Factors Affecting Sustainable Use of Minecraft-based Lessons

Dominique Marie Antoinette B. MANAHAN[a *] & Maria Mercedes T. RODRIGO[b]
[a]*Ateneo Laboratory for the Learning Sciences, Ateneo de Manila University, Philippines*
[b]*Ateneo Laboratory for the Learning Sciences, Ateneo de Manila University, Philippines*
*dmanahan@ateneo.edu

Abstract: This paper examines the factors that affect the sustainable use of Minecraft-based lesson plans. We focus specifically on teachers who received training on using What-If Hypothetical Implementations in Minecraft (WHIMC), a set of Minecraft worlds designed to teach astronomy, geosciences, and ecology. We commissioned a group of teachers to develop lesson plans using at least one of the WHIMC worlds and pilot their implementation in their classes. Another group of teachers received training on developing learning modules with WHIMC but had the freedom to choose when and how to implement their lesson plans during the school year. The teachers cited logistical impediments, scheduling impediments, lack of technical resources, lack of curricular alignment, changes to teaching modalities, limited time for practice, and anxieties about classroom management as barriers to sustainable use of WHIMC. They suggested the training of additional teachers to create a community of practice whose members can collaborate and support each other's use of WHIMC for STEM education.

Keywords: WHIMC, Philippines, Game-based Learning

1. Context

In 2020, the Ateneo de Manila University (ADMU) and the University of Illinois Urbana-Champaign (UIUC) entered into a partnership in which UIUC allowed ADMU to use its What-If Hypothetical Implementations in Minecraft (WHIMC; https://whimcproject.web.illinois.edu/) in schools in the Philippines. WHIMC is a set of computer simulations built in Minecraft Java Edition to engage students in "what if" questions such as "What if Earth had no moon?" or "What if Earth had a slightly colder sun?" WHIMC immerses students in these alternate versions of Earth, giving them opportunities to see how the planet's geography and life forms would differ under these circumstances. It enables students to use science tools to collect data about these alternate Earths and record their observations.

The UIUC team successfully used WHIMC in summer school programs (Lane, et al., 2022). It also recently partnered with several planetariums to include WHIMC installations among the planetariums' exhibits. Furthermore, UIUC has used the data collected from their WHIMC deployments to study learner-related phenomena such as the structure and skill level of learner scientific observations (Hum, et al., 2022) and STEM interest behaviors (Gadbury & Lane, 2022), among others.

Leveraging on UIUC's success, the goal of the ADMU team was to determine whether WHIMC could cultivate Filipino learners' interest in STEM. ADMU researchers were motivated by the need to improve Science, Technology, Engineering and Mathematics (STEM) achievement in the Philippines. The PISA National Report on the Philippines (Philippines Department of Education, 2019) said that, compared to the OECD average of 489 in math and 489 in Science, Filipino students scored a low 353 and 357 respectively. Only 1 out of 5 attained the minimum proficiency level in math. These results are corroborated by students' performance in the National Achievement Test, where only 25%

demonstrated mastery levels in math and only 5% of test takers demonstrated mastery levels in science.

Through a 2021 grant from the Philippines' Department of Science and Technology, the ADMU purchased 212 Minecraft Java Edition licenses and rented a server that allowed it to mirror the UIUC WHIMC site. The ADMU team then worked with teachers to help them gain familiarity with WHIMC and develop lesson plans that integrated WHIMC in science, math, and even English classes. The ADMU team also provided the teachers with technical support during actual conduct of these lessons.

Since then, the ADMU team has trained 23 teachers for WHIMC Java Edition and 24 teachers for WHIMC Education Edition. In the ADMU WHIMC Java Edition server, over 304 students were able to explore it. Furthermore, it developed a Minecraft Education Edition version of some of the worlds (see teachers' guide through bit.ly/WHIMCEETeachersGuide). This version has been used by 78 students and 5 teachers in 2 Philippine schools. The ADMU team also used the data from its deployments to study the effects of WHIMC on student STEM interest (Tablatin, Casano, & Rodrigo, 2023), the relationship between STEM interest and student affective states such as frustration and boredom (Esclamado, Rodrigo, & Casano, 2022), and to compare the quality of Philippine and US student observations (Casano & Rodrigo, 2022).

Despite these successes, continued use of WHIMC is not guaranteed. Indeed, now that the DOST grant has ended, the overarching question we pose in this paper is one of sustainability. Will teachers continue using WHIMC as the ADMU project team starts removing the scaffolds? In this paper, we attempt to examine what factors contribute or hinder the sustainability of WHIMC use in Philippine classrooms.

2. Sustainability of Educational Technology Initiatives

In the context of educational technology initiatives such as WHIMC, sustainability is defined as persistent and ongoing change of the educational culture (Neiderhauser, et al., 2018). Sustainability is a process that unfold when support systems are established and the community in which the initiative takes place maintains the initiative over time. When an initiative is sustained, the innovation or intervention becomes richer and more sophisticated as it evolves. Initiatives factor in changes in context. Increased knowledge of and comfort with the innovation prompts stakeholders to maximize the innovation's affordances.

These characteristics of sustainability are evident in many Minecraft applications. The work of Lincenberg and Eynon (2021) discusses how educators use Minecraft to transform classrooms into social spaces where teachers and students could visit or challenge each other, spaces where students could respond to the curriculum in their own ways, e.g. by solving problems that their teachers gave or that they defined themselves. A review by Baek, Min, and Yun (2020) shows how Minecraft has been successfully integrated in science, math, social science, and language subjects, and has been shown to increase creativity, improve technology skills, increase collaborative skills, and encourage communication.

There are, however, many factors that hinder the sustainability of educational technology initiatives. Ertmer (1999) classifies these barriers into two: first-order barriers are extrinsic to teachers. These include lack of equipment, time, training, or support. Second-order barriers are intrinsic to teachers. These include teachers' underlying perceptions about how teaching and learning should take place. First-order barriers are often cited particularly in developing world contexts. In Tanzania, for example, barriers included a lack of basic infrastructure and a lack of motivation and support from school management are impediments (Kafyulilo, Fisser, & Voogt, 2016). In the Philippines, the cost of Internet access, the lack of curricular alignment, and insufficient teacher professional development make it difficult for schools, teachers, and students to incorporate technology in their classes (Rodrigo, 2021).

Second-order barriers have been discussed in the context of Minecraft-based lessons. Thinking of ways to incorporate Minecraft in lessons necessitates familiarity with technology in general and Minecraft in particular. This creates work that is over and above regular teaching tasks. Innovations such as Minecraft also necessitate a constant upgrading of skills and constant adaptation, which challenges teachers' already limited time (Thorsteinsson & Niculescu, 2016).

This paper reports feedback from teachers who were trained to use WHIMC about the factors that helped or hindered them from using WHIMC in their classes, and the likelihood that they will use WHIMC (again) in the future. By asking teachers for their feedback, we assess WHIMC's sustainability. Is it likely to continue being a useful tool for teachers and students in Philippine classrooms or will first- or second-order barriers become so insurmountable that the use of WHIMC is more likely to fizzle out as so many education technology initiatives do?

3. Data Collection

3.1 Participant Selection

All of the partner teachers were endorsed by the researchers' institutional partners and teacher participants who attended the module development training using WHIMC under the project were invited to participate voluntarily in an online focus group discussion (FGD) session. The module development training provided varied, as there were school schedules that allowed a five-day online training while others had only one full working day available but held on-site in the school's own laboratory. In general, the format of the trainings held provided first a short orientation about the educational framework of WHIMC, a discussion on the features of Minecraft, and a short demonstration on how to navigate through the WHIMC worlds. Then, the teachers were provided an opportunity to initially explore the WHIMC worlds assigned using lent Minecraft accounts and a training guide. The training guide contained three to five guide questions for each WHIMC world that would allow the teacher participants to look into the content and environment of the WHIMC world. After being able to explore the WHIMC worlds, the teachers were given the space to design and draft their learning modules for their own classes. This was done individually for some schools, while other schools designed a module as a group according to the grade level they taught. The presentation included a feasibility assessment by the teacher on whether they could fully implement and integrate Minecraft in their classes. Afterwards, everyone is given a chance to present their module drafts to the rest of the participants and trainers, and hear feedback about how they could improve the module developed. Finally, the trainers gave an orientation on how to prepare their classes for a WHIMC lesson.

Upon invitation to attend the FGD, the teachers were provided session schedule options with a maximum of 1.5 hours each session. The confirmed FGD participants were sent an electronic calendar invite with an online conference link where the FGD would be held at least two weeks before the FGD session schedule they had chosen. On the FGD session schedule, the teacher participants gathered at the online meeting room hosted by the project manager and the project leader.

3.2 Focus Group Discussions

The project leader and project manager prepared a presentation and an online word document for the FGD. The online word document served as the main data gathering tool to collect the FGD participants' basic information and notes on their responses to the FGD questions.

The session began with the project manager and project leader welcoming the participants. The project manager proceeded to state the session objectives, which was "to identify the factors that motivate or hinder the implementation of a WHIMC module in the classroom. During the FGD, participants were given five (5) minutes to post their responses the question applicable to their situation on the Google Doc file provided. The project manager and project leader facilitated the discussion in the online meeting room, where the participants were given the space to share about their responses to the group.

There were two (2) questions raised during the online session. The first question was applicable to the teachers who had already developed and implemented a lesson plan in at least one class, and read by the project leader or manager, “If you implemented a WHIMC lesson plan before, would you implement it again? Why or why not?” The other question was applicable to the teachers who had not implemented a WHIMC lesson plan yet, and asked “If you did not implement one before, why? Would you implement one now? Why or why not?”

4. Results and Discussion

The project team was able to interview a total of nine (9) participants, five (5) male and four (4) female basic education teachers, working in Philippine private and public basic education institutions. The participants had an average age of thirty-five (35) years old, with an average of eleven (11) years of basic education teaching experience, and an average of ten (10) years of teaching a STEM-related subject.

Four (4) teachers who were trained to use WHIMC did not pursue the implementation of a WHIMC lesson plan in their actual classes. The remaining five (5) did so. All of them expressed that, if given an opportunity, they would implement a WHIMC lesson in their classes again. One female teacher from a private school shared that she had observed the depth of learning from her students as they used WHIMC in their class. The students' discussion went beyond the intended topic, and had seen how theoretical concepts actually happen through their exploration inside the WHIMC worlds. She also observed that it developed their affective and social skills, since the students were able to play, communicate and collaborate on their movements within the WHIMC Java Edition server during their online WHIMC class. Two (2) other teachers expressed that they would choose to implement a WHIMC lesson as a supplement or enrichment activity in their classes. For example, it was shared by one of them that there are topics, such as the solar system, where it is difficult to think of experiments for. Thus, the WHIMC worlds exploration could be a good tool to help the students learn deeper about the topic. Then, one teacher from a public school shared that she saw how eager the students were during class which encouraged her to plan for another WHIMC lesson.

The first-order barriers cited by both groups of teachers were similar:

1. **Logistical impediments.** Given that the schools only have a common computer laboratory, which was usually used for the computer education subject, venue availability for a WHIMC class was seen as a concern. It was raised that the school would hopefully increase the computer laboratories and/or update their policies to allow the students to bring their own devices or laptops.
2. **Lesson scheduling.** The WHIMC lessons tended to be quite lengthy, exceeding the usual class period length for some schools. One teacher noted that they had limited contact time with the students within a week (e.g. three times a week to teach one module). The challenge to teachers was to integrate WHIMC into these limited time slots. Having more time would make implementing a WHIMC module more feasible.
3. **Technical resources.** For schools that implemented a WHIMC lesson through an online modality, it was said to be more convenient if the school had available computers to lend to avoid any delays in the student's accomplishment of the WHIMC class' activities.
4. **Curriculum alignment.** Of the four (4) teachers who were not able to implement a WHIMC lesson, three (3) were assigned to teach computer education. Their curriculum goals and competencies were not aligned to the content of WHIMC, and focused on other STEM areas such as robotics and programming. Meanwhile, for one of the teachers under this group that taught Science (specifically, Physics), it was raised that the developed module during the teacher training was not fit for the lesson topics his class had in the pipeline.
5. **Changes in teaching and learning modalities.** Throughout the school year, policies on the teaching and learning modalities have constantly shifted due to the changing COVD-19 restrictions, to which the schools adjusted to every now and then. The change from flexible learning, partially on-site and fully on-site classes affected the lesson planning of the teachers.

The second-order barriers cited by both groups of teachers included the following:

1. **Limited time to practice the lesson design or for dry runs.** Teachers said that they had limited time to explore WHIMC and practice their lesson designs. Additional time to practice would give them more chances to think of and implement WHIMC-based lesson in their classes. They could also use the time to improve upon the lessons that they had already created.
2. **Concerns about classroom management.** Related to the second first-order barrier, teachers expressed anxiety about how they would manage a WHIMC-based class during a 50-minute class period. They were not sure they would be able to orchestrate a proper exploration of the worlds, given the limited time.

The teachers did have some suggestions about how these barriers could be overcome. They suggested that WHIMC training be made available to more STEM teachers. This creates a community of practice whose members can work together on common lesson plans, thereby allowing the school to implement WHIMC-based lessons across more sections of a grade level, as the STEM subjects are usually taught by multiple teachers.

5. Conclusion

We found that for both groups of teachers, those who were and were not able to implement a WHIMC lesson, encountered similar first- and second-order barriers. They noted the feasibility of running a WHIMC lesson in their classes was hindered due to logistical, technical and curriculum concerns. To be able to address said barriers, the school administration’s support is needed to be able to realize the material and content support needs of the teachers. The difference seemed to be that those who were able to implement were also able to overcome the limited time for practice and any anxieties they might have had about classroom management. The teachers did not mention barriers similar to the ones cited in prior literature (see Thorsteinsson & Niculescu, 2016) but it is consistent with some of the findings of general impediments to the use of technology in developing world classrooms (see Rodrigo, 2021).

