Empowering Community Engagement through Service-Learning: Technology-Assisted UUM@Community STEM Sustainability Program

Masnita Misiran[1,3*], Nor Idayu Mahat[1], Hasimah Sapiri[1], Massudi Mahmuddin[2], Zahayu Md Yusof[1,3] and Suhaida Abdullah[1]

[1]School of Quantitative Sciences, Universiti Utara Malaysia, Malaysia
[2]School of Computing, Universiti Utara Malaysia
[3]Centre for Testing, Measurement and Appraisal, Universiti Utara Malaysia
**Corresponding author: Masnita Misiran (masnita@uum.edu.my)*

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ABSTRACT

Living sustainably requires a paradigm shift toward empowering individuals and communities through effective knowledge transfer and engagement. This study presents a structured framework for the UUM@Community STEM Sustainability Program, utilizing a service-learning approach to promote awareness of selected sustainable development goals (SDGs). The framework was developed using the Design and Development Research (DDR) approach, encompassing stages of Analysis, Design, Development, Implementation, and Evaluation. A personalized dashboard was created to monitor program effectiveness, allowing for continuous improvement through feedback and data analytics. Findings demonstrate the framework's capacity to enhance community engagement and empower participants through structured processes and digital tools. The study contributes to the body of knowledge by providing a replicable framework for technology-assisted community outreach and suggests future enhancements such as integrating AI-powered tools and expanding collaboration networks.

Keywords
Service-learning; STEM education; Sustainability; Technology-assisted platform; Knowledge transfer

Introduction

Living sustainably is crucial in making sure that the survival of beings and resources on earth can be managed and maintained forever. A day-to-day living on earth activities cannot be seen as exploiting available resources as if they are replaceable. We cannot also adopt the survival-of-the-fittest mentality, of which people with means secure as many advantages they can, leaving behind those in the vulnerable groups to be doomed for destruction. On the other hand, those in the vulnerable group adopt a welfare mentality, waiting to be rescued indefinitely by someone other than themselves. People need to be aware that every individual is capable of designing the world for the betterment. Empowerment can be achieved by those in the most power, as well as by those with less. The accountability of living sustainably is not a one-man show, it is a collective effort from those with the given intellect (*homo sapiens*) in every community.

Empowering communities has been shown to enhance sustainable living. Taysim and Ayanlaja (2020) highlight how community and parental empowerment reduced the achievement gap between Black and white children in the US. Cislaghi (2018) observed that empowering communities improved gender inclusivity in political movements. Additionally, recent studies such as Yusuf *et al*. (2023) emphasize that community empowerment in urban planning enhances citizen engagement in sustainability efforts. Rosales et al. (2023) also show that empowering communities strengthens local resilience in addressing sustainability issues. Ding and Lee (2024) further demonstrate that psychological empowerment significantly promotes consumer participation in sustainable practices, highlighting the broader impact of empowerment on sustainability. A more dynamic example of how community empowerment can shape the landscape of conventional industry can be seen through the new business entity based on sharing platforms such as Airbnb (Stabrowski, 2017; Sharp, 2018), e-hailing rides (Malik & Wahaj, 2019; McNaughton *et al*., 2020), and e-commerce platform of buy and sell (Rosyadi *et al*., 2020; Xiao *et al*., 2020; Chen, 2021). A more relatable

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success story at home (Malaysia) shows the improved management of zakat through the channeling of funds into a more emphasis on community development (Müller, 2017).

Recent Western studies have also highlighted the significance of integrating service-learning into STEM education to enhance community engagement. For instance, Tripon (2024) discusses how service-learning activities in STEM curricula foster inclusive practices and gender equality in rural settings. Similarly, Vance-Chalcraft et al. (2024) explore the intersection of participatory science, social justice, and higher education, demonstrating how community collaborations can enhance both learning outcomes and civic engagement.

Increased awareness, together with the action towards living sustainably is the only way moving forward. The shifting mentality among individuals in all levels, from survival mode, should be geared toward sustainable living. This paradigm shift should be emphasized from cradle to grave. As the university is a campus that accommodates young and energetic individuals, living in the campus should be primed, where the paradigm shift should start to take place, effectively. Moran (2019) in his book has emphasized positive long-term benefits for the young adults that undergo service learning curricular activities, of which such programs enable students to position themselves in a protagonist setting in the community, as well as strengthening their life purpose. Similarly, Vargas and Erba (2017) found that both the undergraduate students and the community (i.e., working-class high school Latino/a student's) reaped benefits from community outreach programs through the service-learning program. The undergraduate students enhanced their cultural competence skills, awareness of social issues, and a sense of civic responsibility. Whereas, high school students develop self-confidence, self-esteem, and a sense of self-efficacy.

In doing so, a proper framework should be identified to ensure that the interconnectivity of resources, stakeholders, and partners on campus, each can play their effective roles. A program that is sustainable, and impactful should become the goal in every community outreach program. This way, all stakeholders involved will themselves feel empowered, believe in their sense of contribution, with the outreach community will get a personalized program that is most relatable and beneficial for them. Levkow *et al*. (2019) investigated the community outreach program in Canada, where the partnerships between the in-class program through service learning platform and national non-profit organizations have successfully built healthy, equitable, and sustainable food systems on campus through the Good Food Challenge movement. Sharing a similar sentiment, Jettner *et al*. (2017) believe that strategic partnerships are the key factor for the continual success of such a program, although the measurement on the success of the program, in particular on the subjective assessments (for example, the measurement on social cost, returns, and impact) is yet to be fully explored.

This study showcases a community outreach program that utilizes the service-learning approach, conducted in a personalized setting during the pandemic era. It intends to increase the awareness among the public on selected sustainable development goals laid by the United Nation, while simultaneously empowering those involved in the program. In this program, we construct a framework that identifies all stakeholders and target communities. The program is designed in such a way that the students' works are recognized through fair assessments, certain identified skills can be acquired, and the feedback from the community involved to be captured for continuous monitoring purposes. Special acknowledgments are also given for a group of students with exceptional deliverables.

Methodology

The development of the UUM@Community STEM Sustainability Program framework followed the Design and Development Research (DDR) approach, which emphasizes the iterative process of designing, developing, and evaluating interventions to meet specific educational or societal needs. This approach was chosen due to its suitability for creating and refining educational frameworks and technological tools aimed at enhancing community engagement.

