Minecraft Education Edition: The Perspectives of Educators on Game-based Learning Related to STREAM Education

Pang Yee Jiea[1#], Tay Choo Chuan[2], Sharifah Sakinah Binti Syed Ahmad[3],
Ng Khar Thoe[4] & Lim Seh Hoe[5]

[#1,5] Institute of Technology Management and Entrepreneurship, Universiti Teknikal Malaysia Melaka.
[2] Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka.
[3] Faculty of Information Technology and Communication, Universiti Teknikal Malaysia Melaka.
[4] SEAMEO RECSAM, Penang, Malaysia.

[#]corresponding author <g-86124210@moe-dl.edu.my>

Abstract

Minecraft: Education Edition (MEE) is an emerging digital teaching and learning tool in transforming the education around the world. MEE is widely used by the educators because it promotes creativity, encourage collaboration among team members, and improve problem-solving skills in an immersive digital environment through game-based learning. This qualitative case study explores the educational benefits of MEE in Malaysia and Philippines school. The research objective is to investigate the effectiveness of MEE in science, technology, reading, engineering, arts/language and mathematics (STREAM) subjects. This study employed research design including systematic review and qualitative case study methods. The data of this research was collected from semi-structured interviews, observations, or written reports by nine educators who were using this application in their classroom. The data was analysed using thematic coding and descriptive analysis. Case exemplars were illustrated under the sub-headings of 'Science and Technology, Mathematics, Environmental Education/Geography. Reading/Language and Art' that reflected 'STREAM' education practised in classrooms. The analysis of findings revealed that Minecraft Education Edition was widely adopted and adapted into transdisciplinary curriculum in education contexts to engage the students in fun learning environments. In conclusion, the passionate educators who had implemented MEE into their classroom have strongly recommended this student-centred and game-based learning digital tool to be integrated in the 21st century classroom to receive its full benefits.

Introduction

The importance of game-based learning in the classroom was emphasized way back in the mid-20th century by Vygotsky (1967) and Piaget (1962), but the idea of games without integration of technology in preschool and beyond to foster the development of social cognition was criticised as old idea. Though there are arguments on the pros and cons of technology integration in games,

technology-enhanced game-based learning tool such as Minecraft has gained its popularity to bridge the gap of diverse learning style of learners at various age levels that will be discussed in this paper.

Problem Statement and Rationale

In the advent of digital era, many games activities were integrated with technology that posed difficulties to educators of diverse ICT capabilities. For example, although there are tremendous advances in the video game industry, the educators still have "limited experience designing or implementing effective educational computer games" (Baek et al., 2020). Minecraft: Education Edition has become a worldwide trend and is already used widely in some classrooms. With over 100,000,000 copies sold worldwide, Minecraft is the second most popular video game of all time. Many nations, including the United States and Sweden, have opted to include the game in their structured curricula. It is also used to teach science, urban planning, and languages to children in other nations. The popularity of this video game for educational purposes has sparked interest in the field of 'Science, Technology, Engineering, Mathematics' (STEM) education. The pedagogical approaches of STEM as well as 'Science, Technology, Engineering, Arts and Mathematics' (STEAM) education with an additional component of 'Arts' (that included humanities, ethics, ideals, expression) were explored by researchers such as Pang et al. (2019) and Abdul Talib et al. (2019) respectively. However, there was not much research made on the teaching strategies related to STREAM education that was evolved from STEAM education with additional component of Reading (R).

Research Objectives and Activities

The main aim of this case study is to examine the uses, advantages, impact and challenges of integrating Minecraft integration into classrooms for teaching and learning. The gaming experience is then illustrated with photos and screenshots of student-created projects. The most important educational results of using Minecraft in the classroom under supervision of educators are discussed.

The following are the research objectives of this qualitative case study:

1. To discover the effectiveness of a game-based learning called Minecraft: Education Edition (MEE). The foundation for this study lays on the interest on the students in technology and game-based learning and the researchers' experience in teaching STREAM subjects, arts and humanities through video games.

2. To investigate what benefits and impact that may occur in the high school classroom setting.

3. To discover the challenges in game-based learning while using MEE and why certain educators reluctant to use this emerging educational tool for teaching and learning purposes.

Research Questions

Based on the above discussions, the following Research Questions are formulated:

1. How is the Minecraft: Education Edition used in the classroom?

2. What are the benefits and impact of using Minecraft as an emerging tool in game-based learning?

3. What are the disadvantages and challenges of implementing Minecraft: Education Edition into the classroom?

Methodology

This study incorporates multi-pronged approaches integrating systematic review from articles collected from search engines such as Google Scholar as well as qualitative research case study method.

