Asian Journal of Assessment in Teaching and Learning
Vol 12, Issue 1, 2022 (63-75) /eISSN 2821-2916

Constructing STEM 3R Activity through Service-Learning Program during Movement Restriction

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Received: 23 March 2022; **Accepted:** 19 May 2022; **Published:** 23 May 2022

To cite this article (APA): Misiran, M., Ahmad, N., Md Yusof, Z., & Misiran, M. (2022). Constructing STEM 3R Activity through Service-Learning Program during Movement Restriction. *Asian Journal of Assessment in Teaching and Learning*, *12*(1), 63-75. https://doi.org/10.37134/ajatel.vol12.1.7.2022

To link to this article: https://doi.org/10.37134/ajatel.vol12.1.7.2022

Abstract

Service-learning is an experiential learning activity that enables mobility from classes in higher learning institutions to be transferred into the community. In this article, we construct a STEM 3R activity that is aligned with school children's curricula to be delivered in an engaging, active, and personalized way. The activity is constructed by using the ExDiDD (Explore, Discover, Develop, Deliver) framework, and is being assessed through dedicated rubrics. Findings suggest improved excitement and interest in STEM education, as well as increase understanding of the environmental issues throughout the activity.

Keywords: Active Learning, STEM, Green Education, Service Learning.

INTRODUCTION

Malaysia is in critical need of people trained in STEM (Science, Technology, Engineering, Mathematics) related areas. The lack of takers in science-based programs in secondary schools will lead to a drop in STEM-based programs in the university. However, interests among students to roll in science subjects do not change overnight. By the time students reached secondary education level, they already have a fundamental perceived belief of what to expect in subjects offered. STEM subjects are tabooed as difficult to understand, difficult to pass with flying colors, abstract in concept, not for the layman, and can only be learned by those with higher intelligence capability (Williams & Shipley, 2018; Juul, 2021).

We illustrate the comparison in the economic growth for Malaysia and Singapore in Figure 1. Note that Singapore is selected since both countries starting independently quite similarly after regained their independence. But, the paths taken by both countries result in significant divergence. Notice that as time progresses, the differences in economic growth are becoming larger.

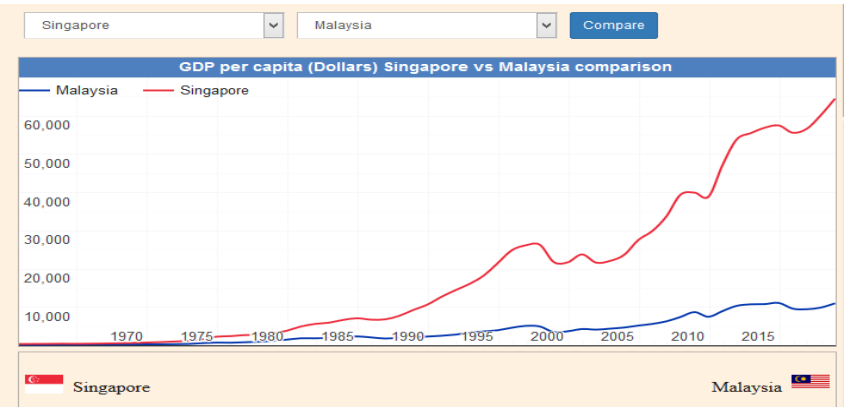


Figure 1. Economy growth by GDP per capita (Singapore vs Malaysia) Source: www.countryeconomy.com

Although having a very limited landmass, today, Singapore is more identified around the globe. And for the right reasons this country can attract professionals around the globe to do business in all kinds and called Singapore home (Fong & Lim, 2019). It has a very supportive landscape for financial services to flourish. Their financial market is mature and product offerings vary. But most importantly, we can see that they invest more in the development of mathematics and sciences knowledge early on. Singapore is the only country that persistently secure the first placement in the Trends in International Mathematics and Science Study (TIMSS), followed by either South Korea, Hong Kong, or Japan in the top five placements (TIMMS, 2019).