Stages of Framework Development

Analysis:

- Identifying the need for a structured framework to enhance community engagement and promote sustainable development goals (SDGs).
- Reviewing relevant literature on community engagement, service-learning, and sustainable practices.

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- Consulting with stakeholders, including university experts, students, community members, and partners, to gather insights and requirements.

Design:

- Developing a conceptual model that incorporates key principles of service-learning and community engagement.
- Outlining the variables involved in the framework (e.g., Mobilizer, Energizer, Funder, Validator).
- Creating a blueprint for the analytics dashboard to monitor and assess program effectiveness.

Development:

- Constructing the framework based on the identified variables and their interactions.
- Designing the analytics dashboard using accessible digital platforms for ease of use and adaptability.

Implementation:

- Applying the framework in the UUM@Community STEM Sustainability Program with real participants (e.g., students, community members).
- Collecting data through surveys, feedback forms, and dashboard analytics to evaluate the framework's effectiveness.

Evaluation:

- Assessing the framework's performance through qualitative and quantitative measures.
- Refining the framework based on participant feedback and monitoring results.

The application of the DDR approach ensured that the framework was systematically developed, validated, and refined to address the identified needs and challenges of community engagement. The construction of the dashboard was a direct outcome of this structured process, allowing for efficient monitoring and evaluation of the program's impact.

Sustainability Program Framework

This framework is formulated to guide the operation of a community outreach program on campus for synergy efforts among stakeholders to ensure impactful stem activities towards UN sustainable development goals 2030. The framework describes a step-by-step process that enables an impactful program towards a quintuple helix approach with a detailed system for monitoring the success of the program. It aims to create an impactful and sustainable program on campus. The framework may assist community outreach programs on campus to identify stakeholders' roles, construct structured process flow in operational, and secure impactful outputs.

A personalized dashboard enables the monitoring processes throughout the stages. The framework consists of 3 key elements that are important to guide community outreach programs in designing a comprehensive quintuple helix program that is based on stem and sustainability goals. 1) tactical process this process consists of 3 core stages (partners, processes, and output). 2) monitoring analytics an analytics dashboard is prepared that is user-friendly, dynamics, interactive, and accessible to utilize data, recognize challenges (and opportunities) of the project. 3) shared values proposition the shared values among stakeholders involved to be captured to cement the spirit of SDG 2030, towards the betterment of human beings and the earth. The outlined steps in this framework would clearly define the role of stakeholders, the expected outputs, and the receiving benefits. An established framework will reduce waste in resources (i.e., time, talents, funds, etc.) while conducting the program.

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The framework is not a modification from any existing model. The framework follows the standard mathematical function below.

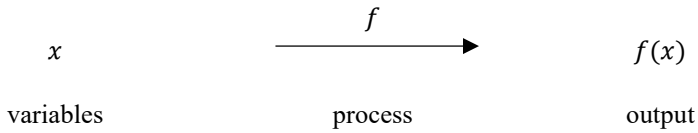

Figure 1. Mathematical Function

The variables in the input element are as follows:

Table 1. Variables in input elements

Variables	Functions
Mobilizer	Mobiler sets the tone for a suitable program that is feasible to be conducted. They should come from people that are familiar with content development, delivery, and well versed in issues under care. Mobilizer can be in a team of different expert backgrounds to ensure the program's effectiveness and relevancy.
Energizer	Energizer should be identified among a group of people that is suitable for sustainable community outreach. Students in the formal classroom can play this role to coincide with the relevancy of their current study and assessment while exploring altruism skills through disseminating knowledge to the community. The in-class program will ensure the continuation, improvement, and monitoring progress of the program, thus maintaining the sustainability of the program.
Funder	Funder acts as a provider for financial assistance to ensure the smoothness of the program. The funds can be used for transportation purposes, the creation of the content, supporting materials, and can also be in a form of incentives, i.e. prizes, gifts, food allowance, etc.
Validator	The validator acts as a measuring stick, the check-and-balance of the program. Their participation in the program can be included in any phase during the program. Inputs from validator can be utilized for ongoing improvement of the program.

These variables are keys as inputs for the sustainable program. Their active roles are needed to ensure the content delivery, targeted participants, and the sustainable program can be properly aligned for smoothness, impactful and sustainability for all parties involved.

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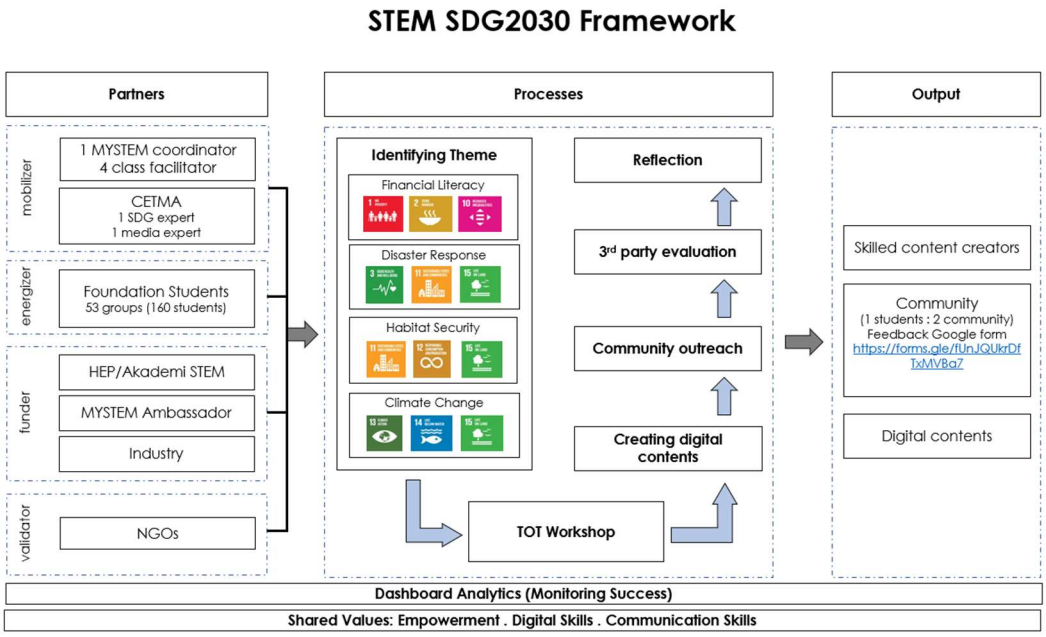

Figure 2. STEM SDG2030 framework (IP: LY2021P06351)

In this program, an elementary course, AQ0013 Fundamental Mathematics 1, from UUM Foundation Studies is selected. This is a core course that should be enrolled by all foundation students. The students who undertake foundation studies are selected from among the high achievers in their final results in high schools, thus their energy and motivation are high, with a strong sense of accomplishment are expected from this group of people. Thus, the task is deemed suitable for this group to deliver with much ease and impact.