In summary, to successfully sustain the implementation of Minecraft-based lessons, it requires the support of school leadership for the needed facilities and technological infrastructures. Having a community of teachers that are equipped to develop and manage such kinds of lessons is also important to push for the institutionalization of lesson plan development and implementation. Additionally, having a more stable mode of teaching and learning as well as a community of practice would allow teachers to successfully plan and consider integrating Minecraft in their class topics.

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A Mathematical App for the Conceptual Understanding of Area and Perimeter

Jumela F. SARMIENTO[a,*], Debbie Marie B. VERZOSA[b], Maria Alva Q. ABERIN[a], Ma. Louise Antonette N. DE LAS PEÑAS[a], Agnes D. GARCIANO[a], Juan Carlo F. MALLARI[a], & Mark Anthony C. TOLENTINO[a]
[a]*Department of Mathematics, Ateneo de Manila University, Philippines*
[b]*Department of Mathematics and Statistics, University of Southern Mindanao, Philippines*
*jsarmiento@ateneo.edu

Abstract: This paper discusses an app that was developed to build a strong understanding of the concepts of area and perimeter in students. An important feature of the app is the three-component feature which highlights progressive learning: *Explore,* designed for the learning of the conceptual understanding of area and perimeter; *Apply*, where area and perimeter concepts are applied; and *Create* intended for constructing representations to develop higher order thinking skills. The pedagogical basis for the creation of the app, the game design elements employed in the app as well as the integration of the app in the classroom will be presented.

Keywords: Mathematical app, area and perimeter, area, perimeter

1. Introduction

There is a longstanding and general consensus worldwide (Hiebert & Carpenter, 1992; Skemp, 2006) and in the Philippines (Department of Education, 2016) that mathematics must be learned relationally; that is, as an integrated network of connections between and among mathematical concepts. Teaching area and perimeter meaningfully entails going beyond the teaching of formulas or procedures so that students could justify these formulas and re-construct them in case they forget (Lithner, 2017). Toward this end, designing instructional materials to facilitate students' learning of area and perimeter is essential.

A problem arises in emerging economies whereby many schools routinely cater to ill-prepared students, which forces teachers to resort to rote-based strategies in teaching area and perimeter. In (Bansilal, 2011), classroom discussion facilitated by a teacher in South Africa focuses largely on helping her students remember the formula rather than on allowing her students to reason about the authentic performance-based assessment mandated by their national board of education. The reason for this teachers' actions was due to her learners' non-readiness for the task, preventing the students from engaging in more meaningful mathematical activity. In Taiwan, which has historically performed well in international assessments, there are teachers who present formulas directly instead of engaging their learners to explore the geometric basis for these formulas (Huang, 2017).

The potential of technological tools for teaching area and perimeter has been explored (Hwang et al., 2020). This paper discusses the *Area and Perimeter* app aimed to provide students the opportunity to understand the conceptual underpinnings of area and perimeter formulas. This app was designed in consideration of scholarly literature and was one of the outputs of a government-funded project in the Philippines (De Las Peñas et al., 2023). It was designed in a game-like environment to address particular learning competencies in mathematics. It is compatible with and runs efficiently in a wide range of Android devices (e.g., smartphones, tablets) and Windows PC (laptops or desktops) without the internet.

2. Pedagogical Basis

The *Area and Perimeter* app was designed based on the concrete-pictorial-abstract approach developed by Jerome Bruner (1996). The idea is to carefully sequence representations that would enable learners to transition from concrete to abstract (Ding & Li, 2014). As such, area formulas (which are abstract concepts) are strongly tied to geometric shapes (which are pictorial representations). The app also consists of three levels: *Explore*, *Apply*, and *Create*. By *exploring* geometric objects, students can think about area and perimeter using particular cases. By playing the app repeatedly, they can generalize, understand the conceptual basis for the area and perimeter formulas, and *apply* them to compute the area and perimeter of a given geometric figure. Finally, students are provided an opportunity to develop higher-order thinking by *creating* geometric objects given the area or perimeter. This sequence of *Explore*, *Apply*, and *Create* allows the student to develop relational understanding instead of relying solely on procedural formulas of area and perimeter.

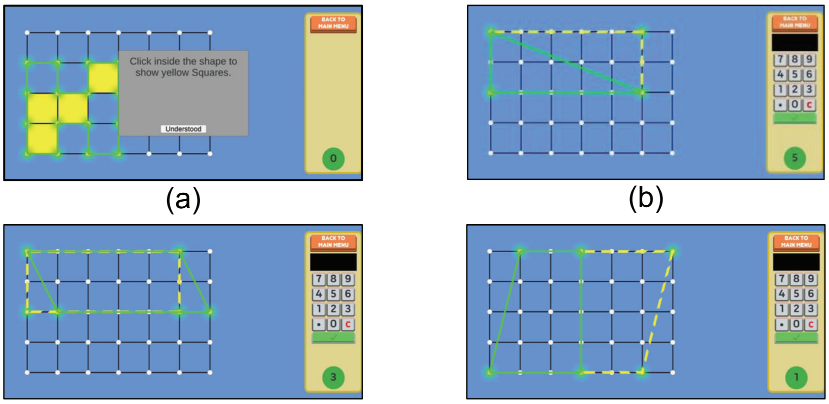
3. The *Area and Perimeter* App

3.1 App Description

In the *Area and Perimeter* app, students have the option to choose the following topics: *Area*, *Perimeter,* or *Area and Perimeter*. The *Area* component includes the following subtopics: *Introduction to Area*, *Rectangle/Square*, *Triangle*, *Parallelogram* or *Trapezoid*. The app allows the student to investigate area properties of rectangles, triangle, parallelogram and trapezoid. The *Perimeter* component includes *Introduction to Perimeter*, *Rectangle* or *Rectilinear Figures.* Herein, a student can learn perimeter properties of rectangle or rectilinear figures. In the *Area and Perimeter* component, students find the area and perimeter of rectilinear shapes and construct rectilinear shapes of given area and perimeter.

There are three levels in the app, to reflect the pedagogical intention to enable students to develop deep understanding of area and perimeter, beyond knowing formulas by rote.

Explore. In this level, students learn the conceptual underpinnings of both area and perimeter. Under the topic *Area* and subtopics *Introduction to Area* and *Rectangle/Square*, students are shown a rectilinear shape then they are supposed to click on each unit square within the shape (Figure 1(a)) and are asked how many squares are enclosed in the figure. This way, they connect the idea of area to the measure of the surface inside the given enclosed region.



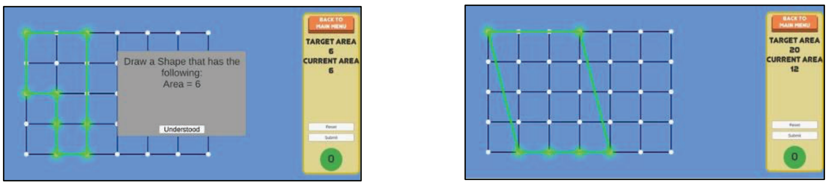
(a) (b)
(c) (d)

Figure 1. Screenshots of the app; Topic: *Area* and Level: *Explore.*

For the sub-topics of triangles, parallelograms, and trapezoids the aim of the *Explore* component is to allow students to learn the reasoning behind the area formulas. For example, for *Triangle*, a rectangle is first shown and then a diagonal is drawn (Figure 1(b)) to show that half of the rectangle is a triangle. This reinforces the idea that the area of a triangle is half the area of a corresponding rectangle. For *Parallelogram*, an auxiliary line segment is shown (Figure 1(c)) to illustrate that translating the triangle at one end of the parallelogram to the other end would result in a rectangle. This reinforces the idea that the area of a parallelogram is the same as that of a rectangle with the same height and width. Finally, for *Trapezoid* (Figure 1(d)), a trapezoid (in green border) is shown and is duplicated (whole figure) and placed adjacent to the former so that the combined figure is a parallelogram. This reinforces the idea that the area of a trapezoid is half the area of a parallelogram with the same height and base. A score on the lower right corner of the screen allows the student to monitor his or her own progress and decide if he or she can choose another feature of the app.

Apply. Unlike the *Explore* level, in the *Apply* level, there are no extra steps, students are directly asked, “How many square units are in the figure?” At the *Apply* level, students use the ideas in the *Explore* component to determine the area of given geometric figures.

Create. In this level, students construct representations themselves, enabling them to develop higher-order thinking skills. Specifically, students are asked to draw a shape by clicking and connecting vertices to produce the required shape with a given area (Figure 2(a)). On the right side of the screen, the target area and current area are given. Thus, if a student constructs a shape with an incorrect area (Figure 2(b)), there is an instant feedback that provides an opportunity for the students to construct a new shape until they get one with the correct area.



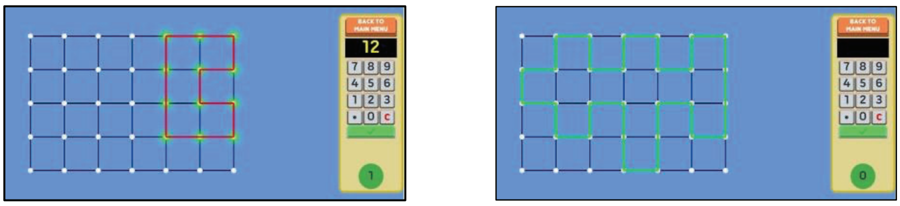
(a) (b)

Figure 2. Screenshots of the app, Topic: *Area* and Level: *Create*

Under the *Perimeter* option, the same levels (*Explore, Apply* or *Create*) are also available.

Explore. In this level, the students are asked to click on the edges of the shape and count the number of red edges such as in an example under *Rectilinear Figure* that is shown in Figure 3(a). When the correct answer is given, the app affirms that the shape has the given number as its perimeter. Through this, students connect the idea of perimeter with the number of edges around the shape.

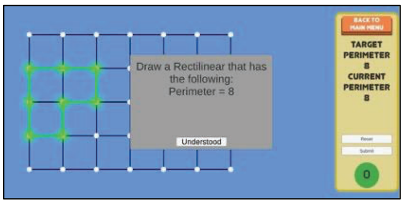
Apply. In this level, students must directly input the perimeter of the given shape (Figure 3(b)) using the ideas from the *Explore* component to be able to find the perimeter.



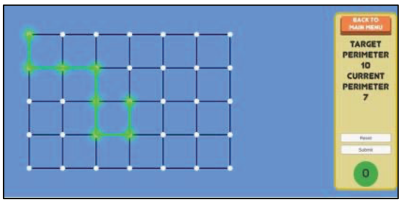
(a) (b)

Figure 3. Screenshots of the app, Topic: *Perimeter* and Levels: *Explore* (a), *Apply* (b)

Create. Here, students are tasked to construct a rectilinear shape with a given perimeter (Figure 4(a)). On the right side of the screen, both the target perimeter and the current perimeter are given. As the students add edges to form a shape, they will see that the current perimeter is updated, and this will guide them in constructing the correct shape having the desired target perimeter. For example, as shown in Figure 4(b), the target perimeter is 10 while the current perimeter is 7 and it is not possible to continue adding edges to construct a rectilinear shape having the target perimeter. Thus, students who meet such situations will construct new shapes until they successfully meet the target perimeter.



(a)

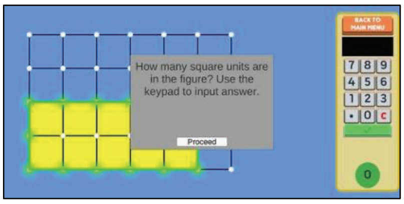


(b)

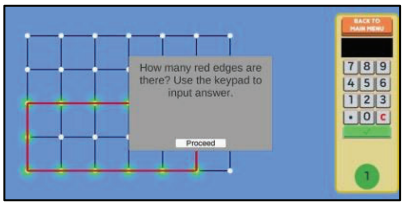
Figure 4. Screenshots of the app, Topic: *Perimeter* and Level: *Create*.

When the topic *Area and Perimeter* is chosen from the Main Menu, students may perform tasks that involve both concepts, to help them attain the reasoning skills to distinguish between these two concepts (Huang, 2017).

Explore. Under the *Explore* level, students first click on each unit square within the figure to show yellow squares and then find the number of unit squares (Figure 5(a)). When the answer is correct, they now click on the edges of the shape to show red edges and then count them (Figure 5(b)). When the answer is correct, the app confirms that the area of the shape is the number of unit squares given and the perimeter is the number of red edges.



(a)

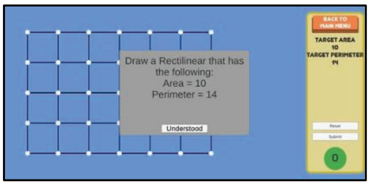


(b)

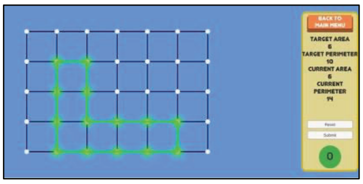
Figure 5. Screenshots of the app, Topic: *Area and Perimeter* and Level: *Explore*

Apply. In this level, students directly input the area and perimeter of the given shape.

Create. In this level, students draw a rectilinear shape with the given area and perimeter (Figure 6(a)). There may be instances when students construct a rectilinear shape with the correct perimeter but incorrect area or correct area but incorrect perimeter (Figure 6(b)). The current area and current perimeter given on the right side of the screen provide the immediate feedback that will enable the students to construct new shapes until they successfully meet the target area and perimeter.



(a)



(b)

Figure 6. Screenshots of the App, Option: *Area and Perimeter* and Difficulty Level: *Create.*

3.2 Game Design Factors

Creating an innovative instructional app in a game-like environment such as *Area and Perimeter* requires a sound framework on which its development can be based. Focusing on how the game is aimed at enabling players to make the leap from the concrete to the abstract, we used Shi and Shih's game-based learning (GBL) design factors (Shi and Shih, 2015) as a guide, apart from "sociality," which *Area and Perimeter* does not inherently feature as it is a single-player game.