Notice that these countries shared similar traits. All of them are known for their innovation, in whatever business area. Innovation cannot be created in a place of conformity, especially through an idle thinking process. It normally comes from a difficult situation, challenging subject matters, and deep-rooted passion to improve the current condition. Thus, we should develop citizens with this drive, those who feel the need to creating, instead of excessive consuming. It's a paradigm shift worth undertaking as a nation. We should stop with maintaining the status quo mentality today.

In doing so, we should scrutinize the current way of instilling interest in our youngsters towards STEM education efforts. As the Malaysian population is segregated into different income groups, we should shift our approach, not into a one-size-fits-all manner. Children from the privileged T20 household are exposed to educational materials that promote creative and critical thinking from their early childhood education, or the type of resources available for them. Besides, most of these kids have well-educated parents, thus the importance of STEM-based knowledge comes only naturally. Activity-based on inquiry, understanding how the world works, and curiosity are encouraged in this household.

This condition may not be shared in the M40, and B40 groups. Especially in the B40 groups, maintaining curiosity in children may not be a priority in this household. The exposed resources and material are not the same during children's early education. Besides, STEM-based knowledge among parents may also be limited. To make things worse, if parents in a household are currently adopting anti-science movements (for example the anti-vaccine group, flat-earther ideology) and make a daily decision on baseless sentiments, the efforts to develop interest among schoolchildren will become even more challenging.

The objective of this study is to propose a STEM 3R activity that is aligned with school children's curricula to be delivered in an engaging, active, and personalized way by utilizing the service learning activity in formal classroom. In this study, we focus our attention to the less exposed community in a sense of a group of people’s inabilities to gain access to certain exposure that are normally easily accessible to the privileged group. These types of categories are inclusive of the exposure to digital means, quality books, access to added skills (i.e., include the art skills, robotic, programming), quality early education, quality upbringing and access to successful role models. As the SDG initiatives have become the key driver towards the better world, efforts have been seen to increase the empowerment from the bottom up. These efforts in particular focusing more on community in bottom tier of socio-economic status around the globe, where the effort to reduce the economic disparity is important in order to achieve many of the goals laid in most of the 17 SDG initiatives.

Thus, the need to develop as many STEM educational materials that are cheap, simple, affordable, and can be easily replicated by teachers or the children themselves is necessary. The idea behind this effort is to empower more people to conduct these activities anywhere. These materials are in particular important for primary school children as they have yet to establish perceived beliefs even though they may be coming from the less exposed group. Their curiosity can still be tapped, as well as believes in themselves is still strong. Thus, we need to make full use of these traits to our advantage.

Among suggestive approaches in the literature to increase interest in STEM knowledge acquisition is through inquiry learning (Nadelson, 2013; Jocz, Zhai & Tan, 2014; Schmidt & Kelter, 2017; Abdurrahman et al., 2019; de Jong, 2019; Yuliati, 2020). Another approach is by introducing this knowledge through the 'nature of science' approach. This refers to how science works, its relationship with society, and how scientists collect, interpret and use data in scientific research (van Griethuijsen et al., 2015). This is supported by Chittum et al. (2017) that showed students' increased interest in the STEM field after undergoing afterschool STEM program, and Ayotte-Beaudet et al (2019) that experimenting science in an outdoor lesson and found that factors including students' level of preparation, an opportunity to make choices, putting students into action, and conducting a reasonably difficult outdoor activity were positively related to students' situational interest.

SUSTAINING COMMUNITY OUTREACH PROGRAM

A lot of community outreach programs conducted on campus are good, they normally promote positivity, inclusiveness, caring for others, and generally, they are mostly concern about how best to improve the livelihood of the surrounding community. However, most of these programs are one-off activities. A different group of students will brainstorm a different kind of activity, similarly, a different cohort of students will also organize different sets of a community outreach program. This situation particularly happens when the programs are conducted based on fulfilling extra-curricular requirements or achieving a specific target in a particular student body and associations. This practice leads to inefficiency of capturing changed behavior among the target participants, miss opportunities in creating improved content of the programs, or worst still, the success of the program is not properly measured and documented.