The Activity Instructions

In this activity, our main objective is to increase our ongoing effort in the engaging community through shared knowledge learned in the university. In this program, we will engage the targeted community in the hope to increase their level of knowledge and awareness through selected themes below:

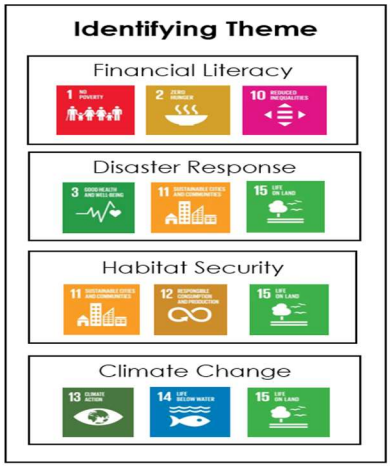

Figure 3. Theme

In these tasks, you need to skim through the chapters in your Fundamental Mathematics I's book and select only ONE (1) subtopic that you like the most. Once you select the topic of your choice, follow through the detailed instructions below:

1. Use your imagination to create an activity that can be conducted in 30 – 40 minutes. This activity aims to create awareness and increase knowledge among your selected participants based on your selected themes.
2. Use the prepared activity in #1 and approach the selected participants for the outreach program. The program should be conducted online, with the ratio of 1 student to 2 participants (*1 student:2 participants*).
3. Prepare your report in the provided template: https://docs.google.com/document/d/1hpTTCnAuPx0TYVdq1NGD8ksSv41bKCXJq0Z-yx9utfM/edit?usp=sharing
4. After the program, both participants and student should fill in this feedback form at: https://forms.gle/eMBj8XDeU3kSSwou7

Now that you have engage community with the issue at hand, you understand that it is important to outreach as many people as possible in help to improve the public's knowledge and awareness in your selected theme. Further,

5. Prepare a maximum of 4 minutes video that will be your outreach effort to the public with your theme. The video can be in any form, and in any language (*if other than English, please provide English subtitles*). Please upload your mp4 video to google drive. Make sure the link to google drive can be accessed (unchecked 'restricted').
6. Upload your report (in #3) and video (in #5) through this link: https://forms.gle/pxqGfA4RJwUnXxw89

An Example: Knowledge on Compounding Interest

To help students with more understanding on the instruction, the example of the framework is given to students, readers can refer to Figure 2 entailing the example on category STEM Financial Literacy, with focus topic in the syllabus including the Geometric Series. A recorded video is also prepared for a more detailed explanation of the construction of the program. In this topic of interest, students can develop an awareness of the compounding interest, that utilizes the geometric series as its fundamental construction. By exploring this concept, the community will learn the stark difference in savings when the time factor (in years) is taken into account, with the same amount of money invested. This knowledge, although simple in theory, is hard to apply in practice, and normally being overlooked in the community, resulting in a vulnerable position in personal (and family) finances.

During the pandemic, students are advised to conduct the program in a more personal environment. Peer-based community is in focus, of which, one student will need to identify 2 of his peers for this program. This approach will improve the retention of knowledge, the tabooed topic can be discussed more extensively, and understanding of the subject matter can be increased. This effort aims to increase the level of financial literacy among all members of the community, especially among young adults. Early assumptions of the program include low financial literacy among young adults in Malaysia, as highlighted in Yew *et al.* (2017), Tang Ruxyn (2017), and Mahdzan *et al*. (2019).

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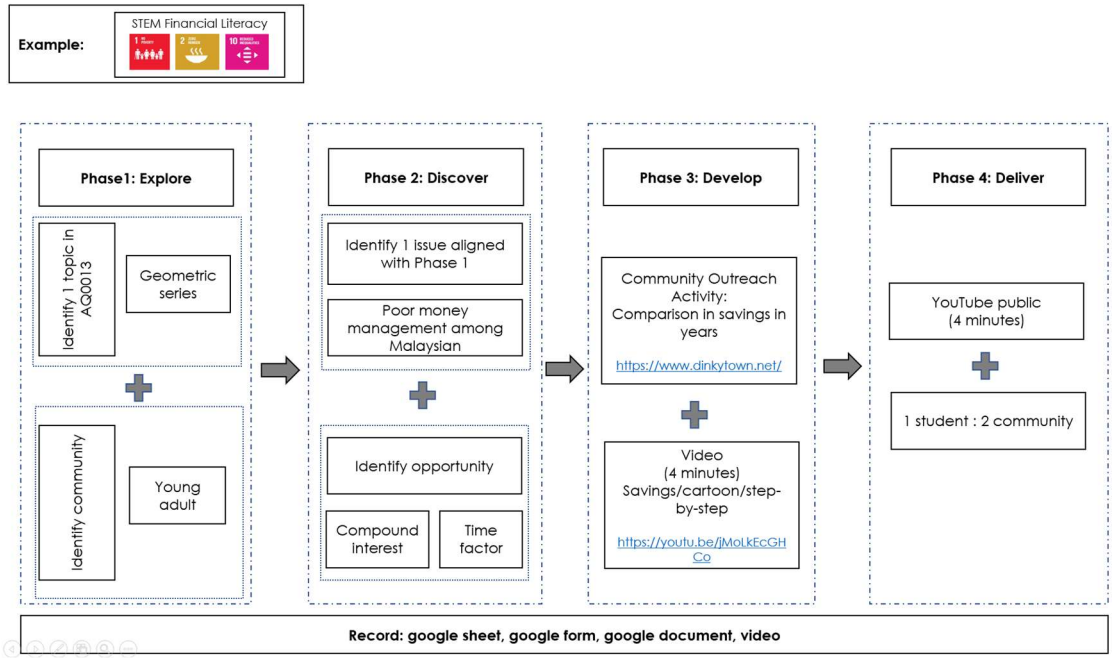

Figure 4. Example of one topic in the syllabus

Results and Discussion

Community Outreach during Pandemic

Pre-program

Students are given early exposure to creating digital media that is impactful for the audience. By utilizing an expert on campus, a mobilizer (1 media expert) is identified to conduct a webinar for this purpose. The two-way workshop is focusing on the do's and don'ts of creating rich digital content that can engage the target audience, is feasible to do, developing branding, and will become a sustain creation.