The data for this qualitative case study were collected from semi-structured interviews and findings from observation based on the researchers' perspectives on their classroom experiences. This approach was chosen in order to analyse, interpret, and explain the case study using qualitative data (Creswell et al., 2013). Data collection for this project includes a 20-30 minute audio-recorded semi-structured interview. The interview questions are as follow:

1) What is your professional background?
2) How do you conduct Minecraft in your classes?
3) What is your student's background and what are their interests?
4) What are the problems faced or challenges of using this game-based learning in education?
5) How to benefit the future generation of students using Minecraft?

Review of Related Literature

Literature review was made through extensive search on topics related to the potential of Minecraft: Education Edition, a video game which has been widely used since its initial release in 2009.

Minecraft in Promoting STREAM Education

Literature review was made with special focus on its features to promote STREAM education. It was revealed that when Minecraft is used in science, math, social sciences, reading/language, arts and composition classes, students gain knowledge and skills. At the same time students were also more active, involved, and enthusiastic. Minecraft is now being used as a teaching tool for a variety of subjects all over the world (de Andrade et al., 2020; Williams & Farber, 2020; Short, 2012).

Pedagogical Aspects Considering Diverse Learning Styles of Learners from Basic to Advance Levels

Data were also extracted from 10 articles published on Google Scholar that were categorised into four domains: curriculum integration; students' perspectives, educators' practice; skills and knowledge and enhancement (Nebel et al., 2016). The analysis of systematic review showed that

Minecraft has been used to provide early access to the topic of spatial geometry during class level 5/6 (Föerster, 2017, Jensen & Hanghøj, 2020), to teach about sustainable planning (West & Bleiberg, 2013), language and literacy (Bebbington, 2014; Hanghøj et al., 2014), digital storytelling (Garcia Martinez, 2014), social skills (Petrov, 2014), computer art application (Worsley & Bar-El, 2020), project management (Saito et al., 2014), science (Pusey & Pusey, 2016) and chemistry (Hancl, 2013).

Findings

This section reports on the analysis of findings of this case study in response to Research Question (RQ) 1, 2 and 3.

Demographic Data

The following Table 1 summarises the demographic data extracted from the findings of the questions posed during interview of the respondents participated in this case study.

Table 1 Demographic Data of the Participants in This Case Study

Teacher Respondent	Country	Expertise Field	Number of Students	Student's Age
1	Malaysia	Science	40	13
2	Malaysia	Physics	37	16
3	Malaysia	Computer Science	90	13-15
4	Malaysia	Mathematics	38	14
5	Malaysia	Additional Mathematics	37	16
6	Philippines	Technology	5	19-20
7	Malaysia	Geography	30	15
8	Malaysia	English Language	35	13
9	Malaysia	Art	38	16-17

Research Question 1: The implementation of Minecraft: Education Edition (MEE) in the classroom

The following are case exemplars illustrating how the educators apply Minecraft: Education Edition in their classrooms under the sub-headings of '**S**cience and **T**echnology, **M**athematics, **E**nvironmental Education/Geography. **R**eading/Language and **A**rt' that reflected 'STREAM' education.

Science and Technology

Science teacher claimed that her students were extremely excited when they were told that they were going to use Minecraft in their science lessons. It was successful to increase student engagement and motivation.

"All of my students can't wait to come to my science class, even those underachievers and those usually absent to school. My students were talking to their friends who are in other class about the Minecraft lessons and how they enjoy it. Obviously, my students enjoy learning science [e.g., honey collecting system (Figure 1)] through Minecraft. They can explain the concept well, using the system built in Minecraft."

(Teacher Respondent 1, Malaysia)

Figure 1 Honey collecting system in science classroom

A Physics teacher when presenting her team's project, she emphasized the concept of auto-doors using sensors, application of 3D Printer and drone.

"The team presents a virtual tour of Melaka, in line with current MCO SOP during this pandemic. These historical buildings are 3D printed (Figure 2) per real life scale according to real photos of the buildings with multiple angles. The virtual tour will be conducted using a drone for aerial view. Everyone from any country can appreciate the rich history of Melaka. Visitors can activate the auto-doors with sensors, switch on lights using the redstone circuit, or take a motorized-boat ride. By applying science concepts in Minecraft, items with basic functions can be expanded to perform complex mechanisms. Our creativity and problem-solving skills have leveled up after this wonderful educational experience."

(Teacher Respondent 2, Malaysia)

Figure 2 3D printing technology in Minecraft

On the other hand, Minecraft can enhance the coding skills among the students when they apply the programming language to automate the building process. The teacher explained how the students can increase the speed to finish their projects by using the command in Minecraft.