As the university is maturing, so does the best practices on campus. There are many community outreach program that is more sustainable has progressed in recent years. Among others include the effort made by the Centre for University-Industry Collaboration that involved many parties together (industry, community, university, students, and also organization) in their quintuple helix initiatives. Similarly, the Department of Student Affairs has amended some requirements to their practice, in which all student's activities must relate to one of the Sustainable Development Goal (SDG) initiatives. In this study, we will make use of another initiative by the University under the teaching and learning portfolio, known as the service-learning initiative. We refer to Figure 2 for the model implementation of this initiative. This initiative acknowledges a community outreach program to be part of a formal class assessment. By allowing for community outreach to be included in part of the formal curricular, this miss-opportunity previously mentioned can be reduced since the documentation is formally assessed and the content delivery is being reviewed constantly.

As a lesson learned from the past, the transformation of a particular country and community does not happen overnight; and not through a one-man show, or even a one-ruled utopian government. Sustainable development should be able to mobilize every individual in the community and the country to work together toward the common goal, in this case, a more economic-sustained lifestyle for every individual towards all SDG initiatives laid by the United Nation. The role of each individual may differ, but the response must be shared. As such, the utilization of abled students to become active participants in the development of the community should be taken into strong consideration.

Agurto et al. (2020) has utilized students in Peru to improve the surrounding community towards the digitalization era, in their case, the improvement of acceptance level towards the electronic wallet. They found that students involved in this program are more empowered, have better self-efficacy, motivation, and improve their community engagement. De Hooge and van Dam (2019) also shared a similar sentiment in which they believe that student can become a driver to reach out community through sustainable programs. While Monico and Kupatadze (2020) introduced the concept of co-teacher and co-mentor model through student-teacher-community partnership, with global aims

to empower students to become active participants in community development. These active engagement programs are normally referred to as experiential learning.

A business school in John Hopkins University, for example, has utilized its connection with international partners to sponsor their experiential learning through service-learning activities, in which students engaged in projects that focus on business leadership in culture, conflict management, and team management. Their learned theories in class are transferred into a community with the support of these funders (Calvin, 2019). Ellenbogen (2017) also notices that this concept will improve understanding and relation between the three players involved – the student, community, and instructor. In the Philippines, a service-learning mechanism enable students to become more empathetic towards the elderly through the programs that they are actively involved in (Anorico, 2019). The findings in Latib et al. (2017) suggest the improved soft skills, such as communication and leadership, among students engaged in service-learning.

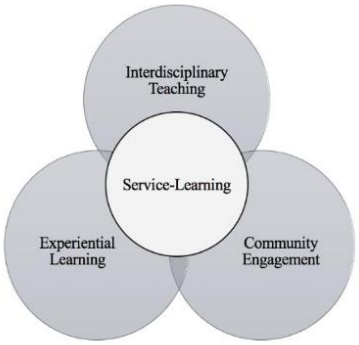


Figure 2. Triad model for service-learning pedagogy (Source: Culhane et al., 2018)

A program such as this also improved the positive image of the university and able to become an agent for social change. In this article, we explore the potential of implementing STEM-based activity to be embedded into the school syllabus through a more sustainable classroom's service-learning mechanism. We selected the environmental awareness theme (3R – reduce, reuse, recycle) in the hope to instill awareness on sustainable living among people in Malaysia.

METHODS

We adopted and realigned the research methodology and phases of Thamwipat et al. (2018) in Table 1 to coordinate with the current movement restrictions and online limitations. We embed a service-learning program under one of the mathematics courses (SQQM3024 Mathematical Modeling) at the university. This course was selected since it is one of the main subjects that need to be completed by BSc (Hon) Business Mathematics students, and is normally enrolled by students in their final year, thus sufficient maturity in STEM-based knowledge is expected.

