several key steps in the research process. These steps include assigning tasks to students, collecting their work files, selecting the appropriate metaverse platform, designing the virtual space, uploading presentation files, creating a survey to assess the usability of the metaverse platform, and analyzing the results to summarize the level of satisfaction regarding its use.

The assignment titled "Engineering in Business for Sustainable Development Goals" was conducted as part of the course 888350. Data were collected from a total of 139 undergraduate students over five semesters, spanning from 2022 to 2024. The process involved the following steps:

- **Assigning Tasks to Students**: This individual assignment required students to select an existing business and explain their reasons for choosing that particular business. Students were then tasked with conceptualizing ideas for improving the selected business using engineering technology. They had to identify which specific SDG goals their innovations would support. As illustrated in Figure 1, the students were provided with clear guidelines and examples to aid their understanding of the assignment requirements. The work was to be presented in a presentation file, followed by an in-class presentation.
- **Collecting Work Files:** The presentation files were collected, and the research team converted these files into PDF format to ensure compatibility with the metaverse platform environment.
- **Selecting the Appropriate Metaverse Platform:** A suitable metaverse platform was selected from various available options, with Spatial being the chosen platform due to its features that support effective presentation.
- **Designing the Virtual Space:** The design of the exhibition space or room needed to be adequate and engaging to attract attention. This included considerations for layout, aesthetics, and interactive elements.
- **Uploading Presentation Files:** The presentation files were organized and uploaded into categorized sections within the metaverse platform, facilitating easier navigation for participants.
- **Creating a Survey to Assess Usability:** Students were given the opportunity to explore the metaverse space and complete a survey assessing their satisfaction with the usability of the metaverse environment.
- **Analyzing Results to Summarize:** The feedback collected was analyzed across various aspects, including accessibility, arrangement of the presentations, visual appeal, levels of engagement, and the overall learning atmosphere fostered by the metaverse experience.

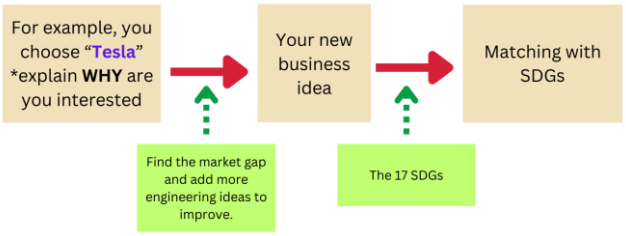


**Figure 1** Task Assignment Process

The Spatial Metaverse Platform was selected as the virtual space to create exhibition rooms for student projects, allowing for a distinctive space to be allocated for each semester. Each exhibition room is interconnected through a portal, facilitating easy navigation between different semesters. The design of these spaces is akin to an exhibition hall showcasing presentation files, where students can access and explore the exhibits from anywhere at any time. This flexibility enhances the accessibility and engagement of the virtual showcase, enabling a broader audience to appreciate the student work as illustrated in Figure 2.


**Figure 2** Virtual Community in Metaverse

### 3) Results:

The results obtained from the data analysis are categorized into two main sections: insights concerning the Sustainable Development Goals (SDGs) and the assessment of student satisfaction regarding the use of the virtual exhibition space.

**Information Related to SDGs:** The analysis revealed that a significant number of students chose to improve businesses related to SDG 9, which focuses on Industry, Innovation, and Infrastructure, with a total of 56 selections, accounting for 16.23%. This was followed by SDG 11, which emphasizes Sustainable Cities and Communities, with 48 selections; SDG 13, centered on Climate Action, with 47 selections; and SDG 7, which pertains to Affordable and Clean Energy, with 46 selections, corresponding to 13.91%, 13.62%, and 13.33%, respectively. These findings are illustrated in Figure 3, highlighting the distribution of student preferences across the SDGs.

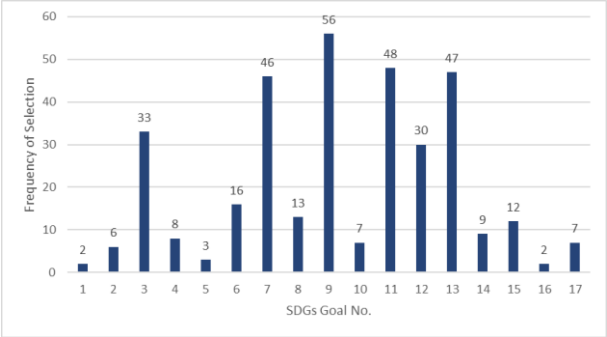


**Figure 3** SDG selection from assignment

**Student Satisfaction Assessment:** From the feedback collected from a current cohort of 36 students, an overall satisfaction rate of 81.5% was reported. The assessment included several specific evaluation criteria:

The platform can be used as a space for collecting and displaying student assignments.
The platform offers an engaging 3D exhibition experience utilizing modern Metaverse technology.
The platform serves as a prototype for creating virtual spaces applicable to other content areas.
The platform is a valuable tool for supporting course content related to 888350: Implementation of STEM in Business for Sustainable Development Goals, particularly within the engineering context.
The platform systematically organizes student projects for each registered semester via a well-structured portal, facilitating easier access.
The platform enhances student engagement by creating activities that improve their skills in utilizing digital platforms within the Metaverse.
Overall, students expressed satisfaction with the virtual space created for showcasing their work.

These results indicate a positive reception of both the alignment of student projects with the SDGs and the effectiveness of the metaverse platform in enhancing the educational experience.

**4) Discussion:**

The analysis of the student assignments revealed that most projects focused on improving businesses related to SDG 9, which emphasizes Industry, Innovation, and Infrastructure. This was followed by SDG 11, which addresses Sustainable Cities and Communities, SDG 13, centered on Climate Action, and SDG 7, which pertains to Affordable and Clean Energy. This trend indicates that there is a significant inclination among students to apply engineering knowledge in enhancing infrastructure and smart city initiatives. Examples of the projects selected for analysis included autonomous vehicles, electric vehicle charging stations, electric vehicle batteries, delivery drones, AIoT (Artificial Intelligence of Things), and renewable energy solutions.

Regarding the satisfaction level with the Virtual Community, the majority of students expressed overall satisfaction with its use. However, there were some comments indicating a desire for a more engaging and visually appealing exhibition environment. Suggestions included introducing more interactive elements and considering the use of alternative Metaverse platforms that offer faster rendering capabilities and a broader range of functional interactions compared to Spatial. These insights highlight areas for improvement in creating a more immersive and effective virtual exhibition experience for future iterations.

**5) Conclusion and Future Work:**

This research has introduced the Virtual Community in the course 'Implementations of STEM in Business for SDGs,' where students were tasked with presenting ideas on how engineering knowledge can be applied to improve or develop businesses in alignment with the SDGs. A total of 139 undergraduate projects were collected from five semesters covering the period from 2022 to 2024. The findings indicate that students displayed the greatest interest in SDG 9 (Industry, Innovation, and Infrastructure). Additionally, current students were given the opportunity to evaluate the usability of the platform developed on Spatial, and they reported a good level of satisfaction with the platform.

Future works will focus on applying the metaverse platform in various areas, such as creating virtual classrooms to enhance interaction and foster new learning experiences. Careful design and selection of platforms will be implemented to ensure they are suited to the intended applications.

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