Figure 5. The workshop on digital media

During Program

Students are given 6 weeks to plan and conduct their program to completion. During the program, lecturers act as facilitators to ensure the coordination of the six classes involved. Continual feedback is also given to students. All resources (video for webinar, explanation on the program, instructions, and templates) are available online with shared links to ensure that students can reassess the needed materials at their convenience. The google-family platforms are utilized as this platform is easy, simple, familiar, and free.

Post Program

Lecturers in each class are assessing their student's work, while the best sixth are selected from each category. The selections are based on standard rubrics across the classes. Once the best sixth has been identified, a dedicated event is organized, funded by program partners, and judged by relevant experts from various stakeholders, the non-profit organization included. Students are celebrated in this event, of which the winner is awarded prize money.

Coordinating Assessment

The ready platform that is cheap and accessible for all is utilized in this program. We use all google-family platforms to accept the submission, deliver templates, and capture data from all stakeholders involved.

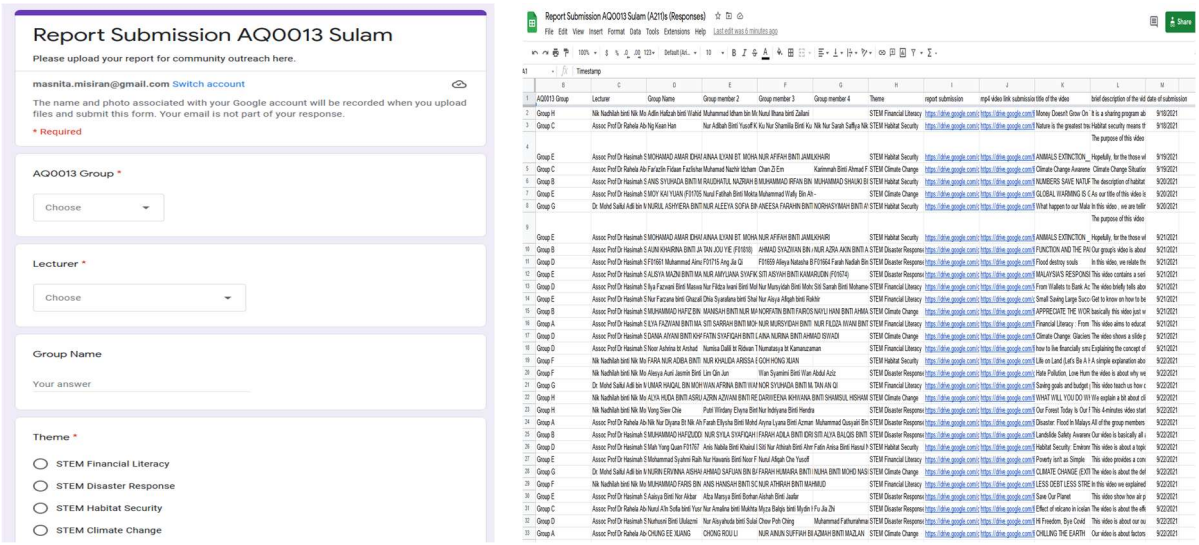

Figure 6. The utilization of google form and google sheet to coordinate submissions for 6 classes

The template for reporting is also standardized and accessible in google documents to make sure that only relevant information is reported. The report document is simple, straightforward, and concise. This way, all groups are clear in the direction of the report and can allocate more time in the outreach community, rather than preparing reports.

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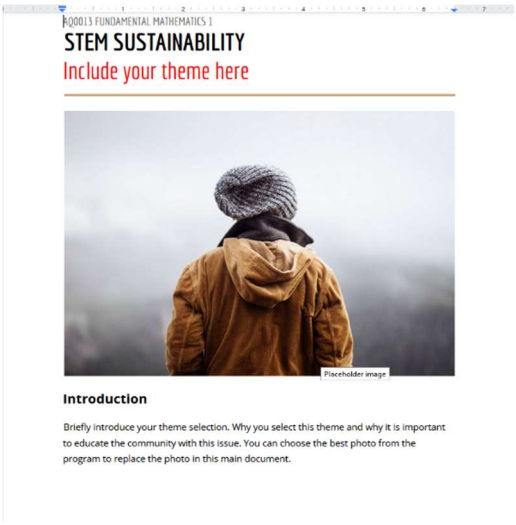


AQ0013 FUNDAMENTAL MATHEMATICS 1

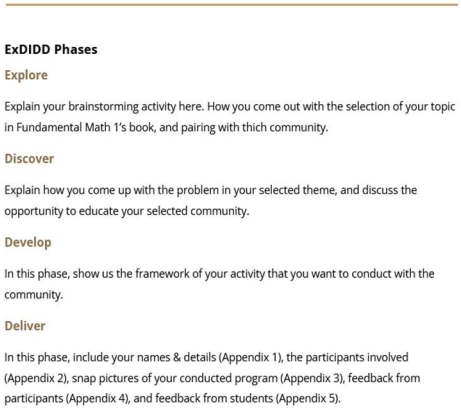
STEM SUSTAINABILITY

Include your theme here

Introduction

Briefly introduce your theme selection. Why you select this theme and why it is important to educate the community with this issue. You can choose the best photo from the program to replace the photo in this main document.

(a)



ExDIDD Phases

Explore

Explain your brainstorming activity here. How you come out with the selection of your topic in Fundamental Math 1's book, and pairing with thich community.

Discover

Explain how you come up with the problem in your selected theme, and discuss the opportunity to educate your selected community.

Develop

In this phase, show us the framework of your activity that you want to conduct with the community.

Deliver

In this phase, include your names & details (Appendix 1), the participants involved (Appendix 2), snap pictures of your conducted program (Appendix 3), feedback from participants (Appendix 4), and feedback from students (Appendix 5).