Table 1. Research phases based on restricted movement order

Phase 1 **Conceptual survey and community demands**	**Phase 2** **Development of PBL-3R activities**	**Phase 3** **Evaluation of the activities**	**Phase 4** **Satisfaction and learning achievements**
Related ideas and concepts were gathered. Engagement with school teachers for suitable syllabus contents. Aligning key components in SDG, STEM activity, and community's needs. Adopting ExDiDD (Explore, Discover,	Creating media and training 30 undergraduate students to create content online. Building smaller groups of students to cater to the needs of movement control's requirement. Several phases of discussions (instructors-	Content of the activity is formally assessed through the course's requirement using the rubric. Delivery and implementation are assessed through the course's requirement via a rubric.	Reflection among participants is recorded and analyzed. Reflection among undergraduate students is recorded.

Develop, Deliver) method to develop content. Identifying targeted community.	students) on content development.		

In this program, university students served as mentors and school students as mentees. There are 12 university students and 36 school students involved in this program. The program focuses on mentees from low-income households, thus, the material used should be low-cost, simple to install, and aligned with the mathematics or science curriculum for a Malaysian primary school.

The activities are constructed based on the structured methodology in Table 2 (Ibrahim et al., 2020). The implementation framework can be seen in Figure 3.

Table 2. ExDiDD methodology

Explore	In this phase, the students need to understand the scenario given to them. They have to brainstorm (mind mapping or drawing) the idea to move further.
Discover	While in this phase, the students start to enumerate several examples to see a pattern of the solution. This stage is very crucial to make sure students engage in discussion and ignite their curiosity to find the solution.
Develop	In this stage, the students construct a formula, model, or procedure for the scenario given to them.
Deliver	The activity is ready to be conducted in the communities using the prepared module in previous steps.

Figure 3. ExDiDD framework

This framework is a systematic process to plan and create meaningful and applicable community outreach programs to society that integrate elements of creativity, connectivity, and collaboration (Ibrahim et al, 2020).

RESULTS & DISCUSSION

This section explains the result through one example of an activity conducted during the service-learning program.

Sample Activity: DIY's Car from 3R Material

The mentors were given the 3R (reduce, reuse, and recycle) theme for this service-learning activity. They discussed an activity they planned to do with their mentees to fulfill the requirements as mentioned in the first phase. The goal of this 3R activity is to raise awareness and motivate mentors and mentees to produce something usable from waste materials to preserve a sustainable material-cycle civilization through efficient resource and material use. Therefore, based on the primary school curriculum, they decided to design an activity that related to the topics of speed, weight, and time. These topics were chosen because they covered all STEM-related subjects, easy to be implemented in a time constraint, and encourage mentees to determine the relationship between the topics as they were learned separately. Mentees have a background in these topics, having learned them in standards four, five, and six.

The total duration of this activity was 35 minutes, with 15 minutes for model development, 10 minutes for speed observation, and 10 minutes for question and answer. The use of 3R materials helps to bring the cost of the activity closer to zero. The materials are eight ice-cream sticks, one Satay's stick, one straw, one wooden skewer, four bottle caps, three stones, the size of a marble, three shirt buttons, a piece of newspaper, a sellotape, an adhesive glue, and three pieces of fifty-cent coins.

Figure 4. 3R Materials

Phase 1: Conceptual survey and community demands

During this phase, the class facilitator acts to coordinate potential topics that can be conducted with known limitations during the movement restriction landscape. In this session, several brainstorming activities are conducted between the stakeholders involved. Discussion with students is conducted to align logistic matters and potential threats of running the program. Similarly, series of discussions are being conducted with teachers to align potential topic in the syllabus that fits the main objective. Some early insights are also collected to understand the demography of the potential community involved.

To ensure that students are coordinated with the task, a dedicated workshop is conducted through a Webex platform by class facilitator. In this workshop, the goal of service learning initiative in Malaysian higher learning institution is being explored. The session is divided into two category – the Service Learning Malaysia-Universty for Society (SULAM) initiatives, and the STEM content creation. Figure 5 illustrates some screenshot of the workshop.