The game goal is to develop an understanding of area and perimeter formulas. This is achieved via a combination of the abovementioned *Explore*, *Apply*, and *Create* difficulty levels, which constitute the game mechanism. The player interacts with the game by tapping squares to highlight areas, dragging between points to construct edges, and tapping a simple number pad to provide answers to area questions. As mentioned above, players are free to select what concept (area or perimeter) and what shape to focus on; the *Explore*, *Apply*, and *Create* difficulties are also available for all these concepts from the beginning. Moreover, in the *Create* difficulty, players are tasked to construct any shape that has particular area and perimeter values, giving them autonomy and testing their creativity. Each concept, shape, and difficulty combine to form an inherently challenging level that requires the player to accomplish a task (e.g., highlight areas, tap edges).

While the *Area and Perimeter* app does not have a narrative by the strictest definition, it does feature a sense of progression through the various topics and difficulties. The game fantasy centered around an interactable grid, which is also the main medium with which the game provides sensation. The game's mystery arises from the variety of the topics and levels, as well as the randomness in the questions generated. These factors taken together give rise to the game value of *Area and Perimeter* as a learning tool for mastering abstract concepts such as area and perimeter formulas using concrete examples.

4. Integration and Use of the *Area and Perimeter* App

This section explores the use of the *Area and Perimeter* app as a pedagogical tool based on the RAT (Replacement, Amplification, Transformation) framework (Hughes et al., 2006). The app can replace the traditional approach of teaching area and perimeter without modifying the content or learning outcomes. For instance, teachers frequently ask students to calculate the areas and perimeters of hand-drawn figures of triangles, squares, rectangles and other quadrilaterals. These figures are now presented in the lattice configuration of the app. Finding the area or perimeter still must be done, but instead of doing it in a static way, geometric figures are now shown in a colorful and dynamic way. Teachers can use the app during drill and practice time.

Secondly, learning may be enhanced by the integration of the app since it can explain perimeter and area ideas with ease and efficiency. The lattice design accurately represents unit squares, which can help learners comprehend the conceptual underpinnings of area and perimeter calculations. This understanding is also possible since students engage in a variety of activities that the app can generate.

Finally, the app may be used to change instructional methods and the learning process. Teachers may conduct classroom activities that are more student-centered by using the app as a tool for group inquiry and projects that promote cooperation among students and provide a supportive learning environment. The *Create* option has the potential to improve student engagement and alter the way that students learn. Thus, teachers are encouraged to utilize this feature during class discussions and activity periods to expose students to questions about area and perimeter that aren't commonly asked.

Teachers can screencast to a smart TV or projector if students don't have their own devices. The proposed exercises can be completed by the entire class at the same time.

The app's three learning levels—Explore, Apply, and Create—can accommodate various learning demands of the students. While the levels on Explore and Apply can be utilized for remedial work, the level on Create is suitable for student enrichment activities.

5. Conclusion and Future Direction

This paper describes the features of the *Area and Perimeter* app designed to help students gain a better understanding of the notions of area and perimeter and help them make sense of the usual formulas associated with these concepts. The three levels of difficulty of the app leads students from basic exploration of the area or perimeter of polygons to application of these ideas in calculating these parameters, and finally to the creation of shapes with a given area or perimeter.

Efforts to improve numeracy and literacy among Filipino learners are even more relevant at this time considering the recognition by the Department of Education (DepEd) of the Philippines that there have been setbacks in learning targets caused by school closures during the Covid-19 pandemic. The DepEd issued the *Adoption of the National Learning Recovery Program* (DepEd, 2023) to help address these setbacks. The *Area and Perimeter* app may be considered as a tool that can contribute to this recovery plan.

The *Area and Perimeter* app may be expanded to include the exploration of areas and perimeters of non-polygonal figures such as circles and other irregular shapes. This will further help students understand the concepts and not resort to sheer memorization of formulas. An avenue for future work would be the translation of the app into Filipino to make it more accessible to students in the Philippines. Finally, the authors plan to conduct further research to evaluate the effectiveness of the app in the learning of students.

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Design of a Mobile App to Promote Understanding and Fluency in Finding the Equation of a Line

Agnes D. GARCIANO[a,*], Maria Alva Q. ABERIN[a], Ma. Louise Antonette N. DE LAS PEÑAS[a], Juan Carlo F. MALLARI[a], Jumela F. SARMIENTO[a], Mark Anthony C. TOLENTINO[a], & Debbie Marie B. VERZOSA[b]
[a]*Department of Mathematics, Ateneo de Manila University, Philippines*
[b]*Department of Mathematics and Statistics, University of Southern Mindanao, Philippines*
*agarciano@ateneo.edu

Abstract: This paper focuses on the design of a mobile app called *Pick or Fish* that fosters comprehension and mastery of the concepts of slopes, *y*-intercepts and equations of lines. The app's pedagogical value lies in its potential to help students understand and become proficient in these concepts. The app is suitable for use on low-cost mobile devices. It functions within an engaging game-like setting featuring visual elements that enable students to see the effect of parameter changes on the direction of a line. The beginner and advanced levels of the app have scaffolding features that gradually introduce the students to the key aspects of linear functions. The mechanics of the app, its pedagogical basis and how integration in the classroom may be achieved as teachers plan the lesson, facilitate open-ended discussion and encourage independent use of the app are also discussed.

Keywords: Lines, slopes, *y*-intercept, equations of lines, mobile app

1. Introduction

There is a view that from both a mathematical and pedagogical perspective, the core and fundamental concept underlying algebra, trigonometry, probability, statistics and calculus is that of *function* (Schwartz & Yerushalmy,1992). In the Philippine high school mathematics curriculum, linear function is one of the first types of functions that students learn. In Grade 8, the topics of slope, *y*-intercept, and equation of a line are discussed. An in-depth understanding of these concepts is necessary in problem solving and mathematical modeling involving linear functions. Furthermore, this is also necessary for doing more advanced work in linear regression, interpolation, and rates of change in calculus. The skill of writing equations of lines enables students to make correct mathematical models of real-world data exhibiting linear trends and make forecasts. Thus, the acquisition of conceptual knowledge and procedural fluency on calculations involving linear functions are important for high school students to have.

In this paper, we present the design of a mobile app called *Pick or Fish* that is intended to help students gain a better understanding of slope and y-intercept and acquire fluency in forming the equation of a line. The app is one of the technological tools developed and designed by the authors made available for use in Philippine schools through the internet, community LTE networks (De Las Peñas et al., 2022) or local networks powered by datacasting technology (De Las Peñas et al., 2023). These tools support the twin goals of mathematics education in the Philippines, which is to develop critical thinking and problem solving (DepEd, 2016). In emerging economies such as the Philippines, studies have shown that mathematics is only superficially learned (Verzosa & Vistro-Yu, 2019), and that the focus of mathematics classrooms is on rules and procedures (Nag et al., 2014; Verzosa, 2020).

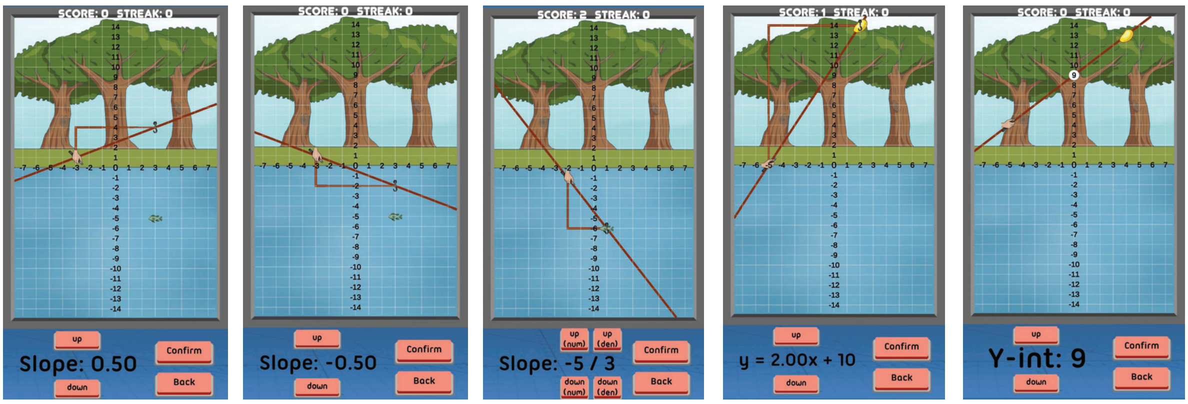
Pick or Fish was designed as a mathematical mobile application (app) that runs in an interactive, game-like environment. It is intended to be played by students to gain proficiency in finding slopes and forming equations of lines. Interactive digital tools such as mobile apps designed in a game -like environment have the potential to enhance the interest of students (Chao et al, 2018). Interest to carry out the tasks is important for students to gain mastery and fluency in the topic. While there are other existing apps and software that allow the exploration of slopes and equations of lines, one of the important features of *Pick or Fish* is that it is built in a game like environment, and there is the inclusion of scaffolding mechanisms that allow a student to work at a particular level of difficulty based on their learning progression on the topic. The latter feature makes the app apt for student centered learning. As an emerging economy, the Philippines has also comparatively limited educational resources. Further, many Filipino students come from low-income families who could not afford graphics calculators, laptops/computers or medium- to high-range mobile phones. Thus, the *Pick or Fish* was designed to be freely available and able to run on earlier Android versions of mobile phones.

2. Description of the *Pick or Fish* App

The app is designed to help students develop their understanding of the concept of slope and *y*-intercept of a line and consequently help build their skill in forming the equation of a line. There are two levels: *Beginner* and *Advanced* and there are several topics per level. In each level, the task is to pick a fruit or fish by either varying the value of the slope, or the *y*-intercept, or both.

2.1 Beginner Level

In all topics in the *Beginner* level, the screen shows a hand with a rod and a target object (either a mango fruit or a fish). The student needs to press the “up” and “down” buttons found at the bottom of the screen to move the rod so that it would touch the fruit or the fish. Doing this, the student can see how adjusting the slope corresponds to changing the steepness of the line as represented by the rod. By playing the game repeatedly, the student can connect positive and negative slopes to the orientation of the line (Figures 1(a) and 1(b), respectively).



(a) (b) (c) (d) (e)

Figure 1. Screenshots of the *Beginner* level of *Pick or Fish*

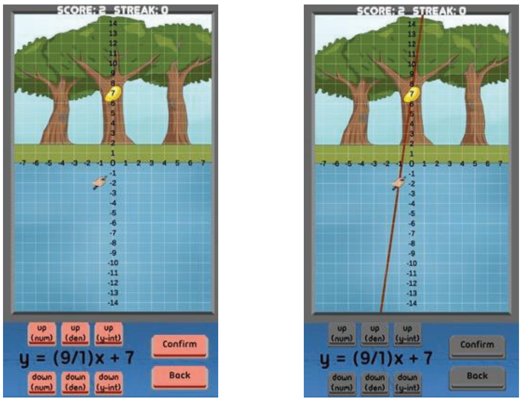
The app scaffolds instruction by first focusing on slopes having integer values, then fractional values. The student can see how the slope also corresponds to the ratio of the vertical and horizontal changes in the line. For example, in Figure 1(c), the slope is -5/3 which corresponds to the ratio in a triangle with vertical dimension 5 and horizontal dimension 3.

In the succeeding topic, *Slopes—Equation of a Line,* an equation of a line in the form $y = mx + b$ is given, but only the value of m needs to be changed (Figure 1(d)). This is the first introduction of the student to the slope-intercept form of the equation of a line. Familiarity with this form is important as it shows that a line is determined by two parameters m and b. The next topic is the *y-intercept.* where the student presses the up and down buttons to get the correct value of the *y*-intercept (Figure 1(e)). Here, the student sees how changing the *y*-

intercept will not change the steepness but would rather shift the line up or down. The last topic under the Beginner Level is the *Slope-Intercept Form of a Line.* Here, the student provides the values of the slope *m* and *y*-intercept b in the equation $y = mx + b$.

2.2 Advanced Level

In the *Advanced* level, the student can utilize their developing notions of slope and *y*-intercept to make the line reach the targeted mango or fish. The topics in this level are like those in the *Beginner* level, except that the rod is not visible at the start–only the hand and target are shown (Figure 2(a)). Thus, the student must apply what they learned in the *Beginner* level and press the necessary buttons (without visual scaffolding) to produce the correct equation that would make the rod reach the target (Figure 2(b)).



(a) (b)

Figure 2. Screenshots of the *Advanced* level, Topic: *Slope-intercept Form of a Line* rod is not shown at the start; (b) rod is shown after pressing "Confirm" button.

A student who makes a mistake has the chance to correct himself. For instance, when working on a sample question related to Slope-*Intercept Form of a Line*, both slope and *y*-intercept values are needed. The student may correctly input the value of the *y*-intercept, which is visible on the screen. However, determining the value of the slope requires more thought. Without visual help he must calculate the ratio of the vertical and horizontal distances between the hand and the object. If the student enters an incorrect value, he receives feedback that the rod misses passing through the object. This feedback serves as a clue, helping the student identify whether the slope must be increased or decreased and gives him an opportunity to input the correct answer.

2.3 Topic/Level Progression

The scaffolded questions built into the app help students to work at the appropriate level of difficulty. Students can go back to any of the levels and topics at any time if they need more practice, or they can do so as guided by their teacher. In each level, once the student presses "Confirm," the app provides visual feedback and a bell or buzzer sound for the student to know if the answer entered is right. In addition, a score found at the top part of the screen enables students to monitor their progress and explore other topics in the app. These features help learners gauge their level of mastery and guide them as they progress through the topics.