(b)

Appendix 1

No.	Name	Age	Address
1			
2			
3			

Appendix 2

No.	Name	Age	Address	School/Company
1				
2				
3				
4				
5				
6				
7				
8				
9				

Appendix 3

Include pictures here

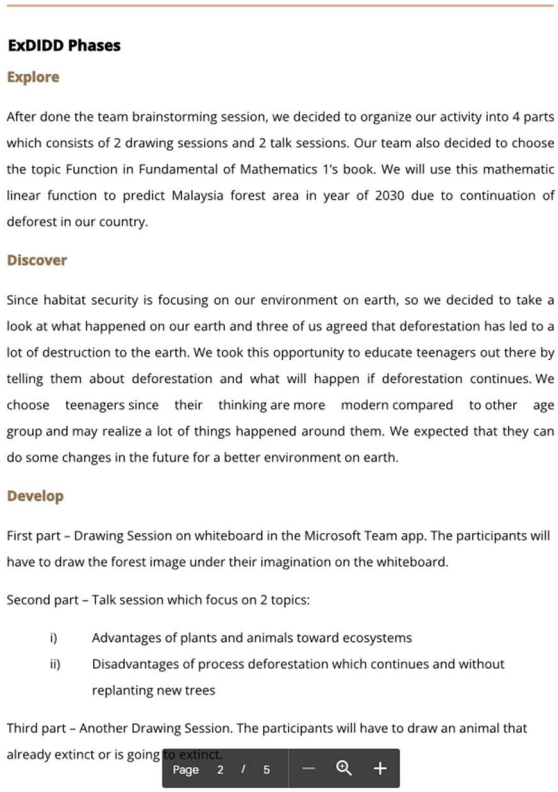
Appendix 4

Should include what participants get, is it a beneficial program, what can be improved, rating, etc.

Appendix 5

Reflect on your journey, what you learn from this experience. What can be improved, etc.

(c)



ExDIDD Phases

Explore

After done the team brainstorming session, we decided to organize our activity into 4 parts which consists of 2 drawing sessions and 2 talk sessions. Our team also decided to choose the topic Function in Fundamental of Mathematics 1's book. We will use this mathematic linear function to predict Malaysia forest area in year of 2030 due to continuation of deforest in our country.

Discover

Since habitat security is focusing on our environment on earth, so we decided to take a look at what happened on our earth and three of us agreed that deforestation has led to a lot of destruction to the earth. We took this opportunity to educate teenagers out there by telling them about deforestation and what will happen if deforestation continues. We choose teenagers since their thinking are more modern compared to other age group and may realize a lot of things happened around them. We expected that they can do some changes in the future for a better environment on earth.

Develop

First part – Drawing Session on whiteboard in the Microsoft Team app. The participants will have to draw the forest image under their imagination on the whiteboard.

Second part – Talk session which focus on 2 topics:

i) Advantages of plants and animals toward ecosystems
ii) Disadvantages of process deforestation which continues and without replanting new trees

Third part – Another Drawing Session. The participants will have to draw an animal that already extinct or is going to extinct.

(d)

Figure 7(a)-(c). The standard template for project reporting
(d). Example of student's reporting based on the standard template

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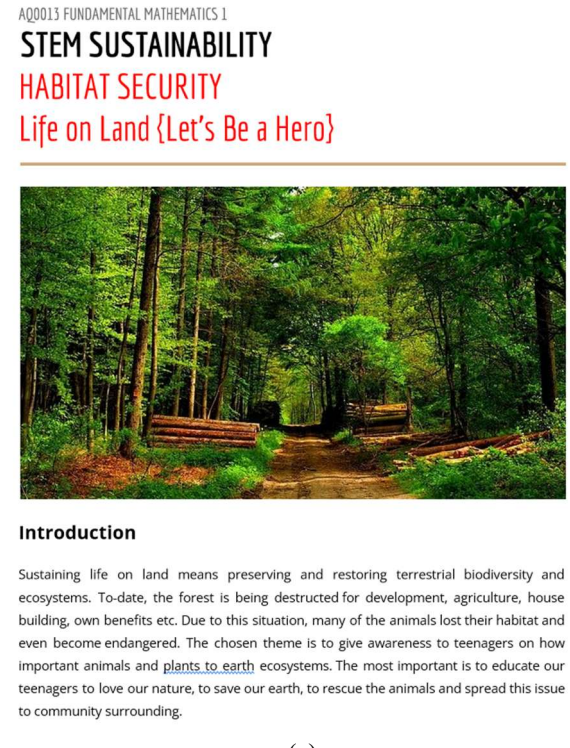
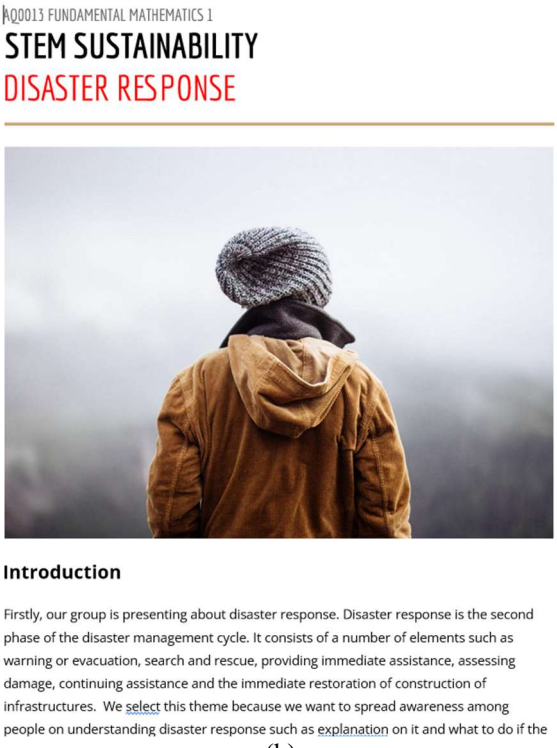


(a)



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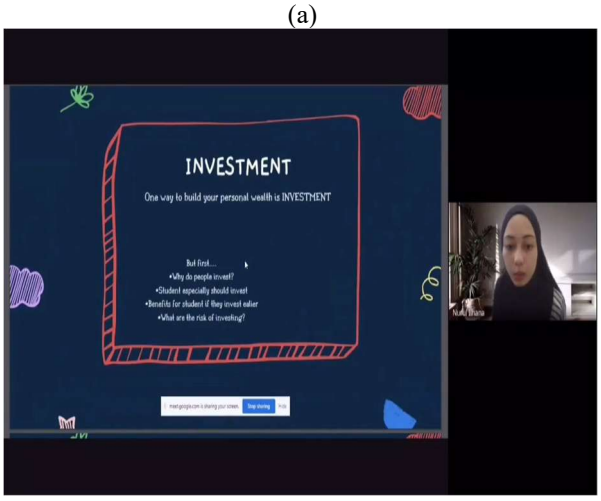