Figure 5. Workshop for students

Phase 2: Development of PBL- 3R activities

The ExDIDD model (Haslinda et al., 2020) was utilized as a framework for carrying out this activity. This model comprises four components which are: Explore, Discover, Develop, and Deliver. A brief description of each component related to this 3R activity is given as follows:

Table 3. ExDiDD method based on sample activity

Explore	The students will be given eight ice-cream sticks, one straw, one Satay's stick, four bottle caps, a piece of newspaper, sellotape, one UHU glue, three pieces of a shirt button, three pieces of 50 cent coins, and three stones with the normal size as "Batu Seremban". They need to explore what they are going to do.	
Discover	After brainstorming, they have to provide the procedures for making the intended car such as its design and dimensions, the number of materials required, and which part to begin first. This is the crucial part where their knowledge, critical thinking, imagination, and creativity blended. In addition, they also had to consider how to load all of the various sorts of weights onto the car to track the speed and time it took for the car to arrive at its destination.	
Develop	A DIY car is developed based on the procedures that have been established using all of the materials that had been given. If the procedures were not working, mentees needed to update them.	

Deliver	Mentees needed to test the developed DIY car by examining how far it can reach the destination before and after adding various weights to the car. At the same time, they need to record the time taken for each observation. Subsequently, mentees have to respond to questions based on their observations. The summary of activity can be accessed through the You Tube link: https://youtu.be/vslPsgv3WbM	

Phase 3: Evaluation of the activities

Students (mentors) will be evaluated based on the success of the conducted activity. Assessments are based on staggered phases, involving the preparation of the modules during activity and the reporting after the activity has been successfully implemented. Rubrics for each of the phases are given to students before the implementation of the activity to ensure that all components are taken into consideration. Students are also encouraged to prepare a feedback platform for participants to future improvement on deliverables.

PERCAMBAHAN IDEA AKTIVITI SULAM A201 SQQM3024

No	ITEM	1 POOR	2	3	4	5 EXCELLENT
1.	Tajuk aktiviti					
2.	Pengenalan					
3.	Objektif aktiviti					
4.	Peserta (latar belakang)					
5	Tempoh masa aktiviti					
6	Rangka Kerja Aktiviti bagi setiap fasa ExDiDD (Explore, Discover, Develop, Deliver)					
7.	Bahan aktiviti					
8.	Gambar perbincangan kumpulan (screenshot)					
9.	Refleksi					
10.	Rujukan					

LAPORAN AKTIVITI SULAM A201 SQQM3024

No	ITEM	1 POOR	2	3	4	5 EXCELLENT
1.	Tajuk aktiviti					
2.	Pengenalan					
3.	Objektif aktiviti					
4.	Peserta (latar belakang)					
5	Tempoh masa aktiviti					
6	Rangka Kerja Aktiviti bagi setiap fasa ExDiDD (Explore, Discover, Develop, Deliver)					
7.	Bahan aktiviti beserta gambar					
8.	Rubrik pemarkahan (termasuklah setiap fasa ExDiDD)					
9.	Hasil aktiviti (nyatakan hasil bagi setiap fasa ExDiDD)					
10.	Gambar-gambar berkaitan bagi setiap fasa ExDiDD					
11.	Maklum balas peserta					
12.	Refleksi sebelum aktiviti					
13.	Refleksi semasa aktiviti					
14.	Refleksi selepas aktiviti					
15.	Kreativiti					
16.	Penulisan					
17.	Format					
18.	Penghargaan					
19.	SWOT					
20.	Rujukan					

Figure 6. Assessment rubrics

Participants (mentees) are given an assessment rubric during the program. This activity started by forming two group. The two group formed namely Mercury and Earth. The facilitator give an instruction on how to proceed with the activity. Firstly, the participant started to think of building a car model using the given recycled item. They were given one hour for the activity to be completed. After that, each group were asked to present their model. The model which then being tested using three different weightage which include candies, stone and paper clip. For each of the weightage they were asked to record their observation on time taken for the car model to reach the destination and present their finding to the facilitator.