3. Pedagogical Basis

The *Pick or Fish* app was designed to elucidate how variables express a relationship in a linear equation. The concept of *variable* is not easily learned because students may not have limited conceptions of how variables are used in mathematics. For Küchemann (1981, p. 104), a variable represents "a range of unspecified values, and a systematic relationship is seen to exist between two such sets of values." Ely and Adams (2012) identified two critical properties from Küchemann's definition: First, a variable is indeterminate, and can stand for a range of values such as in "$y = x + 7$," and second, it is part of a systematic relationship such that when one variable changes, another quantity may vary with it. Drawing on the history of mathematics, they further argue that the development of the notion of a variable represented a major breakthrough from using letters merely to represent an unknown or determinate quantity, such as in the equation "$2 + x = 5$." This development took centuries, making it understandable why students struggle with the transition from unknown to variable–they think that a letter must represent a specific value (Ely & Adams, 2012). This is possibly why students find it difficult to solve tasks involving representational transitions from a graph to an equation or vice versa (Ceuppens et al., 2018).

The visual scaffolds in the *Pick or Fish* facilitate the cognitive shift required to help students see relationships between the equation of a line to its graph and gain a better understanding of the systematic relationship between the variables in the equation. This is done through a game environment, particularly in the *Beginner* level, where students can see how adjusting coefficients in a linear equation leads to changes in the corresponding graph. These scaffolding elements which are introduced gradually through the progression of topics, along with visual aids and feedback mechanisms, help students cultivate a strong conceptual understanding of slope and *y*-intercept concepts, as well as to improve their fluency and proficiency in forming the equations of lines.

4. Game Design Features

Shi and Shih's (2015) Game-Based Learning (GBL) Design Model was used as the framework for the development of *Pick or Fish*. This model highlights 11 game design factors (*game goal, game mechanism, interaction, freedom, challenge, game fantasy, narrative, sociality, sensation, mystery, and game value*) for the design, analysis, and evaluation of game-based learning applications. Ten of these factors were incorporated into *Pick or Fish* and are discussed in detail below.

The *game goal* for *Pick or Fish* is to deepen one's understanding of slopes and the formulation of the equations of lines. This is achieved via its drill-like *game mechanism* where the player must provide the correct slope, *y*-intercept or equation of a line that passes through two given points (the hand and the fruit or fish). This drill-like mechanism complements the game goal as it allows players to repeatedly practice with different questions or tasks provided in the app to develop their fluency in the topic. Contributing to the *game mechanism* are the factors *interaction, freedom, and challenge.* Players *interact* with the game by tapping buttons to increase or decrease the slope and/or *y*-intercept of a line. They are given the *freedom* to select from multiple topics and levels that, as previously mentioned, allow for scaffolded instruction. These levels *challenge* the player to correctly answer five questions in succession, after which they will receive a prompt to move on to the next topic. These elements are important for developing learners' fluency in the topic as they can use the app to set their own learning pace (i.e., staying with a current topic or level until they have developed sufficient mastery) or to address specific learning gaps (i.e., selecting the topic or level that corresponds to a competency that they need to improve).

As *Pick or Fish* can be considered a single-player arcade game, it places no emphasis on *sociality* and features a simple *game fantasy* and *narrative* in which players are tasked to pick fruits off trees or catch fish by correctly identifying the equations of lines. The *game fantasy* is then further enhanced by the game's *sensation* and *mystery* aspects. For *sensation*, the game uses a simple but vibrant background with an overlain Cartesian plane, as well as sound prompts to let the player know when they input a correct or incorrect answer. It must be noted that on this Cartesian plane, for the slope topics under the game's *Beginner* level, adjusting the slope not only changes how the line is tilted but also changes the line's "rise" and "run" as represented by the appropriate triangle. This topic or level progression adds *mystery* to the game, with each new topic or level providing a new experience to the player.

Finally, the *game value* arises from the combination of all these factors, as *Pick or Fish* is aimed at providing players an engaging environment in which they can develop their understanding of equations of lines.

5. Integration and Use of the *Pick or Fish* App

This section describes how *Pick or Fish* can be utilized as a pedagogical tool. The steps below were adapted from the work of Woods et al (2018).

Step 1. Determine learning goals. The app is appropriate and useful in attaining the learning competencies involving slope, *y*-intercept and equation of a line. The design makes it easier for students to make the shift needed to see connections between a line's equation and graph and to comprehend the systematic link between the variables in an equation.

Step 2. Plan ahead. The teacher should plan for the logistical requirements of using the free to download app. Students should be taught how to properly download the software on a desktop or an Android device by their teachers. An Android emulator is required to run the program if it was downloaded to a PC.

Step 3. Present and practice. This step entails the presentation of the lesson and a demonstration on how to play the app. The teacher can ask, "Should the rod be moved up or down, left or right?" or "What happens to the direction of the rod when the up button is clicked?" These instruction questions will prevent students from using guesswork as a strategy to find the slope, *y*-intercept and equation of the line. Students have the chance to practice and become comfortable with the app during this phase.

Step 4. Process and verbalize. Finally, open-ended questions will allow students to explain their thinking process and reasoning. This can be done by asking reflection questions like "What helps you determine which button to click?", "How do you know that slope should be positive? or negative?", "What is the meaning of *y*-intercept?", or "How can one form the equation of a line?"

For practice and mastery, the teacher may advise the pupils to utilize the app asynchronously or outside of class. Students can share screenshots of their outputs over time in order to monitor their development. A follow-up discussion can be done to address difficulties and misconceptions of the students.

6. Conclusion and Future Direction

A deep conceptual understanding and fluency in creating equations of lines is a basic learning competency expected of high school students. However, many students still find the ideas of slope and *y*-intercept abstract and lack the proficiency in using these elements to formulate the equation of a line. This problem is carried on to more advanced work in mathematics where the concept of linear functions and equations are necessary.

In this paper, the *Pick* or *Fish* app is introduced as an interactive tool that can help students gain more insight and fluency in finding the slope and *y*-intercept of a line and write its equation. The app is aligned with the Philippine Department of Education's Most Essential Learning Competencies in Grade 8 Mathematics (DepEd, 2020). The app's game-like features help motivate learning and entice students to play to improve their understanding of abstract concepts. The popularity of mobile phones and tablets in the Philippines makes the app easily accessible as it can be readily downloaded and require low storage.

The next step in this research is to conduct studies on determining the effectiveness of the app in student learning. The app may still be improved by the inclusion of undefined slopes of vertical lines. An aspect that may be pursued in the future is the incorporation of more scaffolding mechanisms that can offer help to students who may struggle with the transition from beginner to advanced levels. Gathering more feedback from students and teachers on the use of the app will also help direct future research in this area.

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Towards Identifying the Learning Affordances of Social Media as Telemedicine Platforms among Physicians in a Developing Economy

Michelle BERNABE[a,b*], Rowena CAGUIAT[a] & Ryan EBARDO[a]

[a]*De La Salle University Manila, Taft Avenue, Manila, Philippines*
[b]*University of St. La Salle, Bacolod City, Philippines*
**michelle_bernabe@dlsu.edu.ph*

Abstract: This preliminary study investigates the integration of social media platforms in telemedicine from the viewpoint of physicians, utilizing the affordance theory. Through qualitative interviews with eight experienced physicians, the research explores the learning affordances of social media in healthcare in the Philippines. The findings reveal that social media facilitates digital information exchanges through remote communication, real-time symptom verification, and virtual fetal monitoring, leading to enhanced patient-provider interactions. However, certain restrictions, such as prior checkups and patient referrals, are identified to ensure responsible healthcare practices. The study provides essential insights for policymakers and healthcare professionals to optimize social media's role in telemedicine, revolutionizing healthcare delivery and improving patient outcomes. By understanding the specific learning affordances and challenges, this research contributes to enhancing the integration of social media platforms in healthcare practices and fostering patient-centered solutions through improved exchange of information between physicians and patients.

Keywords: Telemedicine, Affordance Theory, Social Media, Facebook, health technology

1. Introduction

Incorporating social media into telemedicine has been the subject of numerous studies in the recent past (O'Connor & Aardema, 2019; Wu, Chen, & Lin, 2020; Lee & Yoo, 2021). O'Connor and Aardema (2019) note that these platforms present possibilities to improve the efficiency and effectiveness of healthcare delivery via telemedicine. Identifying the potential benefits and risks of this developing trend requires understanding the role of affordance theory in the context of social media as telemedicine platforms (O'Connor & Aardema, 2019; Wu, Chen, & Lin, 2020; Lee & Yoo, 2022).

The use of social networking sites as part of telemedicine has the potential to revolutionize patient care. Social media allows doctors to remotely consult with patients, check their health, and disseminate informational resources (Wu, Chen, & Lin, 2020). Patient involvement and satisfaction can be increased, healthcare access expanded, and geographical obstacles removed with this integration (Wu, Chen, & Lin, 2020).

Despite the potential benefits, there are knowledge gaps regarding the specific affordances of social media platforms in the context of telemedicine from the physician's perspective (Smith, Johnson, & Davis, 2022). Most research has ignored the unique viewpoints and experiences of doctors who utilize social media as telemedicine platforms in favor of focusing on patient-centered outcomes and user perspectives (Smith, Johnson, & Davis, 2021). Telemedicine's benefits and drawbacks can be better understood if we gain insight into clinicians' perspectives and experiences using social media platforms for telehealth (Smith, Johnson, & Davis, 2022).

The main objective of this research is to examine, from a medical practitioner's vantage point, how social media can be used to take advantage of their educational affordances in the context of telemedicine. To determine the advantages and disadvantages of incorporating social media into telemedicine (Brown, Williams, & Wilson, 2022; Chen, Chen, & Lin, 2023) and the specific learning affordances that influence physicians' perceptions and practices. A qualitative method was used to learn more about how doctors use social media platforms for telemedicine (Brown, Williams, and Wilson, 2022; Chen, Chen, and Lin, 2023) and to record their rich experiences.

This study will contribute to healthcare policymaking by identifying the learning opportunities offered by social media in telemedicine. Additionally, it will expand our understanding of social media's potential benefits in resource-constrained healthcare settings, as it is conducted in a developing economy. Lastly, using a qualitative approach, the study delves deeper into the learning aspect of affordance theory within the context of social media as a telemedicine platform.

Section 2 summarizes existing research on the use of social media as a platform for telemedicine. The third section investigates the applicability of affordance theory to social media. Discussion follows in Section 4. In the final section, we discuss the preliminary findings of this ongoing research and its potential limitations.

2. Related Review of Literature

O'Connor and Aardema (2019), Wu, Chen, and Lin (2020), and Lee and Yoo (2021) emphasize the potential revolutionary impact of integrating social media into telemedicine. Notably, O'Connor and Aardema (2019) and Smith et al. (2022) argue that social media platforms offer specific affordances that can enhance the effectiveness and efficiency of telemedicine, particularly for healthcare professionals like physicians. To comprehensively understand the potential benefits and challenges of this innovative approach, it is essential to consider the perspectives of physicians regarding these affordances and their influence on healthcare practices.

Social media's affordances within telemedicine are diverse and extensive. As highlighted by Wu, Chen, and Lin (2020), social media platforms enable remote interactions, allowing physicians to establish virtual connections with patients, offer medical guidance, and monitor their health status. These platforms also facilitate the exchange of medical knowledge, educational resources, and health-related updates, enabling the dissemination of critical information (Lee & Yoo, 2021). Additionally, social media platforms serve as valuable tools for creating networks among physicians, fostering collaboration, and facilitating discussions on specific cases or the solicitation of expert opinions from peers (O'Connor & Aardema, 2019). Furthermore, the interactive features inherent in these platforms promote patient engagement and empowerment (O'Connor & Aardema, 2019).

While the integration of social media into telemedicine offers substantial advantages, it also presents challenges. Wu, Chen, and Lin (2020) underscore the potential benefits, including expanded healthcare service accessibility, increased patient participation and satisfaction, and the ability to overcome geographical limitations. Nevertheless, integrating social media platforms into telemedicine requires addressing significant concerns, including patient privacy and confidentiality, data security, and the potential for misinterpretation or misdiagnosis during virtual consultations (Chen, Han, & Cheng, 2022). In this context, healthcare professionals must effectively manage regulatory and ethical considerations associated with the use of social media platforms (Chen, Han, & Cheng, 2022).

To optimize the utilization of social media platforms in telemedicine, healthcare professionals and policymakers should establish explicit guidelines and protocols for patient validation and referrals, ensuring the continuity of care and minimizing the potential risks of medical malpractice (Bergmo, 2015; Desai et al., 2020; Hollander & Sage, 2020; Ohannessian et al., 2016). Moreover, providing training and support to healthcare professionals in the appropriate use of social media platforms can enhance their competence (Bergmo, 2015; Desai et al., 2020; Hollander & Sage, 2020; Ohannessian et al., 2016). Integrating telemedicine education into the medical curriculum can better prepare future healthcare professionals to efficiently leverage the advantages offered by this technology (Bergmo, 2015; Desai et al., 2020; Hollander & Sage, 2020; Ohannessian et al., 2016).

3. Theoretical Foundations

The Affordance Theory which delves into the perceived opportunities and capabilities that are presented by social media platforms to healthcare professionals within the area of telemedicine. This study seeks to get valuable insights into physicians' motives and experiences regarding using social media as a telemedicine tool through the theoretical lens of affordances to advance healthcare delivery in this study’s context.

Gruzd, Staves, and Wilk (2017) argue that the utilization of digital technology in social media platforms holds the capacity to revolutionize the field of health and social care. These platforms offer many chances for remote contact, sharing of information, establishment of support networks, utilization of collaborative features, access to educational resources, and engagement with other interactive activities. The aforementioned affordances are of paramount importance in augmenting the provision of healthcare, surmounting geographical impediments, enhancing accessibility to healthcare services, and bolstering patient involvement and contentment.

This study utilized the Affordance Theory to enhance comprehension of the perceived opportunities and capabilities provided by social media platforms to physicians. These platforms enable remote communication, information sharing, support networks, and other interactive features that contribute to the improvement of healthcare delivery. The theoretical framework's emphasis on the capabilities offered by technology is congruent with the research's aim to investigate the utilization of social media as a telemedicine tool from the viewpoint of medical professionals. This approach facilitates a thorough analysis of the potential advantages and obstacles associated with the platform.