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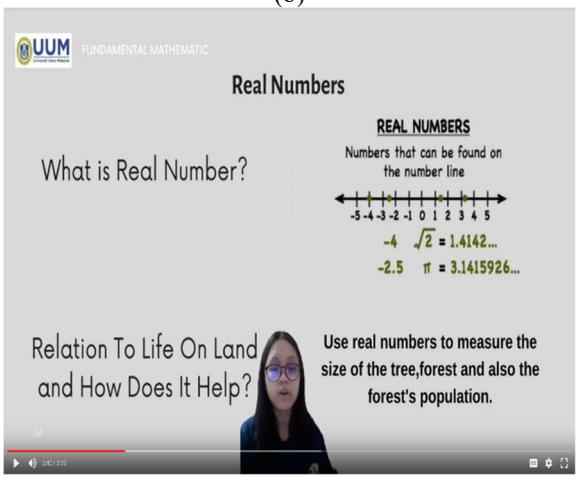

(d)

Figure 8(a)-(c). Screenshot of selected students' work (reports)
(c) – (d). Screenshot of selected student's work (videos)

Monitoring Impact

Among the key elements in a community outreach program is understanding the impact it gives to the participants. For a standalone program with an impromptu mode of conduct, the impact is difficult to measure and assess. This situation results in dissipated impact monitoring and makes it difficult for organizers to make improvements to the available program.

To prevent such a scenario to occur, we develop an analytic dashboard with the intention is to capture the programs conducted, especially programs that are based on sustainability. This way, yearly data can be captured in systematic ways, participant's demographic can be understood visually and more effectively, together with their feedback,

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changes in behavior, as well as some open-ended comments for future improvement. Figure 7 – 9 illustrate the dynamic analytic dashboard for the program.