> *"During my students' initial start-up, their progress was too slow because they have to build block by block manually and the structure they planned to build is too big. However, after I taught some coding skills and leveraged the coding (Figure 3) commands into Minecraft, the commands work well and improve their progress significantly in building the walls. For example, they need 5 minutes to build a 50-block wall manually, but with commands they only need around 20 to 30 seconds. There was another problem when building the roof. Different coding must be used in the automated "agent" to build diagonally, so it took the students some time to learn, explore and complete the coding. Finally, the automated agent can help them to build the roof faster than the manual building by 3 times."*

(Teacher Respondent 3, Malaysia)

Figure 3 Coding used in Minecraft to enhance students' technology literacy
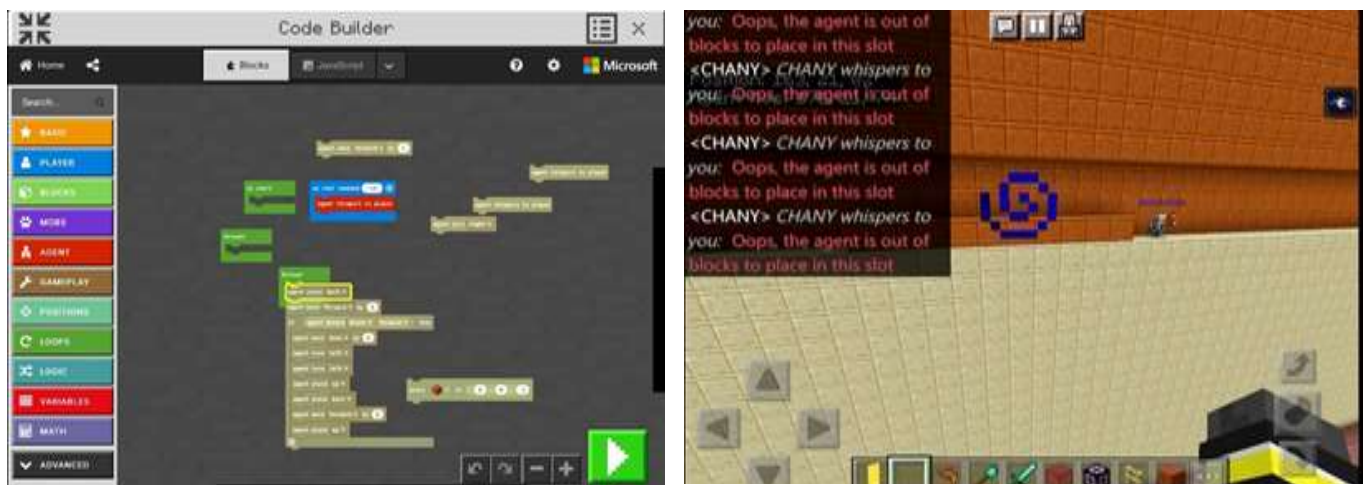
Mathematics

There are many features in Minecraft that can be leveraged on to teach Mathematics as illustrated below.

> *"Minecraft made maths lesson really fun. The students gained new experiences in learning the coordinate system as part of the academic domain of mathematics. The students also can understand the space, area, volume well, by constructing the bricks in a virtual world (Figure 4). Through playing Minecraft, the students actively apply their new ways of participating in mathematics."*

<div align="right">(Teacher Respondent 4, Malaysia)</div>

Figure 4 Scale drawing in Mathematics classroom

> *"I was surprised that all the students were engaged with the building activities in Minecraft. The students were equipped with a general high level of playing and building skills in the game, prior to the learning activities, they completed the tasks given much more quickly than I expected. Their achievements and success are much higher than the targeted level. I would like to see students develop more complex projects and structures in the future, by applying the math concepts into the games."*

<div align="right">(Teacher Respondent 5, Malaysia)</div>

A teacher explains how he guided his team members to apply mathematics concepts while planning with scale drawing (Figure 5) to build the Luneta Park (Figure 6) in Minecraft.

> *"At first, we built the elevated floor together with its side structures. We do not have any measuring tools, so our team uses two coloured blocks as our guide just to put the monument on its centre. To lessen the statue of Dr. Jose P. Rizal's size, we measure itself*

first by counting how many blocks that can possibly occupy when it's in its lesser size. We didn't ruin its whole old size because we aren't prepared to replace it yet, so we measure its possible size that is lesser than the other one by putting and counting glass blocks and smooth deep slate blocks as its markers to remember certain counts."

(Teacher Respondent 6, Philippines)