Activity: DIY Car

Group's Number:

NO.	CONTENTS	1	2	3	4	5
1)	Creativity					
2)	Shape of the car					
3)	Tidiness					
4)	Constructive Skills					
5)	Teamwork					
6)	Questions Answered					

Figure 7. Assessment rubric for DIY Car activity

Phase 4: Satisfaction and learning achievements

Reflections from mentors as well as mentees are captured throughout the activity. The following sample reflection is obtained from Sample Activity 'DIY's Car from 3R Material'.

a. Reflection among Mentors

This service-learning program provided mentors with a tremendous opportunity to improve their learning outcomes which included soft skills such as communication, leadership, and teamwork. Technology is being utilized in the midst of pandemic, to ensure the discruption of learning is at a minimal level. Students developed digital skills and able to utilize alternative platform for discussion.

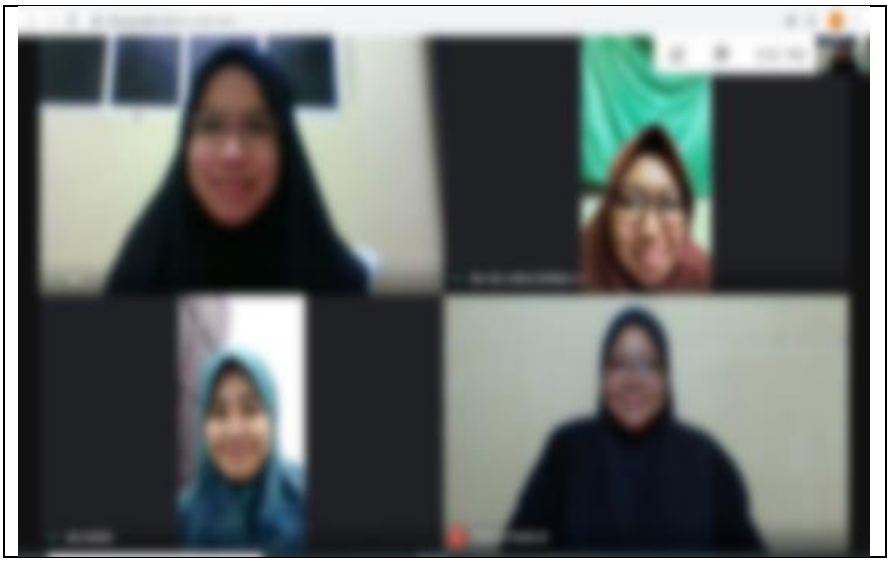


Figure 8. Google meet platform is utlize for discussion

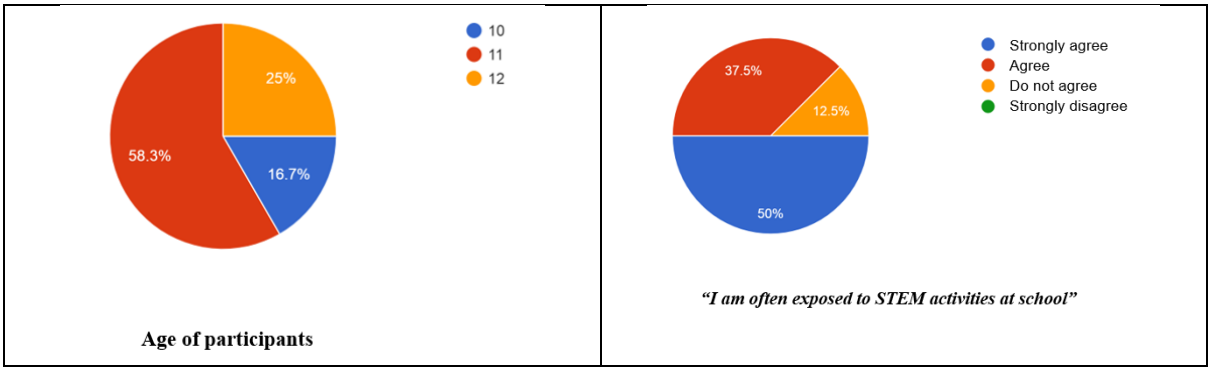
The SWOT analysis in Table 4 provides a systematic analysis of the activity which helps the mentors to build strengths, address weaknesses, reduce risks, and maximize chances of success when conducting such an activity.