4. Methodology

This study will employ a qualitative descriptive approach with thematic analysis, drawing from methodologies articulated by Sandelowski (2000), Vaismoradi et al. (2013), and Braun & Clarke (2006). The purpose is to deeply understand participants' experiences in their natural settings. Thematic analysis, as detailed by Braun and Clarke (2006), will assist in identifying patterns and themes in the data. Purposive sampling will select eight physicians with diverse expertise based on criteria such as consistent use of social media for telemedicine and a minimum active period of two years in this domain (Palinkas et al., 2015) which is presented in Table 1.

Data collection will involve semi-structured interviews with the physicians, adhering to the approach delineated by Smith et al. (2018). Interviews will be audio-recorded and transcribed verbatim. An interview guide, derived from study questions, will explore topics like functionalities of social media platforms, influencers on physician practices, and the pros and cons of integrating social media into telemedicine. The analytical procedure, as explained by Braun & Clarke (2006), will span from understanding the data to constructing and categorizing themes, supported by participant statements. After filtering, eight pertinent codes were identified and grouped into four distinct themes, further detailed in the following sections.

Table 1 Participants

Participant ID	*Specialization*	*Gender*	*Age*	*Years using Social Media Telemedicine*
001	*OB-GYN*	*Female*	*34*	*3*
002	*Internal Medicine*	*Male*	*42*	*3*
003	*Family Medicine*	*Female*	*36*	*3*
004	*Pediatrician*	*Female*	*58*	*3*
005	*Pulmonology*	*Male*	*43*	*3*
006	*Allercology*	*Female*	*46*	*6*

007	*Opthamology*	*Male*	*37*	*10*
008	*Opthamology*	*Male*	*42*	*5*

5. Preliminary Results and Limitations

This results section, framed by the affordance theory, examines the impact of social media as a telemedicine platform on healthcare professionals and physicians. It specifically highlights the features and capabilities of social media platforms and how they influence physicians' practices. Exploring these affordances reveals how social media improves healthcare delivery, overcomes geographical limitations, enhances access to services, and boosts patient engagement. To illustrate these findings, the researchers provide representative quotes from the interviews and detailed themes in Table II - Resulting Themes for clarity and insight.

Table 2. Resulting Themes

Theme	Codes	Exemplar
Validation	Real-Time Symptoms Verification	"I find it helpful that I can easily validate and verify a patient's symptoms in real-time using telemedicine through video call" – Case 2
	Virtual Fetal Monitoring	"I use virtual fetal monitoring during prenatal checkups to ensure the baby's health." - Case 1
Restrictions	Prior Checkup	"I only accept telemedicine consultations if I have previously checked up on the patient." – Case 6
	Patients Referral	"I accept telemedicine consultations only when
Ease of Use	Effortless Access	"easy access and hassle-free way to connect with patients, enabling us to provide medical care and support without the limitations of physical distance." – case 5
	Comfortable Engagement	"I can engage with my patients in a way that feels comfortable and caring, ultimately enhancing the quality of their healthcare experience." – Case 4
Backtracking	Medication History	"Telemedicine enables me to efficiently track and review my patient's medication history, ensuring that I can make well-informed decisions and avoid potential drug interactions during our remote consultations." – Case 3
	Medical Record Retrieval	"I can easily access and review my patients' medical history, allowing me to provide more personalized and informed care during our virtual consultations." – Case 5

5.1 Validation

Telemedicine enhances healthcare via remote technologies such as accurate patient information validation, real-time symptom verification, and virtual fetal monitoring during prenatal checkups. These capabilities enable physicians to deliver effective care remotely, overcoming geographical limits and enhancing patient outcomes (Bergmo, 2015; Desai et al., 2020; Kreps et al., 2019).

5.2 Restrictions

Telemedicine offers various affordances, including remote consultations, information sharing, and establishing social connections with patients. However, prior checkups and patient referrals are often required to ensure responsible healthcare practices. These measures help validate patient information, maintain continuity of care, and minimize medical malpractice risk. By balancing the benefits and restrictions of telemedicine, healthcare professionals can optimize its use while upholding quality and safety standards (Bergmo, 2015; Desai et al., 2020; Hollander & Sage, 2020; Ohannessian et al., 2016).

5.3 Ease of Use

Telemedicine platforms offer ease of use, enabling smooth interactions between healthcare professionals and patients (Sundararaman et al., 2017). Their accessibility allows patients to connect from anywhere with internet, enhancing patient experiences and communication (Wade et al., 2017; Donelan et al., 2019). Such benefits can revolutionize healthcare and improve outcomes (Bashshur et al., 2016; Dorsey et al., 2017).

5.4 Backtracking

Telemedicine's affordances, such as backtracking of treatment plans (Bhavnani et al., 2018), medication history reviews (Gagnon et al., 2016), and swift medical record access (Lau et al., 2018), enhance healthcare. These affordances streamline workflows, improve diagnostic accuracy, and benefit both patients and providers (Terry et al., 2017; Wade et al., 2020).

6. Conclusion and Recommendations

Telemedicine, leveraging social media platforms, revolutionizes healthcare by offering affordances like remote consultations and virtual monitoring (O'Connor & Aardema, 2019; Wu, Chen, & Lin, 2020; Lee & Yoo, 2021). These features improve patient access and engagement while overcoming geographical limitations (Gibson, 1979). Nevertheless, there are inherent challenges in this integration, necessitating measures such as prior checkups to maintain ethical healthcare (Bergmo, 2015; Desai et al., 2020; Hollander & Sage, 2020; Ohannessian et al., 2016).

To optimize the use of social media in telemedicine, healthcare professionals and policymakers can establish clear guidelines and protocols for patient validation and referrals, ensuring continuity of care and minimizing the risk of medical malpractice (Bergmo, 2015; Desai et al., 2020; Hollander & Sage, 2020; Ohannessian et al., 2016). Additionally, providing training and support to healthcare professionals in effectively utilizing social media platforms for telemedicine can enhance their proficiency (Bergmo, 2015; Desai et al., 2020; Hollander & Sage, 2020; Ohannessian et al., 2016). Integrating telemedicine education into medical curricula can further equip future healthcare providers with the skills to leverage these affordances effectively (Bergmo, 2015; Desai et al., 2020; Hollander & Sage, 2020; Ohannessian et al., 2016).

Future research should delve into the affordances of social media in telemedicine for both patients and professionals (Smith et al., 2022). Longitudinal studies are needed to evaluate its long-term effects on healthcare outcomes and experiences. With technological shifts and policy changes, continuous investigation is vital to guide evidence-based practice in this evolving domain (Smith et al., 2022). Such endeavors can lead to enhanced, patient-focused telemedicine through social media.

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Analyzing Sentiments of ChatGPT Users: Philippine Setting

Gisele DIZON[a] & Dr. Ma. Rowena R. CAGUIAT[b]
[a]De La Salle University, Philippines
[b]De La Salle University, Philippines
[*]gisele_dizon@dlsu.edu.ph

Abstract: The research is focused on a statistical examination of data from Twitter, a popular social networking platform where lively debates may be exchanged on a wide range of topics, including ChatGPT. The primary goal of this research is to conduct sentiment analysis on the ChatGPT-related tweets in order to get insight into how Twitter users in the Philippines feel about this AI-powered language model. In addition, the study delves into the n-grams and most commonly used words associated with AI, highlighting the preponderance of AI-related phrases and their practical significance. However, 16.57% of tweets expressed negative sentiments, suggesting areas for improvement and privacy concerns. In conclusion, this research provides valuable insights into user sentiments surrounding ChatGPT during a period of significant milestones and growth. The findings offer guidance to developers and stakeholders for addressing potential challenges and further enhancing ChatGPT's success in the ever-evolving AI landscape.

Keywords: ChatGPT, sentiment analysis, artificial intelligence, NLP

1. Introduction

Artificial intelligence (AI) has recently emerged as a game-changing technology that has the potential to significantly impact many fields. AI is a field of computer science that aspires to program computers to do tasks that normally require human intelligence. AI's core goal is to create machines with human-level intelligence (Wang et al., 2023). Language comprehension, pattern identification, problem solving, and deductive reasoning are all necessary for this task. Machine learning, natural language processing (NLP), robotics, and many more technologies are all part of the wide subject of AI. The widespread implementation of technologies that use AI has had a tremendous impact on the areas of industry, healthcare, education, the military, cyber security, and even defense (Firat, 2023).

The use of NLP algorithms to simulate human speech in conversational bots like ChatGPT (Generative Pre-trained Transformer) is a notable use of artificial intelligence in various fields. ChatGPT is considered as a language-based artificial intelligence system that belongs to a wider group of transformers. As stated by (Kooli, 2023), deep neural networks such as transformers, were developed specifically to process and create sequences of data, such as text. OpenAI's ChatGPT, which was opened to the public in November 2022, has quickly gained popularity, with one million people signing up in just five days. Facebook took 300 days, Twitter 720 days, and Instagram 75 days to reach this number (Biswas, 2023). Moreover, Iskender (2023) emphasizes that ChatGPT is a chatbot that can create responses that resemble those of actual people to a variety of inquiries and prompts since it was trained on a sizable dataset of text from the internet. Despite ChatGPT's novelty, understanding its users' sentiments is crucial for a number of reasons. To begin, ChatGPT adopters' opinions and sentiments can contribute to shaping the general public's image of new technology. The success or failure of ChatGPT may be determined in large part by the insights revealed by this data. Second, ChatGPT adopters may have discovered issues or problems with this new technology; their feedback can aid in finding and fixing these problems before they become common. As a result, the potential of ChatGPT's success on the market might be improved by investigating the perceptions of the tool's users.

Researchers collected data from Twitter, which enables users to read and post short messages (called "tweets"), in order to get insight into the sentiments of ChatGPT users. The ability of the Twitter platform to present daily trending topics on a national and global scale and to allow a large number of users to voice their thoughts and opinions on these subjects at the same time makes it more timely and popular than other social media platforms (Taecharungroj, 2023). Twitter was chosen for this research because of its widespread use and open data policy. Twitter is used for sentiment analysis research because, unlike other platforms like Facebook and Instagram, it makes its data and tweets public. Twitter is ranked number 4 on Alexa's list of the most frequented websites throughout the globe (Munggaran et al., 2023). Twitter's public nature encourages more conversation and the development of a larger user base that can quickly respond to and discuss breaking news and popular issues.

2. Objectives

Despite the advancements in sentiment analysis and AI language models, several gaps remain in the literature concerning sentiment analysis in the Philippine setting. The purpose of this research is to delve into and dissect the feelings and thoughts of ChatGPT users in the Philippines. Because of its cultural richness, multilingual environment, and particular emotional manifestations, the Philippines provides a fascinating and novel context for the study of sentiment analysis. The widespread use of AI technologies in the Philippines makes it all the more important to investigate the emotions conveyed by users in conversations with Generative AI language models like ChatGPT.

3. Research Questions

a. What are the predominant sentiments expressed by ChatGPT users in the Philippines?
b. What is the polarity of sentiments by ChatGPT users in the Philippines expressed on Twitter?

4. Research Framework

Leveraging data obtained from Twitter tweets specifically mentioning ChatGPT, this study employs sentiment analysis techniques to discern the prevailing attitudes of users towards the language model.

Figure 1. Three main stages of the research framework

The research framework involves three main stages: data collection, data preprocessing, and sentiment analysis. First, Twitter's API is utilized to gather a substantial dataset of tweets containing references to ChatGPT. Next, the collected data undergoes preprocessing to eliminate noise, handle privacy concerns, and convert text into suitable formats for analysis. Finally, sentiment analysis is conducted using lexicon-based approaches to determine whether the sentiment expressed in tweets is positive, negative, or neutral.

5. Literature Review

5.1 Related Studies

Due to the novelty of ChatGPT, the researchers were unable to locate any large studies that dealt specifically with this topic. There is, however, a body of work devoted to the GPT family of text-generating AIs (including, but not limited to, GPT-2 and GPT-3). Furthermore, we found enough information on Twitter data mining to investigate users' sentiments. Therefore, we describe certain papers that are very relevant to our study below.

To study public opinion on hybrid work arrangements using tweets, Trivedi et al. (2022) developed a Robustly Optimized BERT Pre-training Approach (RoBERTa). According to the RoBERTa, the consensus opinion of users is favorable toward the hybrid work approach. Another article by Alhijawi & Awajan (2022) used Twitter temporal data mining to forecast the popularity of a film. In order to foretell user pleasure and the popularity of movies among users, the authors suggested a rating prediction model and a temporal product popularity model. Similarly, Sanjaya et al. (2022) presented a sentiment analysis using Twitter data to discover perceptions of electronic wallets usage. The results of the sentiment analysis reveal that Twitter users in Indonesia are less likely to have a positive opinion of electronic wallets. Moreover, Haque et al. (2022) performed sentiment analysis to qualitatively analyze selected set of tweets. Results showed that the vast majority of early adopters are enthusiastic about the potential benefits of this technology in areas like software development disruption, entertainment, and creative expression. And only a limited percentage of users worried about things like the possible abuse of Chat-GPT.

5.2 Generative AI models

In recent years, generative AI models have received a great deal of attention and interest from the general public due to their capacity to generate material that is very similar to that generated by humans. These models are capable of responding to a wide variety of inputs, from pictures and text to audio and video (Dwivedi et al., 2023) and even human voice. The two most well-known GPT-based AI products published by OpenAI in 2022 are ChatGPT (OpenAI, 2022b) and DALL-E (OpenAI, 2022a). Some other Generative AI models may also make user images called Magic Avatars (Pavlik, 2023); for example, Stable Diffusion from Stability.ai and Lensa. The Language Model for Dialogue Applications (LaMDA) is the foundation of Google's latest Generative AI system, Bard (Pichai, 2023) which was launched recently.