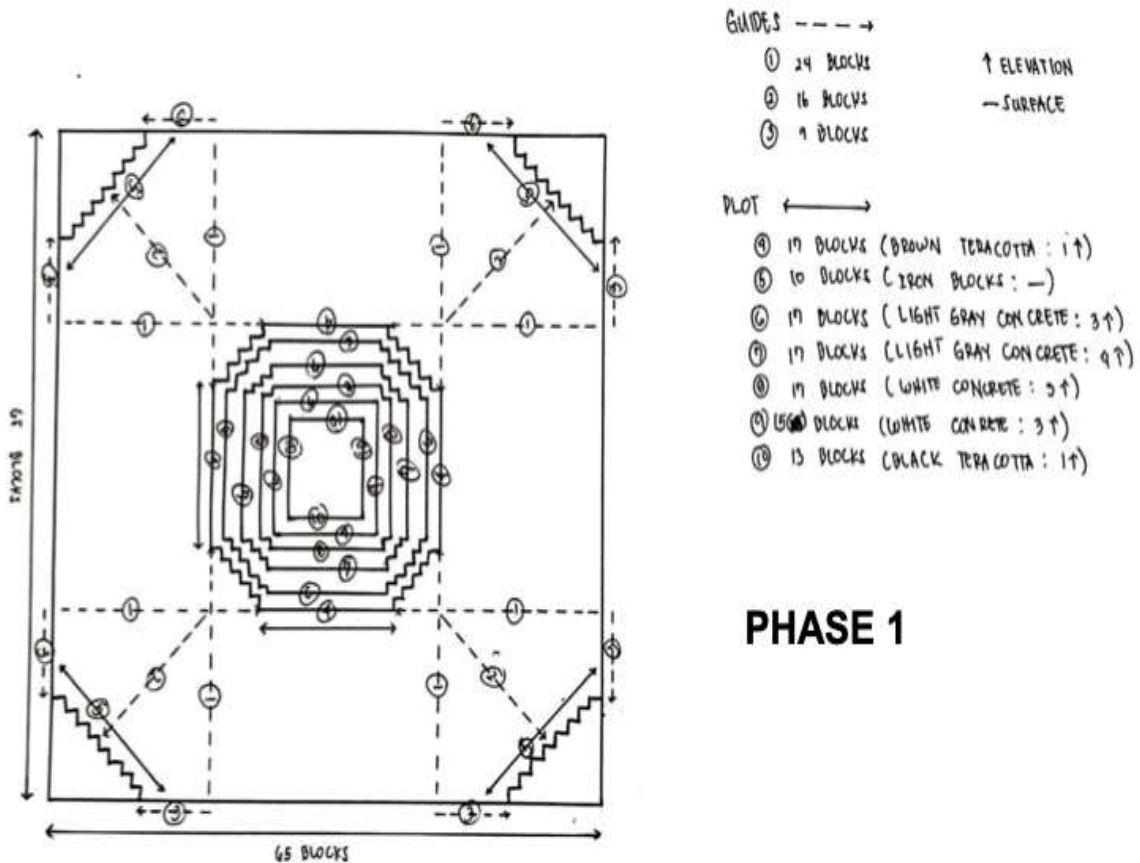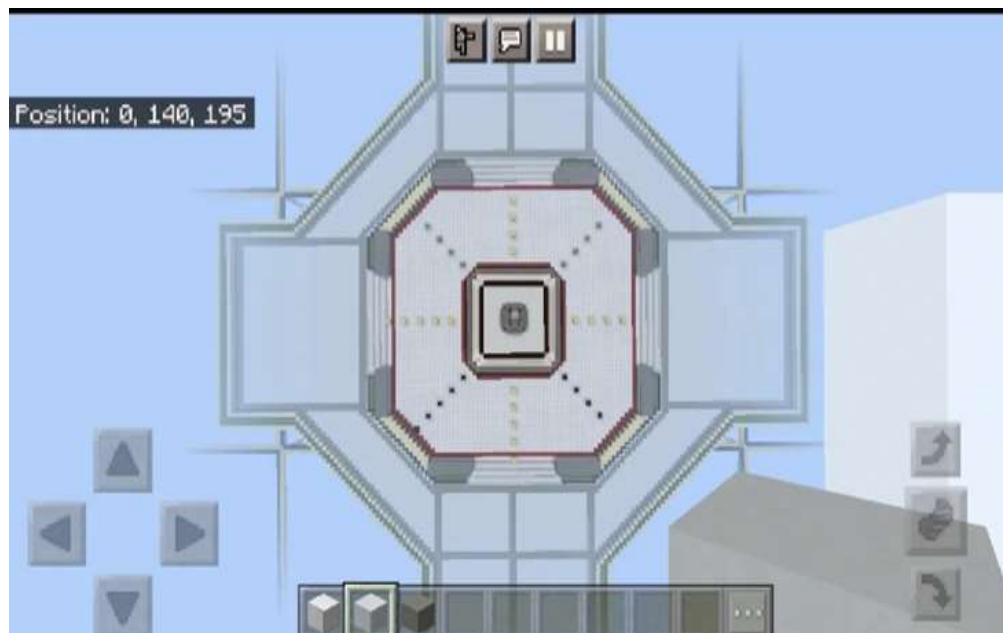Figure 5 Scale drawing before building the Luneta Park in Minecraft

Figure 6 Completed Luneta Park in Minecraft

One of the respondents explained how her students build and calculate the area using a scaled paper during the planning stage (Figure 7). They build a Chinese reunion dinner with a Chinese traditional entrance which is the symbolic of the family gathering during the Chinese New Year Eve with 1:1 ratio (Figure 8).