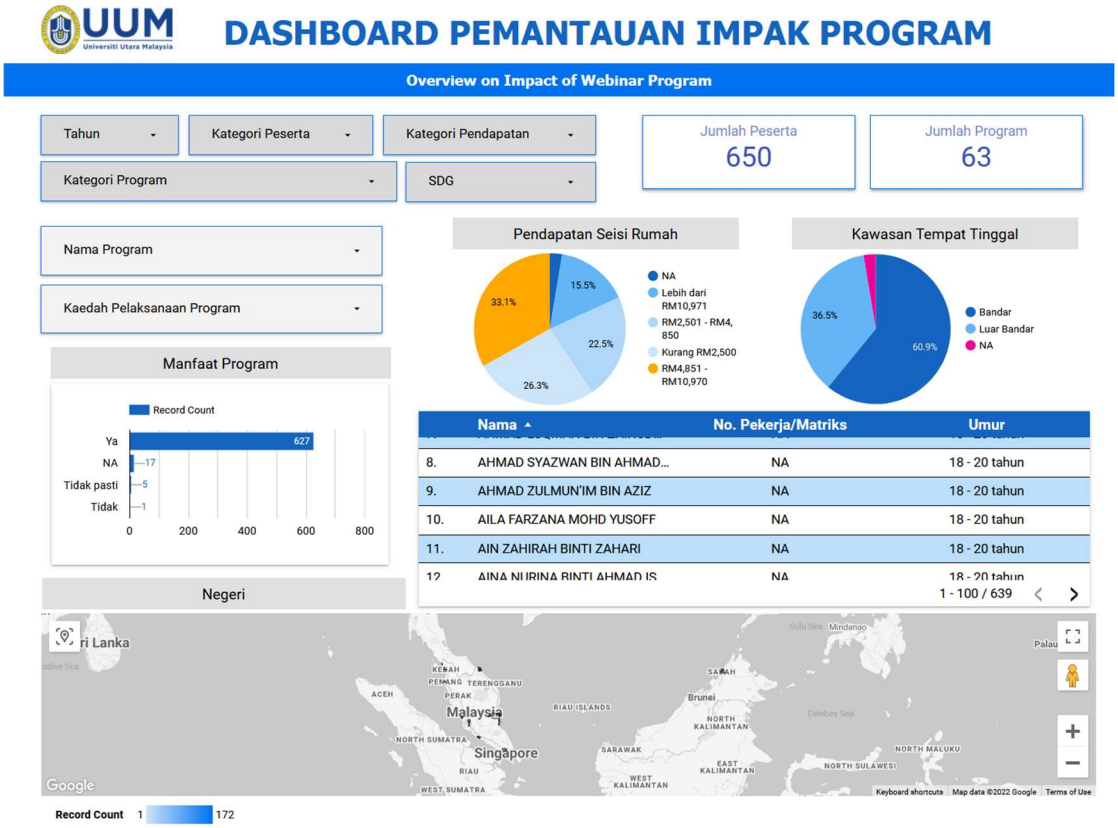

Figure 9. Dashboard for program monitoring

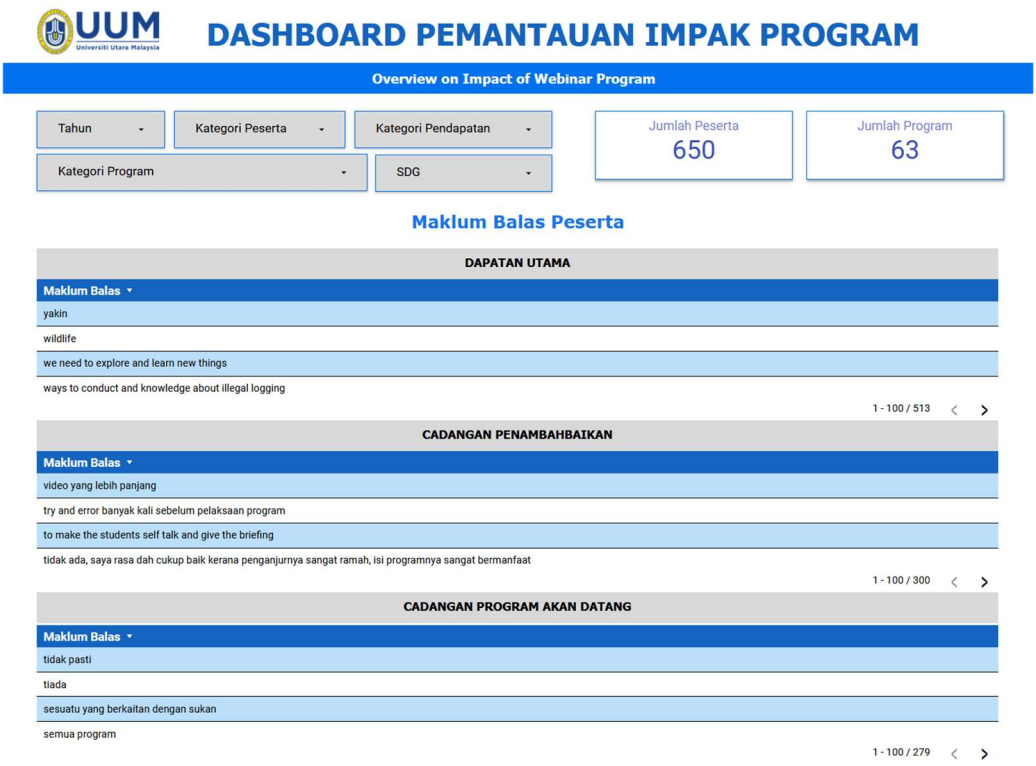

Figure 10. Capturing feedback from participants

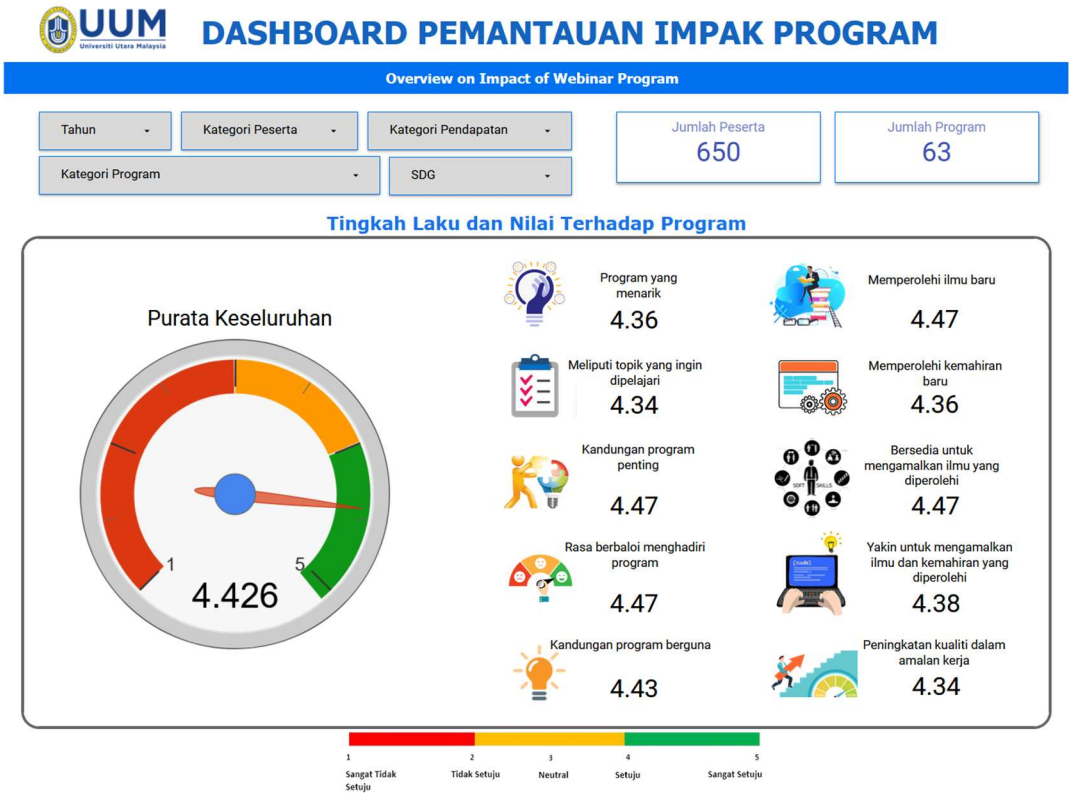

Figure 11. Participants perceived values and increased skills from program

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Acknowledging Success

At the end of the program, students are celebrated and recognized in a dedicated program to showcase their works.