Table 4. SWOT analysis based on sample activity

STRENGTH • All the group members cooperated well in this project. • The implementation of the activity provided benefits to both mentees and mentors. • Received good feedback from mentees and their parents. The mentees and their parents request the activity again.	**WEAKNESS** • The activity took a long time to finish because some of the participants were not good at mathematics. • The participant's cooperation during the activity was due to their interest in Mathematics. However, some of the mentees gave the least cooperation because they were not interested in mathematics
OPPORTUNITY • Getting exposed more to STEM activity and STEM industry in the future. • Improved skills toward the implementation of the activity. The mentors could learn how to manage activity and improve it in the future. • Build a good relationship between group members, mentees, and parents. It helped the mentors be more friendly because there was some of us just know each other during this project	**THREAT** • Difficulty in finding the mentee due to implementation of Conditional Movement Control Order in certain areas. One of the group members needed to go to another village to get permission from the mentees' parents. • The loss of internet connection due to unpredictable weather. Sometimes the internet connection would be difficult to excess due to rain and also the area had problems with internet coverage. • Different demographic due to pandemic Covid-19. The activity needed to hold in 3 states because of restricted movement order and also needed to follow the standard of procedures by the government. Besides, all the schools in this country already closed down due to the increasing number of Covid-19 patients

b. Reflection among Mentee

All of the mentees shared the same opinion. For activity one, they said that they had knowledge regarding 3R but never had an idea to utilize the recycled item creatively. This activity had encouraged them to think creatively using recycled items. the mentees were able to use their creativity well to implement the DIY car by using the 3R materials. This activity helped them to be more innovative. Besides, the mentees were able to know how to work in a team effectively and able to solve mathematical problems using the correct method. The mentees were able to apply their knowledge learned in the school especially for the mathematics and science subjects. They also learned some new information about the 3R's and what they could do with all of the recycled materials. Google form is used as medium to retrieve feedback from participants. Figure 9 shows selected findings from the activity.



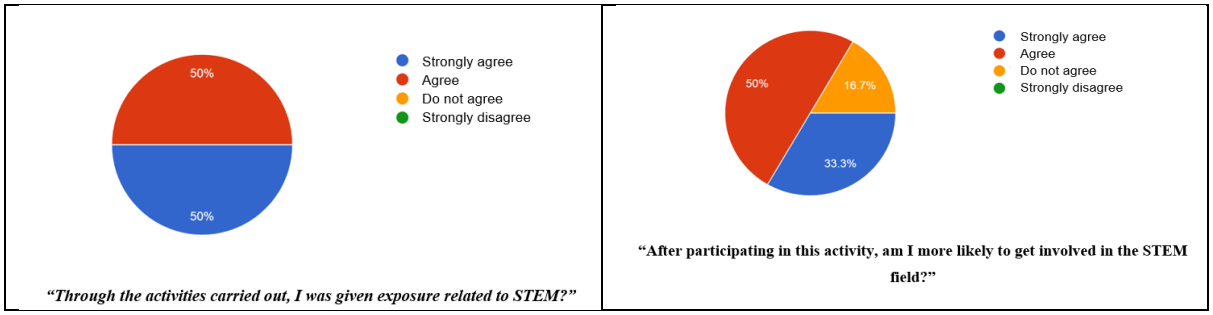


Figure 9. Selected findings from participants.

c. Parents Feedback

During the pandemic, the teaching and learning activities in schools are heavily distrupted. Normal engagement between teachers and students are replaced with online activity, thus hindered experiential learning activities to be conducted in comparison during normal schooling time. School students are bounded in their restrictive environment, with minimal contact with other people, and environment. Such restriction will stunt growth in learning, in particular when the domestic lifestyle does not support active participation in learning. The limitation of education's capability among parents and care giver a home also contributing to this risk. By conducting community outreach activity such as this, experiential and active learning can be conducted more effectively, with strict standard operating procedure is fully adhered.