> *"When we built the 3-Dimensional food in Minecraft, it was very hard to put the block. At the end we use the Minecraft pixel art generator to convert images to pixel art to build the food. We need to apply the Mathematics concept of area to ensure the final creation is the actual ratio of the real food."*

(Teacher Respondent 3, Malaysia)
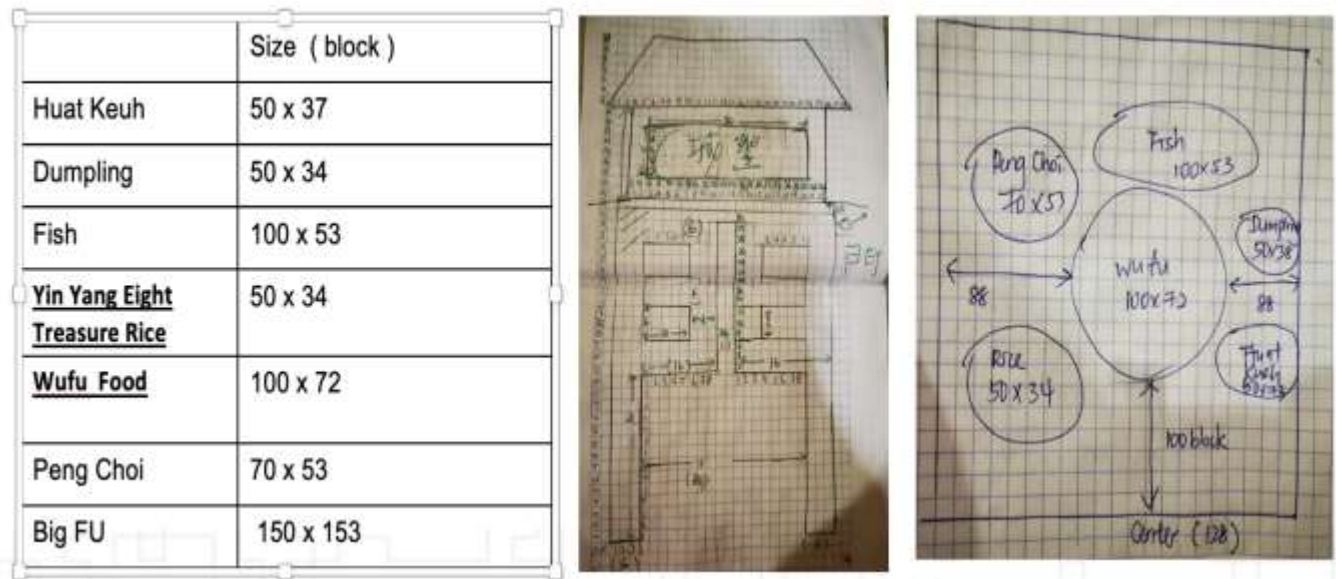
Figure 7 Calculation of area using scaled paper

	Size (block)
Huat Keuh	50 x 37
Dumpling	50 x 34
Fish	100 x 53
Yin Yang Eight Treasure Rice	50 x 34
Wufu Food	100 x 72
Peng Choi	70 x 53
Big FU	150 x 153

Figure 8 Building in the Minecraft with 1:1 ratio

Environmental Education/Geography

The Geography teacher explained the application of Minecraft: Education Edition in examining features and characteristics of places and environment through space and coordinate learning (Figure 9) that can also be related to the learning of science and mathematics concepts with building of school as an example (Figure 10).

Figure 9 Space and coordinate learning through the school building activities

Figure 10 Building the school during the geography lesson

"Students are required to build the school by observing the places and environments. Students also guided to enter the world of Ancient Egypt and interact with one of the earliest world powers, learning about its fascinating geography, advanced economy, governing structure, iconic architecture, and unique culture."

(Teacher Respondent 7, Malaysia)

"Students' ability to navigate their environments, enhance their sense of direction, and learn basic science and engineering concepts improved as a result of their participation in the Minecraft class. Students, for example, had to use maps to locate the elements required."

(Teacher Respondent 1, Malaysia)

Reading/Language

The language teacher claimed that the Minecraft game foster can enhance students' communication and context-based language use through the game's open-ended nature and collaborative approaches such as comic book (Figure 11) to promote 'Reading' skill that is also a strategy being applied in science lesson.