5.3 Sentiment Analysis

Since the development of NLP, texts have been seen as data sources, and studies have started to look at the subjective meanings of phrases in the context of data extraction. Information on how individuals feel about certain events, circumstances, goods, or even political beliefs may now be gleaned from their online discussions of these topics, thanks to techniques known as "opinion mining" and "sentiment analysis." Many new academic subfields have emerged in response to the proliferation of social networking sites, all with the goal of mining useful data from these platforms (Wankhade et al., 2022). Several practical contexts call for in-depth exploration using sentiment analysis. For example, doing a product analysis to learn what features or characteristics a client's value.

Subhashini et al.'s (2021) article offers the findings of a thorough evaluation of current research on opinion mining. It also discusses representing knowledge in views, classifying them, and extracting text characteristics from opinions that include noise or ambiguity. A method for adaptable aspect-based lexicons for sentiment categorization is proposed by

Mowlaei et al. (2020). The authors presented a statistical technique and a genetic algorithm-based strategy for building two dynamic lexicons to help in the categorization of attitudes based on their characteristics. More accurate scoring of ideas dependent on context is made possible by an automatically updated dynamic lexicon (Kumar & Uma, 2021).

To the best of the researchers' knowledge, the study presented is the first to perform a comprehensive examination of the Twitter sentiments on ChatGPT in the Philippines. This research contributes to the existing body of knowledge by giving a glimpse of Twitter sentiments to this newest innovation.

6. Research Methodology

In this investigation, sentiment analysis method was utilized to understand perception of ChatGPT users in the Philippines. The users' perception toward AI chatbots like ChatGPT can be used as a measure of sentiment because of the widespread impact of its outputs. In the dictionary-based sentiment analysis, each word is given a value that is derived from its definition in the dictionary, beyond its positive or negative connotations. The sum of these values identifies the emotional value of the sentence. Natural Language Toolkit (NLTK) was used to perform sentiment analysis of the obtained tweets in this study. NLTK represents a Python library. It offers a solid foundation for constructing Python applications and organizing data. The toolkit is also crucial in transforming textual data into a certain format, from which sentiments may be retrieved (Tunca et al., 2023). The primary purpose of the NLTK is to analyze human language data for use in natural language processing. Additionally, NLTK also offers a variety of pre-processing functions to support all NLP techniques, such as part-of-speech tagging, tokenizing, lemmatizing, stemming, parsing, and performing sentiment analysis for selected datasets.

7.1 Data Collection

The data comprising the tweets used in this study were obtained from Kaggle, a free and online community platform which allows users to find and publish data sets. The data is formatted as CSV (Comma Separated Value) which is a flat text file about tweets. The Twitter dataset consists of 478,379 tweets from public Twitter accounts related to the search term "ChatGPT". Twitter's Stream API was used to accumulate records in the dataset from January 4th to March 29th, 2023. In addition, only general tweets in the English language were processed. Other types of tweets such as mentions, replies retweets, and retweets with comments were discarded.

7.2 Data Preprocessing

When expressing their thoughts and feelings about an issue, individuals often fail to employ correct proper language structure. Instead, the study of these structures becomes more challenging by the use of slang, misspelling, alternative emoticons, and abbreviations, and sometimes puns. As the quality of the output is dependent on the quality of the input, the complexity of the textual data has a major impact on the efficiency with which sentiments are analyzed (Elbagir & Yang, 2019). Therefore, a number of preprocessing procedures have been executed to remove unnecessary data from the collected tweets in order to make the data more suitable for mining and feature extraction, consequently increasing the reliability and precision of the results. Preprocessing the tweets also removed retweets and duplicates, resulting in a dataset containing 507 tweets. To preprocess these data, NLTK was utilized. To begin, a regular expression (Regex) was executed in Python to identify and remove URLs ("http://url"), retweets (RT), user mentions (@), and undesired punctuation from tweets. Hashtags (#) are included as part of the tweet, but the "#" sign has been deleted since they frequently clarify the subject of the tweet and provide important information relevant to the topic of the tweet. After a dataset has undergone the preprocessing steps, it is ready to be classified based on sentiment using the VADER algorithm. For the purpose of determining the frequency of words and, consequently, their visualization in Word Cloud, a number of NLTK functions are employed as additional preprocessing steps.

7.3 Sentiment Classification

In general, sentiment analysis may be used to investigate the polarity of a given context, whether that context be positive, negative, or a neutral sentiment. In this phase, Valence Aware Dictionary for Sentiment Reasoning (VADER) was employed. VADER is both a language for expressing emotions on social media and a rule-based tool for analyzing user sentiment (Tunca et al., 2023). VADER analyzer was used to examine both the polarity of sentiments and intensity in each tweet.

8. Results

This section provides the results of a Twitter sentiment analysis conducted using VADER and NLTK.

8.1 Descriptive Analysis

During the data collection period from January 4 to March 29, 2023, there were primarily 478,379 tweets associated with the ChatGPT topic, which provides ample opportunities to observe trends.

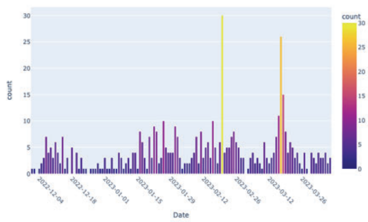

Figure 2. Number of Tweets per Day

A large number of tweets were observed between November 30, 2022 to April 8, 2023 during which ChatGPT reaches 100 million monthly users at a faster rate than Instagram or TikTok (Chow & Perrigo, 2023), and receives an estimated 1 billion visitors, an average of over thirty-five million visitors per day (Brandl & Ellis, 2023).

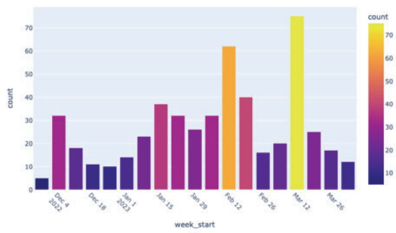

*Figure 3***.** Number of Tweets per Week

Figure 3 reveals that the week beginning March 12 had a high number of tweets, most likely because ChatGPT Plus was released as a subscription service, providing faster responses and priority access to new features than the free version of ChatGPT (Deutscher, 2023), and possibly because ChatGPT experienced a data breach when a bug exposed users' personal information (Wagenseil, 2023).

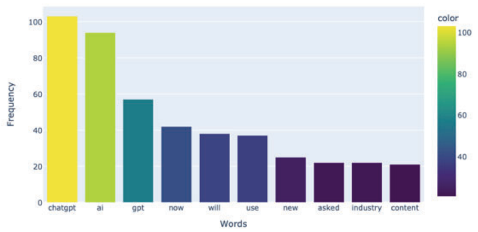

*Figure 4***.** Top 10 Most Unigram Frequent Words

As shown in Figure 4, numerous words are associated with artificial intelligence, such as “chatgpt”, “ai”, “gpt”,“just”, “use”, “new”, “like”, “asked”, “openai”, and “industry”. In the same way, Figure 5 depicts the ten prevalent bigrams and common words, including (artificial, intelligence), (powerful, dominating), (dominating, industry), (dominating, crypto), (crypto, industry), (large, multimodal) and so on. For instance, the terms “ai” or “artificial intelligence”, and “industry” can be seen in both unigram and bigram graphs, indicating that people believe artificial intelligence will be the dominant industry of the near future.

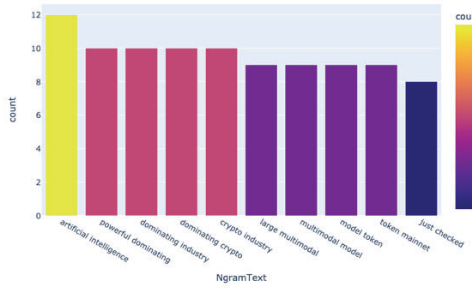

*Figure 5***.** Top 10 Most Bigram Frequent Words

It is worth noting that the terms 'chat', 'gpt', 'chatgpt' were excluded from these n-grams to get better results focusing on other aspects related to ChatGPT.

*Figure 6***.** Word Cloud of Tweets

Figure 6 shows a visual representation of the most frequently occurring words in the processed tweets from the dataset. This Word Cloud is a useful tool for evaluating widespread sentiment since it illustrates at a glance the most discussed topics related to ChatGPT on Twitter. Words like "chatgpt," "ai," "use," "new," and "will" stand out because they are frequently used in discussions about ChatGPT.

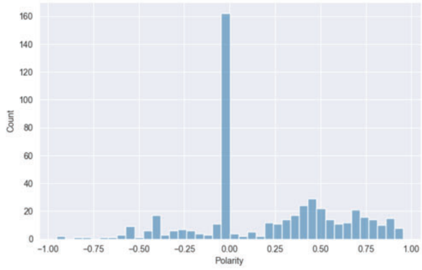

Figure 7. Distributions of sentimental polarities

The lexicon-based VADER technique was used to extract features by loading the appropriate NLTK library. The module's applied techniques yielded three sentiment scores (positive, negative, and neutral) as the module's output scores. These scores are measure whether each tweet is a positive tweet, a negative tweet, or a neutral tweet with a value ranging from [−1 to +1]. Figure 7 presents the tweets' sentiments with corresponding values. The values of [-1, 0, 1] were set to refer to positive, neutral, and negative sentiments.

Table 1. *Count of Tweets According to Polarity*

	Count	Percentage
Positive Tweets	263	51.87%
Neutral Tweets	160	31.56%
Negative Tweets	84	16.57%
Total	507	100.00%

Table 1 depicts that the majority of tweets contained positive and neutral sentiments about ChatGPT. Remarkably, (263) 51.87% of the collected tweets contained positive sentiments, (160) 31.56% contained neutral opinions, and (84) 16.57% expressed negative sentiments. In comparison to other classifications, the number of positive tweets was the highest, indicating that the majority of users expressed a positive attitude toward ChatGPT.

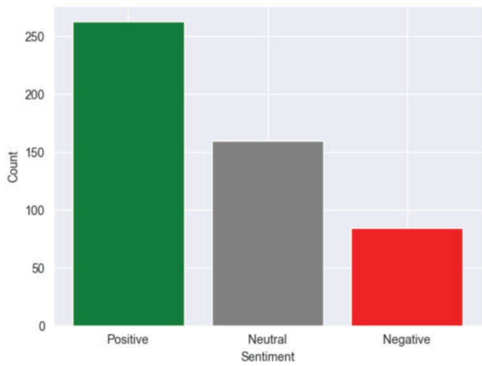

Figure 8. Sentiment Analysis of Tweets

Figure 8 displays number of tweets by sentiment of each polarity in a bar chart. Positive tweets constitute the majority of the dataset, accounting for 263 of all the analyzed tweets in the Philippines. This suggests that a significant portion of the Twitter users' sentiments were positive during the time the data was collected. The high percentage of positive tweets could indicate that people were expressing joy, satisfaction, excitement, or contentment in their experience with ChatGPT is probably because users perceive it as a viable means of enhancing commercial operations (Taecharungroj, 2023). The capability of ChatGPT is exerting a significant influence on different technology industries. For example, the platform gives the opportunity for students to pose inquiries and address any uncertainties, augmenting the whole educational encounter. Despite the inherent restrictions, ChatGPT is anticipated to have practical applications in real-world scenarios, and businesses have a strong inclination to utilize it for the sake of generating profits (Haleem et al., 2022).

Neutral tweets account for 160 tweets or 31.56% of the tweets in the Philippines. These tweets represent a balance between positive and negative sentiments, as they do not strongly lean towards any particular emotion. Neutral tweets may include informational tweets, facts, or updates on ChatGPT without expressing a specific opinion or emotion. This significant proportion of neutral tweets could indicate that many users were simply sharing information or updates about ChatGPT rather than explicitly expressing their emotions.

On the other hand, there are only 84 negative tweets which make up about 16.57% of the tweets in the Philippines. While this percentage is lower than positive tweets, it still represents a considerable proportion of the analyzed tweets expressing negative emotions, such as anger, sadness, disappointment, or frustration about ChatGPT is likely due to the potential of this technology to generate and disseminate deceptive news and information that appears credible has caused significant concern among many individuals (Taecharungroj, 2023).

In order to mitigate negative sentiments expressed towards ChatGPT, developers can employ several strategies, like educating users about the capabilities and limitations of the system, which can help manage their expectations and reduce potential frustrations. Granting users, a sense of control over the system, for instance, by allowing them to customize its behavior within certain bounds, can enhance user satisfaction and mitigate negative sentiments. Lastly, developers should promptly address specific concerns raised by users, demonstrating responsiveness and a commitment to resolving issues.

Overall, the sentiment analysis provides valuable insights into the prevailing emotions among Twitter users in the Philippines during the data collection period. The higher percentage of positive tweets might suggest a generally positive atmosphere on ChatGPT, while the presence of negative and neutral tweets also reflects the diversity of opinions and discussions happening on Twitter.

9. Conclusion

The findings from the analysis of the Twitter dataset related to ChatGPT provide valuable insights into the sentiments and discussions surrounding the AI-powered language model. The dataset was obtained during the time which ChatGPT witnessed a significant surge in popularity, reaching 100 million monthly users at a faster rate than Instagram or TikTok. During the week beginning March 12, there was a notable increase in the number of tweets, possibly driven by the release of ChatGPT Plus, a subscription service offering faster responses and priority access to new features. In addition, concerns about privacy and security may have contributed to the spike in tweets after a data breach in which user information was exposed due to a security breach.

The examination of n-grams and frequently-used terms found a strong connection with AI, showing the importance of this issue in ChatGPT-related talks. It also reflects a view that AI will play a preponderant role in defining future sectors and a curiosity with AI technology and its possible uses. However, the VADER lexicon-based system for analyzing sentiment found that most tweets were either neutral or favorable towards ChatGPT. Around 51.87% of tweets were positive, indicating that the platform garnered a favorable response from users. Neutral tweets constituted 31.56% of the dataset, reflecting informative and objective discussions without strong emotional sentiments. Negative tweets represented 16.57% of the tweets, expressing concerns, criticisms, or frustrations about certain aspects of ChatGPT.