Feedback from parents are also obtained to see the success of this program. Positive response are acquired from all parents involved. Parents involved are happy and satisfy with the conducted activity. They reported increased excitement from their kids, and can see the benefit of the conducted program. They are looking forward for a more active program to be conducted, in particular program that is educational. Figure 10 shows some feedback from satisfied parents.

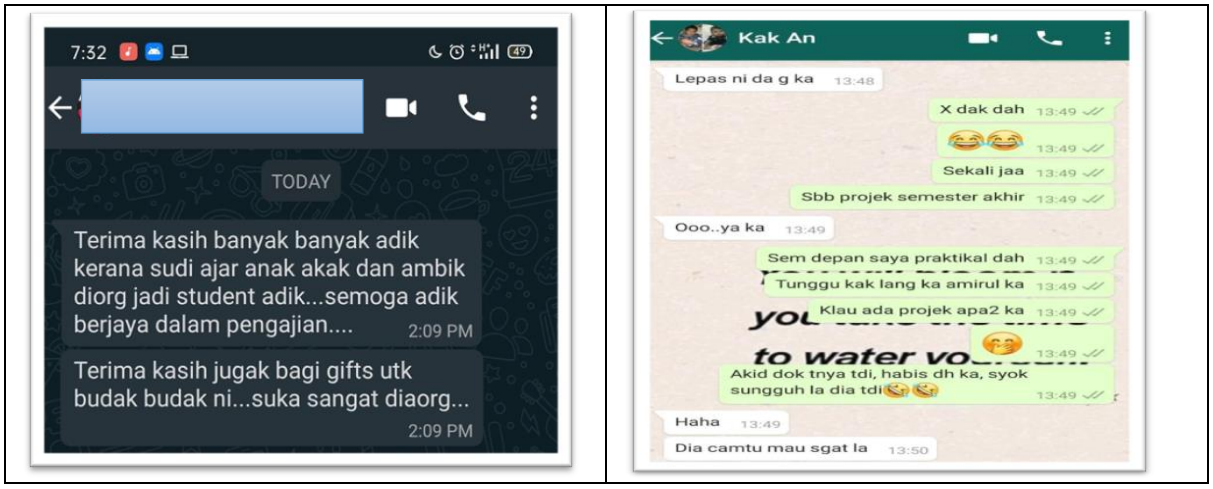


Figure 10. Positive feedback from parents

CONCLUSION

Service learning is one of the programs that improve students' knowledge and soft skills. This type of experiential learning enables the smooth transfer of knowledge from students in higher education institutions into the community. From the conducted activities, we can observe positive change among students that are involved in this program. Before the program, students in class are reluctant to conduct service learning based on several reasons. These reasons include the practice outside their norms, in which previous classroom experience does not require the engagement outside classroom. This alternative assessment is understandably challenged their comfort zone, change the way they study and needs commitment as assuming and active role in this subject. However, after the program completion,

students are observed to understand the need to giving back to community, their self confidence improved, and they see themselves as part of active community. The transformed role from inactive to active students in community should be encouraged and utilized in future projects.

We also identified potential threats to the success of service learning program. The alignment between time limitation, embedded course assessments, fundings, and continuity of the program should be better addressed to ensure its sustainability. A framework that caters all elements above should be constructed in order to effectively outreach targeted community, thus enabling the smoothness and supports for the conducted program. A monitoring mechanism should also be constructed to measure the change of behavior among the community involved in this program.

Regular and structured engagement activities such as this will improve the ease of communication between stakeholders among higher learning institutions, thus enables more transparent, functional, and beneficial networking among the party involves. This platform needs to be utilized for the effective delivery of transformation in the community. It can be used as a way to dissipate knowledge, increase skills, and heighten awareness towards common goals. A sustainable relationship between stakeholders is foreseen to gearing the people towards a more successful future, be it in more innovative product offering, reduce in inequality and mismatch skills, and a more seamless connection between industry players, policymakers, universities, local authorities, and community.

Moving forward, a comprehensive framework that enables smart interaction between stakeholders with their respective roles can be developed, together with the measurement of success in each phase involved. A dedicated social return on investment model should be developed to achieve this objective.

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