> *"Students use the world provided to help to build their own visual narratives. Before building, the students need to create story boards for each panel and write out the dialogue. When the students had to name their completed buildings and neighbourhoods, they needed to be able to write well. The students often interacted with classmates in writing. Surprisingly, the students, who were mostly Mandarin Language speakers, also strengthened their English, because many of the online tools were in English."*

(Teacher Respondent 8, Malaysia)

Figure 11 Comic book with dialogue in the Minecraft: Education Edition

Art/Culture

Minecraft was widely used in art lesson. Students applied their creativity to create a world using pixelated blocks without any limitations in their imaginations. By using multiplayer mode, the players can interact with other players on public servers, thus Minecraft enable players to enhance their communication skills and at the same time to develop their own creative spaces and to explore the creative spaces of others. An exemplar is their Minecraft built in Chinese New Year classroom decorations (Figure 12).

"Minecraft is the best education tool that I used before, to provide another kind of motivation and creative way. It allows students to create, to demonstrate knowledge, and to role play. Students used their creative way to collaborate and communicate knowledge and to brainstorm ideas. This game had greatly contributed in the art world"

(Teacher Respondent 9, Malaysia)

Figure 12 Students built the Chinese New Year classroom decorations using Minecraft

Research Question 2: Benefits and impact of using Minecraft as an emerging tool in game-based learning

Several beneficial characteristics could be established after a thorough analyse of the interviews of a few educators as summarised in Table 2. Many of these advantages are due to gameplay mechanics in general. Blocks, for example, can be arranged in such a way that they can replicate almost any static object or form, providing triggers for a wide variety of educational and research projects.

Table 2 Interview Findings of Teacher Respondents of Case Exemplars on the Benefits and Impacts of Minecraft

Respondents	Benefits	Impacts
Teacher 1	1. Increase interest, students enjoy learning 2. Able to navigate environment, use maps	1. Motivate underachievers to attend class. 2. Improved STEM concepts & sense of direction
Teacher 2	1. All appreciate rich history, interactive	1. Level up creativity and problem-solving skills
Teacher 3	1. Leveraged the coding commands 2. Learnt new skill e.g., pixel art generator	1. Learnt coding skills, improve progress of work 2. Applied mathematics concept in real world
Teacher 4	1. Made maths lesson really fun	1. Gained new experience on academic domain

Teacher 5	1. All students were engaged in building	1. Higher achievement and success than targeted
Teacher 6	1. Cooperative teamwork building together 2. Learn the importance of counting the blocks	1. Be flexible learners with problem-solving skills 2. Ensure the accurate ratio of the building
Teacher 7	Learnt about fascinating multiple subjects	Enhanced observation skills and experience
Teacher 8	1. To create story boards and visual narratives etc 2. Able to write well, interact with writing	1. Enhanced communication, verbal & visual skill 2. Strengthened English language proficiency
Teacher 9	1. Create, demonstrate knowledge, role play	1. Provided another kind of motivation, creativity

Research Question 3: Disadvantages and challenges of implementing MEE in the classroom

The interview findings on the disadvantages and challenges are summarised in Table 3.

Table 3 Interview Findings of Teacher Respondents on the Disadvantages and Challenges of Implementing Minecraft

Respondents	Disadvantages	Challenges of Implementation
Teacher 1	1. Students were more concentrate on playing rather than building	1. Not all science concepts can be built easily 2. Teachers need to prepare the suitable science content
Teacher 2	1. Spent time to teach the techniques to build workable machine	1. The machines hardly work if the students do not fully manage the Minecraft skills
Teacher 3	1. Simple coding does not fulfil the higher-level computer science curriculum	1. Teacher needs to check the coding row by row 2. Task given must be related to the curriculum
Teacher 4	1. Time consuming to teach simple mathematics	1. Wrong calculation of the ratio results in the incomplete building
Teacher 5	1. Only apply simple mathematics concept	1. Difficult to design of the game task to suit students' level
Teacher 6	1. Need high speed internet 2. Require high techniques	1. Connection problems 2. Hard to observe Intrinsic structures
Teacher 7	1. Students' focus was distracted in the game's world	2. Cannot visit the real building during pandemic to observe the real structure
Teacher 8	1. Time consuming in building the storyboard	1. Teacher lacks Minecraft skills
Teacher 9	1. Not all students can join multiplayer	1. Limitation of 30 participants in the same world while doing multiplayer

Conclusion

This study presented case exemplars that were illustrated under the sub-headings of '**S**cience and **T**echnology, **M**athematics, **E**nvironmental Education/Geography. **R**eading/Language and **A**rt' that reflected 'STREAM' education practised in classrooms.

Implications and Significance

The implications from the enormous influence of Minecraft in STREAM education were derived based on the results of our interviews and the wide range of examples given by the educators. Minecraft: Education Edition features boxes, artefacts, and scenarios that enable educators and students to make real-world connections. Hence, Minecraft has the ability to improve the effectiveness of teaching and learning through game-based learning.