It appears that users are generally pleased with ChatGPT, as seen by the positive attitude of the majority of tweets. However, the existence of critical tweets indicates that the platform has room for development and may face issues that need to be addressed. Limitations of the approach and context-specific elements that may impact the sentiments expressed on social media platforms should always be taken into account when doing any sort of sentiment analysis. ChatGPT's developers and stakeholders may utilize the insights collected from this study to better understand user impressions and input, which might lead to future enhancements and improvements.

As a result of its impressive performance and widespread popularity, ChatGPT may now be considered a frontrunner among AI-powered language models. Its promise as a game-changing technology is evidenced by both its subscription model and its quick user growth. If ChatGPT is to sustain its current success in the rapidly changing AI world, its developers and stakeholders will need to stay cautious in responding to user concerns and protecting user data. In addition, a proactive strategy to monitoring user sentiment is essential as the platform continues to explode in popularity. This necessitates persistent monitoring of social media for conversations, user input, and emerging issues. Engaging with users actively through official channels, such specialized support teams or feedback mechanisms, can aid in addressing issues promptly. Further research and development are anticipated for ChatGPT and natural language processing in order to augment their capabilities and address existing constraints. Some of the areas that can be focused on for further development are enhancing comprehension of context, refining training methodologies, mitigating biases, advancing dialogue systems, accommodating many languages, and integrating with other artificial intelligence technology.

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Implementing an Inquiry Learning with Mobile-supported Mathematical Board Game to Promote Primary Students' Attitude toward Mathematics Learning

Sakda CHALEEPLIAM[a], Sasivimol PREMTHAISONG[a] & Pawat CHAIPIDECH[b*]
[a]*Khon Kaen University Demonstration School International Division, Khon Kaen University, Thailand*
[b]*Faculty of Education, Khon Kaen University, Thailand*
*Pawach@kku.ac.th

Abstract: One of the teaching approaches most used by educators is the inquiry-based learning, and with the development of technology, students have access to more games. Therefore, many researchers have integrated investigative learning methods with mobile-supported board games. The purpose of this research is to investigate students' conceptual understanding and their attitude toward mathematics learning using inquiry-based learning methods and mobile-supported board games. In this study, the participants were primary school students in the northeastern region of Thailand. The finding demonstrated that students have better conceptual understanding after using an inquiry learning with mobile-supported mathematical board game. Moreover, students had a positive attitude toward mathematics learning. Specifically, it allowed students to gain confidence and motivated them to study mathematics. Consequently, this study revealed that an inquiry-based learning combined with mobile-supported board game has the potential to foster positive attitudes towards mathematics learning with technology and may develop into other content in future primary mathematics learning.

Keywords: Board game, Inquiry-based Learning, Mathematics, Attitude

1. Introduction

Digital technology is now widely embraced in education, especially in subjects such as mathematics, aiming to boost students' understanding and enthusiasm. Educators are increasingly turning to digital technologies to create engaging learning environments that blend entertainment with education. For example, researchers have designed digital board games to enhance students' learning (Premthaisong & Srisawasdi, 2020; Nukprach, Chaipidech & Srisawasdi, 2023), and Chang and Panjaburee's research in 2022 demonstrated that Virtual Reality technology positively impacts learners' achievements, problem-solving abilities, and engagement. In the area of mathematics in primary school, the difficulty of effectively transferring new knowledge due to students accepted unfavorable views towards the subject is significant (Ardelenau, 2019). The study shown the potential for improved learning outcomes and improved attitudes when modern digital technology-infused learning environments are used to encourage investigative problem-solving (Ardelenau, 2019). One of the approaches that many researchers adapt for teaching in the classroom, is inquiry-based learning. For example, the complexity of classifying quadrilaterals, as demonstrated by Japanese sixth graders' tendency to perceive rhombuses differently from parallelograms, encourage educators to employ a variety of teaching approaches, such as inquiry-based learning (Okazaki & Fujita, 2007). Moreover, an inquiry-based learning fosters problem-solving skills and cognitive engagement by encouraging systematic knowledge exploration (Kohen, Schwartz-Aviaia, & Peleg, 2023). This strategy holds promise for facilitating students' solution discovery and fostering positive attitudes while confronting difficult mathematical problems, thereby contributing to a deeper appreciation for mathematics.

From the benefit of digital technology and the inquiry-based learning approach, many instructors utilize inquiry-based learning integrated with digital technology, such as Srisawasdi and Punjaburee (2019), which used a game-transformed inquiry-based learning approach to teach high school students about chemistry. In the area of mathematics, as reported by Lin and Cheng (2022), the use of digital technology and the inquiry-based learning approach in mathematics education has been found to have a positive impact on students' motivation and accomplishment of goals. Consequently, this study incorporates mobile-supported board game into an inquiry-based learning can be considered a pedagogical approach for technology-enhanced mathematics education, to promote students' understanding of concepts and positive attitudes toward mathematics learning.

2. Literature Review

2.1 Mobile-supported board game

Due to the benefits of game-based learning and technology, many educational researchers are interested in how to use smart phones to support students' learning. Numerous research studies have demonstrated that the integration of technology-supported game-based learning has the potential to enhance student motivation and foster improved conceptual comprehension across various academic disciplines, including mathematics and science. For example, Chao et al. (2018) posited that mobile-supported game-based learning in mathematics, can enhanced students learning. In addition, according to Lin and Cheng (2022), the utilization of technology-enhanced board games has been identified as a valuable approach for enhancing students' motivation and improving their academic performance in the context of primary mathematics. Moreover, according to the findings of Yeo and Campbell (2022), most a primary mathematics teacher in the USA agreed that the utilization of games that were supported by technology are an effective tool for teaching mathematics.

2.2 Inquiry-based Learning in Mathematics

Inquiry-based learning (IBL) is a learning approach that emphasizes developing problem-solving abilities, by training learners to investigate knowledge by questioning students to use their thinking process and finding logical conclusions, or to self-correct solutions. Many researchers employed Inquiry-based Learning to integrate with various technologies. According to Kohen et al. (2022), the utilization of Inquiry-based learning combined with technology has been shown to be a successful approach in the instruction of mathematics as well as this finding, it corresponds to Pedersen and Haavold (2023), who showed that IBL has potential in fostering a positive attitude and attraction towards the mathematics learning for students in the age-range 11-16. In addition, Radmehr et al. (2023) presented the potential of inquiry-based learning as a more effective pedagogical approach to instructing undergraduate students. It was found to enhance students' conceptual understanding, particularly in complicated mathematical topics. Furthermore, the implementation of Inquiry-Based Learning in Mathematics classes promoted a positive learning environment and attitudes towards mathematics (Aldridge & Robinson, 2022).

3. Research Methodology

3.1 Research Design

The research design was one group pre-test and post-test design. The participants were selected by using a purposive sample, in this case fifth-grade students. The data collection instruments consist of an attitude questionnaire and a quadrilateral conceptual test.

3.2 Participants

The study involved a sample of 25 fifth-grade participants from a public school located in the Northeastern region of Thailand. The chosen school was a technologically advanced institution with access to the Internet. In addition, prior knowledge about quadrilaterals were needed. That was why they were chosen to be the in this research.

3.3 Research Instruments

In this study, there are two research instruments. The first instrument is a conceptual test involving the conception of the properties of quadrilaterals. The test was adapted from the study of Okazaki and Fujita (2007) about the properties of quadrilaterals. There are five questions in the test. Each question consists of six to eight statements. The participants had to read and fill in the correct symbol if they think that statement is correct, the cross symbol if they think it is incorrect and the question mark symbol if they are not sure. In the first question, there are eight quadrilateral figures, the students are asked, which are parallelograms. Second question, there are six quadrilateral figures, the students are asked which are rectangles. The third question, there are six quadrilateral figures, the students are asked which are squares. The fourth question, there are six statements about properties, the students are asked about the properties of parallelograms. The fifth question, there are five statements, regarding the properties of rectangles, and in the last question, there are five statements, regarding the properties of squares. The second instrument is an attitude questionnaire regarding the use of technology to learn mathematics. A 5-point Likert-scale survey is being used to examine student attitudes. It consists of 20 questions covering four each on mathematics confidence (MC), four each on technological confidence (TC), four each on attitude towards using technology to learn mathematics (MT), four each on affective engagement (AE), and four each on behavioral engagement (BE). The following subscale reliability levels are indicated by Cronbach's alpha values: MC, 0.87; MT, 0.89; TC, 0.79; BE, 0.72; and AE, 0.65. Pierce et al.'s (2007) questionnaire was used to create this.

3.4 Data Collection and Analysis

The data collection of this research is shown in the figure 1. Before the approach, the students were given 20 minutes to do the pre-test of conceptual understanding and attitude questionnaire. After completing the instruments, they were expected to interact with a mobile-supported board game with inquiry-based learning, which consists of three phases: First phase, Pre gaming phase begins with open-ended questions and provides basic information about quadrilateral that students can use in the next step. Second, Gaming phase is a learning process through a quadrilateral board game with mobile phone to find answers to the first open-ended questions. Third phase, Post gaming phase is a summary of knowledge gained in answering those open-ended questions together. After finishing the learning process, students were administered the same questionnaires again for 20 minutes to determine their conceptual understanding and attitude toward mathematics learning with technology.

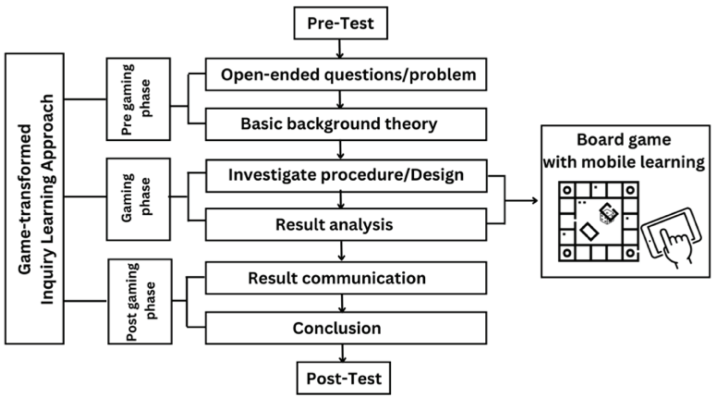

Figure 1. An illustration of the experimental procedure of this study.

The data collection process took one week (5 periods, 250 minutes) of which the first two periods consisted of a pre gaming phase in which open-ended questions and background theory were provided.

3.5 Learning Material

The game carried on round by round. Firstly, each student began by picking up a question card. Then, they answer the questions on that card and scan a QR code to check the answers. If they got the answer right, they would get one coin. The coins could be collected for winning the game in case nobody won in the game. After that, each student could decide to follow one of the three directions. To clarify, the first direction is to roll the dice to race the horse. The students had to press the button of the mystery box, which contained five different-colored dices. If the student got the dice in any color, they could move the horse chess which shared the same color forward on the betel table. Also, if the chosen dice showed any number, they could move their dice forward as the same step on the betel table. During the game, the student can choose to either trap or reward their friends by putting +1 or -1 on their track. +1 refers to a step forward, whereas -1 refers to a step backward. Additionally, while playing, the student must bet which horse will win as well. Following the figure 2, With the rules of this game, students will encounter questions for themselves as well as assess the responses of other students regarding the properties of the quadrilateral.

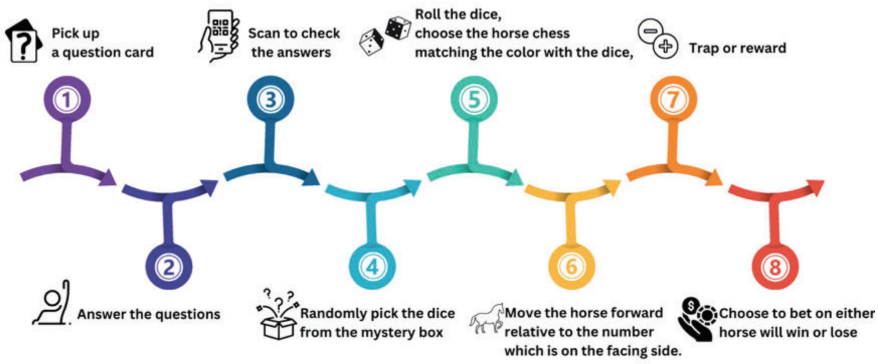

Figure 2. An illustration of gaming steps with the quadrilateral board game.

4. Result and Discussion

4.1 Conceptual understanding of quadrilateral

This study using parametric statistics analysis of paired t-test, a comparison of pre-test and post-test conceptual understanding scores revealed that the post-test score of students' conceptual understanding was significantly higher than the pre-test score (t=-5.580, p<.05). The statistics the paired t-test are displayed in Table 1.

Table 1. *Paired T-Test Result for Conceptual Understanding on The Properties of Quadrilateral.*

Conceptual Understanding test	N	Mean	S.D.	t
Pre-Test	24	18.17	5.435	-5.580*
Post-Test	24	24.58	6.021	

*p<0.05

As shown in the table above, the results indicate that students' post-test scores are significantly higher than their pre-test scores after using the board game with mobile integrated game-transformed inquiry-based learning approach. Based on the result in this study, students could improve their conceptual understanding of the properties of quadrilaterals. Regarding the basis of prior research, Nukprach et al. (2023) found that using eye tracking of students when they learnt through the technology-supported board game could promote students' cognitive exertion which increases while playing board games. Hence, integrating board game with technology have been found to effectively aid in the comprehension of mathematical concepts on the properties of quadrilaterals.

4.2 Students' Attitude toward Mathematics Learning with Technology

As shown in the table 2, we can see that it has a statistically significant effect on both mathematics confidence (MC) ($F (1, 24) = 11.565$; $p < .05$; partial $\eta 2 = .335$) and affective engagement (AE) ($F (1, 24) = 7.271$; $p < .05$; partial $\eta 2 = .240$).