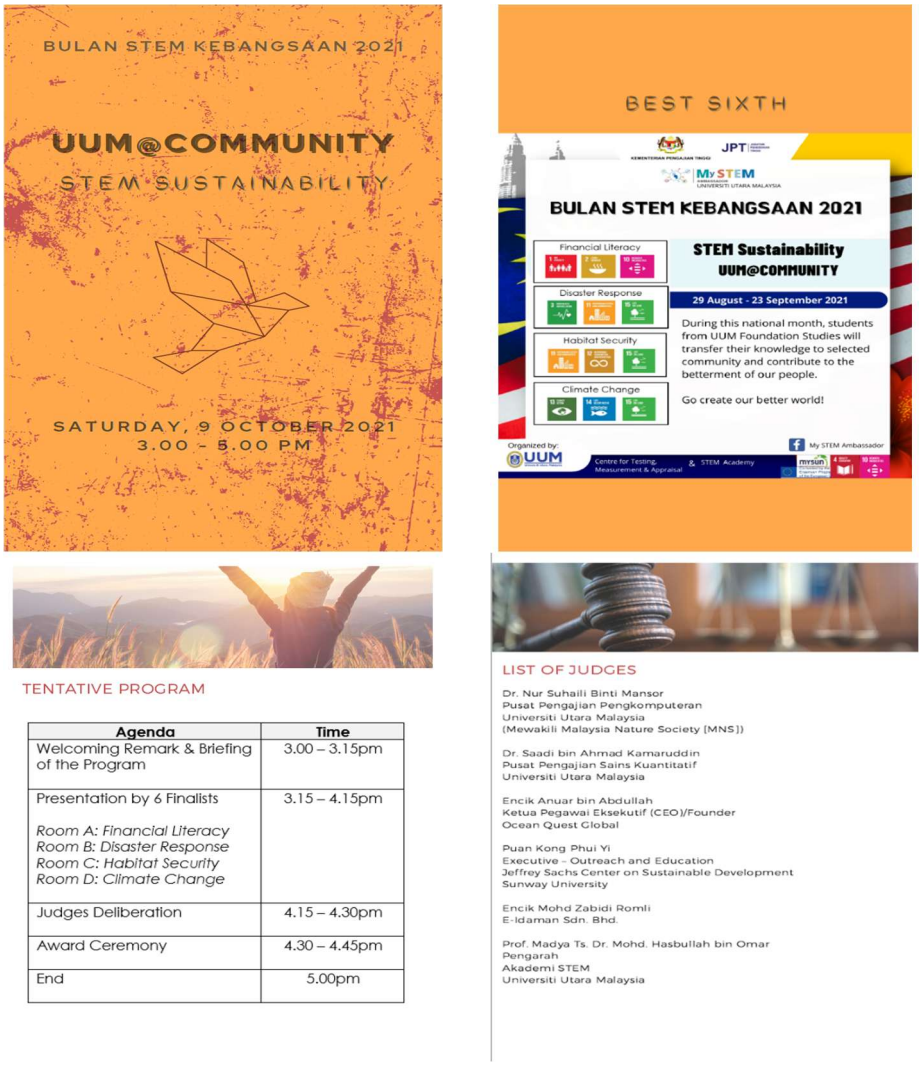

Figure 12. The showcase of student's work

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The best works are presented and evaluated by judges from practitioners, NGOs, and academia. The best three in every category are awarded prizes.

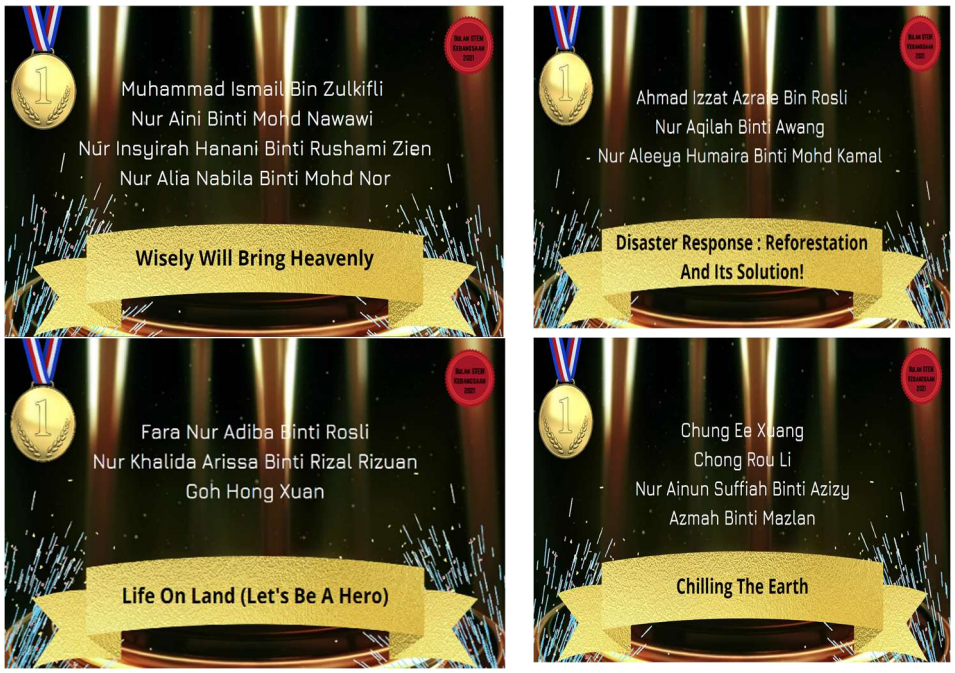

Figure 13. The winners for each category are celebrated with prizes

Leveraging Digital Platforms for Broader Outreach

One promising area for improvement is the integration of digital platforms to facilitate knowledge dissemination, monitoring, and evaluation. By leveraging cloud-based tools and mobile applications, the UUM@Community STEM Sustainability Program can broaden its reach beyond localized communities to include diverse participants from various geographical regions. The adoption of such technologies aligns well with the rapidly growing digitalization of educational methodologies and community engagement.

Integrating Data Analytics for Impact Assessment

A robust data analytics framework can enhance the program's capacity to measure impact and identify areas for improvement. Incorporating advanced analytics tools to track engagement, feedback, and skill acquisition across participants would provide a clearer understanding of the program's effectiveness. Furthermore, integrating AI-powered sentiment analysis and natural language processing (NLP) tools can help capture nuanced feedback from participants, offering deeper insights into their experiences and perceptions.

Expanding Collaboration Networks

The quintuple helix approach could be strengthened by expanding collaboration networks beyond traditional academic and non-profit partnerships. Engaging private sector stakeholders, technology firms, and governmental bodies can provide additional resources, expertise, and credibility to the program. Collaboration with industry partners can also offer valuable mentorship opportunities for students and enhance the practical applicability of their projects.

Recommendations for Future Enhancements

- *Develop a Mobile Application*: A dedicated mobile app could provide a streamlined interface for participants to access resources, submit feedback, and engage in collaborative activities.

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- *Establish Data-Driven Monitoring Systems*: Utilize AI and machine learning tools to enhance the evaluation process, allowing for real-time tracking of progress and outcomes.
- *Expand Partnership Networks*: Reach out to corporate entities and governmental agencies to enhance resource mobilization and create a wider impact.
- *Enhance Training Modules*: Provide students with access to digital content creation tools and workshops focused on effective online engagement strategies.
- *Incorporate Citizen Science Models*: Encourage participants to contribute their own data and observations, fostering a sense of ownership and involvement in sustainability efforts.

These improvements aim to elevate the UUM@Community STEM Sustainability Program's effectiveness and scalability. By embracing technological advancements and expanding collaborative networks, the program can further enhance its contributions to achieving the SDGs.

Conclusion

A well-planned service learning program is helpful towards in making a successful community engagement, hence empowering communities for greater social and economy sustainability. University as a place where experts lay, play an important role to assist in monitoring changes in community hence well development plan can be recognised. Moving forward, this study would look into the opportunity to include some important measurements in the dashboard such as measurement on economic cost, social costs, return on investment (roi), impact, tangible, and intangible community benefits. Besides, enhancement on community empowering program can be geared up through citizen scientists and sustainable framework on this is targeted for future interest.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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