Minecraft: Education was used by teachers to increase students' cognitive load, as well as their commitment, interest, and learning results. Even though Minecraft as modern games have much superior three-dimensional environments, the game tends to be aesthetically pleasing. Additionally, by updating additional shades and texture packs, as well as the simplistic visualisations, the game can be modified and tailored to the topic at hand, and the simplistic visualisations can help the player to concentrate on the intended topic integrating cross-curricular (Toh et al., 2007) and transdisciplinary studies as suggested by Ng (2018) who had initiated the LearnT-SMArET platform [an offshoot programme of 'Learning Science and Mathematics Together' in a Borderless world or abbreviated as LeSMaT (Borderless)] for students. Under the LeSMaT blended learning project initiative, an e-platform using hybrid approach (Ng & Nyunt, 2010; Ng et al., 2013; Ng et al., 2020; Nyunt, et al., 2014) was developed for students (including some of the Minecraft exemplars as reported in this case study) to submit projects with numerous focus of studies to promote '**Learn**ing **T**ransdisciplinary **S**cience integrating **M**athematics, **Ar**ts/Reading/Language/Culture, **E**ngineering/Environmental Education/ Economy/Entrepreneurship and **T**echnology' (LearnT-SMArET).

Limitations and Suggestions for the Way Forward

Despite the numerous advantages obtained from Minecraft: Education Edition, this game-based learning has a number of limitations in terms of topics covered by educators, players, and gameplay/technical challenges. In the opinion of educators, while Minecraft is relatively easy, implementing it in the classroom still necessitates the expertise of specialists. The other limitation of this research is the analysis of this single case study are based on the anecdotal evidence from a few educators thus it cannot be generalised. We should also mention that Minecraft used in this research was in a planned, structured and purposeful manner. If real pedagogical objectives are to be achieved, this form of format must be maintained. In the absence of proper planning, a video game like Minecraft, which has substantial pedagogical benefits, would be ineffective. Students will not want to stop playing if these precautions are not taken. In fact, the lack of focused learning goals, inflexible curriculum, and no prior gaming skills are all obstacles for using Minecraft in the classroom.

Educators who want to incorporate Minecraft into their classroom must maintain a student-centred approach and give the opportunity to the students to manipulate the learning style. As a result, it is a critical issue for educators to possess the requisite enthusiasm and an open mind in order to allow students to try new things as well as enjoy learning. As this qualitative case study showed, Minecraft is a very effective educational tool, but it can only work if educators relinquish the control that traditional classrooms demand and enable students to immerse themselves in the game as well as guide their own learning.

For successful Minecraft integration into teaching and learning environments, educator-centeredness versus learner-centeredness is needed. The challenges faced by the respondents in this study need to be overcome to ensure the implementation of game-based learning brings more benefits than the disadvantages. The researchers proposed that future research needs to be conducted into the educational and literary benefits of the use of Minecraft in the classroom from the perspectives of students and parents. Modular approach can also be used to guide students' development of Computational Thinking (CT) skills and coding as what had been researched on by Pang et al. (2020).

Significance and Contribution in Line with Philosophy of LSM Journal

This study examined the uses, advantages, impact and challenges of integrating Minecraft with STREAM education. Exemplars were illustrated with evidences of benefits and impacts on psycho-social aspects as well as skills development of students in transdisciplinary studies.

Reference

Abdul Talib, C., Mohd. Rafi, I.B., Thanga Rajan, S., Abd. Hakim, N.W., Ali, M., & Ng, K.T. (2019). STEAM teaching strategies in related subject. In *Education, Sustainability and Society (ESS)*. *2*(4). 14-18. Retrieved: https://educationsustability.com/paper/4ess2019/4ess2019-14-18.pdf

Baek, Y., Min, E., & Yun, S. (2020). Mining educational implications of Minecraft. *Computers in the Schools*, *37*(1), 1-16.

Bebbington, S. (2014). A Case study of the use of the game Minecraft and its affinity spaces for information literacy development in teen gamers (Unpublished doctoral dissertation). University of Ottawa, Ontario, Canada.

Cresswell, K. M., Slee, A., Coleman, J., Williams, R., Bates, D. W., & Sheikh, A. (2013). Qualitative analysis of round-table discussions on the business case and procurement challenges for hospital electronic prescribing systems. *PLoS One*, *8*(11), e79394.

de Andrade, B., Poplin, A., & Sousa de Sena, Í. (2020). Minecraft as a tool for engaging children in urban planning: A Case study in Tirol Town, Brazil. *ISPRS International Journal of Geo-Information*, *9*(3), 170.

Foerster, K. T. (2017, April). *Teaching spatial geometry in a virtual world: Using minecraft in mathematics in grade 5/6*. In 2017 IEEE Global Engineering Education Conference (EDUCON) (pp. 1411-1418). IEEE.

Garcia Martinez, S. (2014). *Using commercial games to support teaching in higher education* (Unpublished doctoral dissertation). Concordia University, Quebec, Canada.

Hancl, M. (2013, September 24). *Vom Bohr'schen Atommodell und fliegenden Kühen* [From Bohr model and flying cows] [Web log]. Retrieved from http://www.hancl.de/cis/?p=729

Hanghøj, T., Hautopp, H., Jessen, C., & Denning, R. C. (2014, October). Redesigning and reframing educational scenarios for Minecraft within mother tongue education. In *European Conference on Games Based Learning* (Vol. 1, p. 182). Academic Conferences International Limited.

Jensen, E. O., & Hanghøj, T. (2020). What's the math in Minecraft? A Design-Based Study of Students' Perspectives and Mathematical Experiences Across game and School Domains. *Electronic Journal of e-Learning*, *18*(3), 261-274.

Nebel, S., Schneider, S., & Rey, G. D. (2016). Mining Learning and Crafting Scientific Experiments: A Literature Review on the Use of Minecraft in Education and Research. *Educational Technology & Society*, *19* (2), 355–366.

Ng, K.T. (2018). Development of transdisciplinary models to manage knowledge, skills and innovation process integrating technology with reflective practices. *International Journal of Computer Applications*, 975, 8887. Retrieved from: https://www.ijcaonline.org/proceedings/icrdsthm2017

Ng, K.T., Baharum, B., Othman, M., Tahir, S., & Pang, Y.J. (2020). Managing technology-enhanced innovation programs: Framework, exemplars and future directions. *Solid State Technology*. 63, 1s, 555-565. Retrieved from: http://www.solidstatetechnology.us/index.php/JSST/article/view/741

Ng, K.T., & Nyunt, K.A.K. (2010). *The development of an on-line learning hub in SEARCH for youth science and mathematics researchers.* In Global Learn 2010 (learntechlib.org), 1158-1167.

Ng, K.T., Parahakaran, S., Rhea, F., Egbert, W., & Lee, T.L. (2013). Promoting sustainable living in the borderless world through blended learning platforms. *Open Praxis*, *5*(4), 275-288. Retrieved from https://www.learntechlib.org/p/130663/article_130663.pdf

Nyunt, K.A.K., Ng, K.T., Baharum, B., & Chockalngam, A. (2014). Development of a hybrid system to enhance borderless learning: Challenges and opportunities for the underserved. *Advancing Open and Distance Learning: Research and Practices*, 331.

Pang, Y.J., Tay, C.C., Syed Ahmad, S.S., & Ng, K.T. (2019). Promoting students' interest in STEM education through robotics competition-based learning: Case exemplars and the way forward. . In *'Learning Science and Mathematics' (LSM) online journal*. Issue 14, 107-121. Retrieved from: https://www.recsam.edu.my/sub_lsmjournal/images/docs/2019/2019_8_PYJ_107121_Final.pdf

Pang, Y.J., Tay, C.C., Syed Ahmad, S.S., & Ng, K.T. (2020). Managing technology-enhanced innovation programs: Framework, exemplars and future directions. *Solid State Technology*. *63*, 1s, 849-859. Retrieved from: http://www.solidstatetechnology.us/index.php/JSST/article/view/770

Petrov, A. (2014). *Using Minecraft in education: A qualitative study on benefits and challenges of Game-Based Education*. University of Toronto

Piaget, J. (1962). The relation of affectivity to intelligence in the mental development of the child. *Bulletin of the Menninger clinic*, *26*(3), 129.

Pusey, M., & Pusey, G. (2016). Using Minecraft in the Science Classroom. *International Journal of Innovation in Science and Mathematics Education, 23*.

Saito, D., Takebayashi, A., & Yamaura, T. (2014, October). *Minecraft-based preparatory training for software development project*. In 2014 IEEE International Professional Communication Conference (IPCC) (pp. 1-9). IEEE.

Short, D. (2012). Teaching scientific concepts using a virtual world - Minecraft. *Teaching Science*, *58*(3), 55-58.

Toh, L., Yeap, C.H., Ng, K.T., & Isma, F. (2007). *Cross-curricular teaching incorporating human values: A collaborative research by reflective practitioners*. In 'Learning Science and Mathematics' (LSM) online journal. Issue 2, 9-31.

Vygotsky, L. S. (1967). Play and its role in the mental development of the child. *Soviet psychology*, *5*(3), 6-18.

West, D. M., & Bleiberg, J. (2013, March). Education technology success stories. *Issues in Governance Studies.* Centre for Technology Innovation.

Williams, M. K., & Farber, M. (2020, April). Gaming Pedagogy and Connected Learning: Perspectives *from the Global Minecraft Mentoring Program*. In Society for Information Technology & Educator Education International Conference (pp. 1894-1899). Association for the Advancement of Computing in Education (AACE).

Worsley, M., & Bar-El, D. (2020). Spatial Reasoning in Minecraft: An Exploratory Study of In-Game Spatial Practices. *Computer supported collaborative learning*, 2.