Table 2. *The students' subscale means of attitude by time and univariate MANOVA.*

Subscale	Attitude		F	Sig	η^2
	Pre-Test Mean (SD)	Post-Test Mean (SD)			
MC	12.71(2.216)	14.75(2.739)	11.565	.002*	.335
TC	13.50(2.359)	14.54(2.395)	3.968	.058	.147
MT	14.62(3.943)	15.04(3.470)	0.204	.656	.009
AE	13.71(3.277)	15.46(2.859)	7.271	.013*	.240
BE	13.46(2.553)	14.67(2.632)	3.631	.069	.136

*p<0.05

As shown in the table 2, it refers that a board game with mobile is the key to gain students' confidence in learning Mathematics (MC). In other words, mobile-supported board games promote the student's happiness (AE) when they can solve difficult math problems. The findings of this study align with the research conducted by Premthaisong and Srisawasdi (2020) and Lin and Cheng (2022), which explored the integration of technological devices with board games as a pedagogical tool for teaching primary school students is a great tool for teaching students in primary school. Similarly, Hwang and Chang (2011) observed that this instructional approach not only fostered students' interest and attitude towards learning, but also positively impacted their academic achievement. The utilization of mobile learning as a means of evaluating the enhancement of students' attitude and academic performance.

However, some students, who are normally familiar with using physical board games rather than the digital kinds, did not have a great performance and lack confidence in playing mobile-supported board games. Consequently, it resulted the significance value of technological confidence of no less than 0.05. Nevertheless, there are numerous other technologies that can be applied to board games to create mobile-supported board games that promote positive attitudes and academic achievement for students in primary school.

5. Conclusion and Limitation

The purpose of this study is to investigate the conceptual understanding and the attitude toward mathematics learning with technology, of primary school students by using mobile-supported mathematics board game. Based on the findings of this study, we can confirm that the strategy is an effective tool for teaching difficult issues in mathematics learning. Moreover, they have a positive attitude of technology-enhanced mathematics learning with game-based inquiry learning. According to the findings of this study, mobile-supported board games have the potential to foster greater innovation in mathematics classrooms. Due to this study being conducted in Thailand, it can apply in other developing countries. However, a limitation of this study is the small number of samples, which is a single sample, which makes it impossible to compare conceptual and attitude scores to traditional teaching techniques and gamified inquiry-based learning with mobile learning. Therefore, in future work, there should be comparison group to ensure the learning gains because of this approach.

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Application of Blended Learning with PhET Simulation to Encourage Learning in Mathematics of Fractions

Atcharaporn ASSAWAPHUM[a], Sasivimol PREMTHAISONG[a], & Pawat CHAIPIDECH[b*]
[a]*Khon Kaen University Demonstration School International Division, Khon Kaen University, Thailand*
[b]*Faculty of Education, Khon Kaen University, Thailand*
*pawach@kku.ac.th

Abstract: Technology in education is essential for both teaching and learning. The purpose of this study is to correct mathematic misconception about the addition and subtraction of fractions, as well as explore students' attitudes toward using technology to learn mathematics. In this study, blended learning activities was used with PhET simulation. Both hands-on and digital technology activity were implemented. The findings of this study revealed better comprehension in students who learned with a blended learning activity with PhET simulation. In addition, there was a general improvement in students' attitudes toward using technology for learning mathematics. The results implied that using blended learning activity with technologies in mathematics classrooms could correct leaners' misconception as well as fostering positive attitudes toward learning mathematics in primary level.

Keywords: Mobile learning, attitude, blended learning, misconception.

1. Introduction

Technology can potentially enhance the teaching and learning of mathematics, leading to gains in higher-order thinking skills (Wenglinsky, 1998), as well as student achievements and self-efficacy (Mistretta, 2005). The National Council of Teachers of Mathematics (2000) explained, "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student learning". Adewuyi (2001) noted that the style of teaching employed by teachers is a potent factor in motivating learners to learn; mathematics is a subject that is very easy to make difficult and very difficult to make easy. The perennial methods of teaching mathematics through listening, looking, and learning have failed. If anything, it has made students dislike mathematics (Akinsola, 2002). The current teaching and learning of mathematics include technology, such as using applications to calculate answers or playing math games through various websites and applications to review knowledge or import into lessons before learning begins or can be used in organizing learning activities that excite students about learning. Learning mathematics through simulations is another way for students to learn about technology. Simulations, such as PhET (https://phet.colorado.edu), provide a dynamic nature to multiple representations by making abstract concepts concrete, supporting an inquiry environment, and allowing for multiple trials and rapid feedback cycles, while also being engaging and enjoyable for students and teachers (Meadows, 2019). Simulation-based learning, it can be applied to many learning management methods; for example, Akinsola et al. (2007) used a simulation-games environment that could improve students' achievements and attitudes toward mathematics. The study found that the poor academic achievement of students in mathematics is partly due to the teaching method used and that stimulating teaching methods such as simulation games can sustain and motivate students' interest in learning mathematics. The results of this research suggest that emphasizing the use of simulation games to teach mathematics can improve mathematics teaching and learning in schools. Both the use of technology and simulation in managing mathematics learning result in learning achievement and knowledge. The students' understanding is going to improve. If the advantages of using various technologies are applied in mathematics classes, there could be many benefits. Blended learning is another method of teaching and learning that use technology and face-to-face teaching together.

Blended learning combines both face-to-face instruction and technologically based online instruction. It combines traditional and advanced online learning methods, such as chatrooms, podcasts, and live online lectures (Barrett & Sharma, 2007). By using blended learning, learners take lectures in a face-to-face class and can interact with each other through online platforms. These online learning experiences may replace classroom instruction, but interaction with peers and instructors is also possible on these platforms (Pandya and Shroff, 2022). The use of blended learning in education can enhance student learning and make the whole learning experience more enjoyable. Moreover, Indrapangastuti et al. (2021) demonstrated that blended learning is more effective than conventional learning in improving students' achievement of mathematical concepts.

In mathematics learning, most students had issues for understanding mathematical concepts. For example, Retnawati et al. (2011) reported that up to 88.57% of students have trouble understanding the mathematical concepts that they are supposed to be learning. Moreover, Waskitoningtyas (2016) found that there were lots of reasons why students have difficulty learning mathematics, such as a lack of interest in the subject, the need to learn numerous formulas, boring teaching methods, and teachers not paying enough attention to students with low levels of understanding. One of the concepts that students have difficulties with is fractions. Alghazo and Alghazo (2017) found that If students have misconceptions about fractions now, they will continue to have misconceptions in the future. Thus, Aksoy and Yazlik (2017) mentioned that students should learn about fractions because fractions are related to many other math topics, such as percentages, decimals, probability, and algebra. Therefore, to correct misconceptions in mathematics related to addition and subtraction of fractions, it is necessary to employ teaching methods that engage students' interest in learning. This will enable students to perceive correct mathematics concepts better and allow them to share their thoughts, engage in discussions, and exchange opinions in the classroom. Hence, the researchers utilized blended teaching with simulation from PhET on fraction concepts in mathematics classrooms.

2. Literature Review

2.1 Technology-supported Learning in Mathematics

Over the past two decades, there has been an increase in the use of high-tech tools in classrooms. A new generation of information teaching techniques has emerged that combines digital media, human-computer interaction, and educational technology. For example, Verzosa et al. (2022) studied the development of an app and videos to support fractions. They found that videos immerse learners in a range of fraction representations that can extend their initial part-whole understanding of the fraction concepts. In addition, Hsu (2020) used Virtual Reality for mathematics classrooms. The results showed that VR has the effect of improving students' learning motivation and learning effectiveness in the digital teaching of mathematics. Furthermore, computer simulation is one of the technologies which could help students use multiple representations, support their efforts to create knowledge, concentrate on conceptual ideas, and offer quick feedback (D'Angelo et al., 2014). Simulation is helpful not only because it can provide believable numerical answers but also, perhaps more importantly because it requires a comprehensive comprehension of the problem to be solved (Reinhardt & Loftsgadeen, 1979). Problems are often unique or inaccessible to students. For such cases, students may be able to use interactive simulations as a supplement or even a substitute for an experiment. For example, the study of Srisawasdi et al. (2015) examined the effect of the teaching method of simulation-based inquiry with a dual-situated learning model (SimIn-DSLM) on students' conceptual understanding. This finding suggests that the SimIn-DSLM method could be used. To induce a mechanism of change within students' conceptual knowledge of sound wave phenomena, and the change of their conceptions could place them into the meaningful conceptual framework of basic scientific knowledge. Moreover, Arifin et al. (2022) studied the effectiveness of using PhET Simulation in primary school students' mathematical understanding of fractions. The results showed that using PhET Interactive Simulation significantly improved students' mathematical understanding of fractions. From the above, researchers focus on the technology used in simulation in mathematics teaching and learning. The use of simulations in teaching and learning can develop the students' competency.

2.2 Blended Learning in Mathematics

Traditional classroom instruction and online learning have been modified and progressively replaced with "Blended Learning." The concept of blended learning, which combines multiple instructional models, has garnered considerable attention in recent years. The Blended Learning approach has been applied to mathematics education at the elementary school level. Research by Indrapangastuti et al. (2021) demonstrated the effectiveness of using blended learning to enhance students' mathematics concepts. The study's results suggested that the blended learning model is significantly more effective than the conventional learning model for enhancing students' mathematical concept achievement. These findings match Jemakmun (2022) research on blended learning to improve mathematics abilities. This study found that the blended learning model with formative and summative assessments improved students' mathematics learning outcomes, especially for those with high early math abilities. Blended learning methods can be combined with other teaching methods. Yennita and Zukmadini (2019) studied blended learning and Problem-based learning to improve critical thinking skills and student learning activities. This study concludes that applying problem-based learning (PBL) using the blended learning method can improve critical thinking skills and student learning activities.

Due to recent technological advancements, Marsh and Drexler (2001) and Willett (2002) claimed that blended learning represents all teaching models integrated with technology, such as e-mails, streaming media, and the Internet, and can be combined with traditional teaching methods. The blended learning concept has been defined and developed alongside internet technology. Therefore, researchers attempted to use blended learning, combining teaching technologies with face-to-face (F2F) instruction to assist students in archiving their learning objectives and practicing both learning and working (Driscoll, 2010).

2.3 Misconceptions In Mathematics

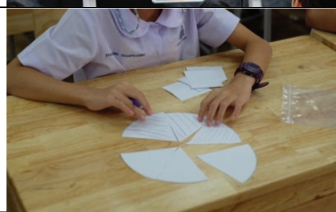
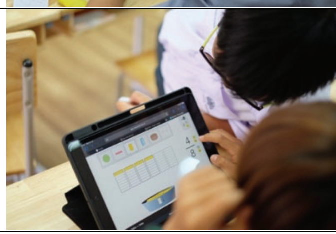
Mathematics is one of the subjects taught at all educational levels. Students were typically introduced to mathematics at a young age. This is because mathematics has indirect effects on student activities. (Trivena et al., 2017) However, many students keep considering mathematics as a difficult and unattractive subject. If students believe that mathematics is relaxing, enjoyable, significant, and essential for their academic success and future, this will have a positive effect on their motivation to learn. Misconceptions and errors are possible. Other factors may include inexperience, difficulties in comprehending or interpreting inquiries, and a requirement for numerical literacy. A misconception, on the other hand, is the result of a misunderstanding or incorrect application of a rule or mathematical concept (Spooner, 2002). Errors are one method for measuring students' comprehension of concepts, problems, and procedures.

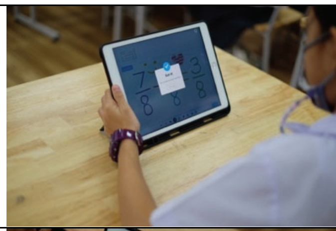
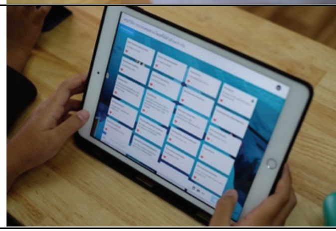
Fractions are one of the concepts with which students need assistance. In order to comprehend the concept of fractions, students must have an established understanding of fractional properties. Trivena et al. (2017) conducted a study on misconceptions about addition and subtraction of fractions among primary school students to determine the level of fraction addition and subtraction mastery among primary school students. Students' understanding of addition and subtraction was dominated by misconceptions, indicating a limited comprehension of the concepts, according to the findings. This is consistent with the research conducted by Pulungan and Suhendra (2019), who investigated misconceptions and errors involving fractions; based on the study's findings, it was discovered that some elementary school pupils continue to have misconceptions regarding the concept of fractions. Various categories of errors are caused by these misconceptions when solving fraction problems. As a result of the student's misunderstanding of the actual concept of fractions, these misconceptions appear. The study emphasizes the importance of addressing misconceptions when teaching fractions to enhance students' understanding.

3. An Example of Teaching Mathematics with Blended learning Integrated Simulation on Fractions

In this section, the researchers intend to show the application of technologies in the mathematics classroom in an effort to enhance students' conceptual comprehension and foster positive attitudes towards utilizing technology for the purpose of learning mathematics. The researchers employed the Problem-based learning (PBL) approach as a pedagogical tool for delivering instruction in the present study. Furthermore, the present study also employed a blended learning approach that incorporated both hands-on learning materials and computer simulations. This pedagogical strategy aimed to enhance students' comprehension of the subject matter by facilitating their visualization of the concepts covered during class sessions. In particular, learners consistently regarded this instructional method as an essential part in their acquisition of fractional concepts. (See Table 1)

Table 1. *An Example of Teaching Mathematics with Blended Learning Integrate Simulation on Fraction*

Components	Learning materials	Description of learning process	Examples of learning activity
1.Identify the problem	Video	Teachers present problems to students using familiar everyday situations.	
2.Brainstorm possible solutions	Hands-on	Students used real materials and predicted answers through learning materials.	
3.Research the problem	PhET Simulation	The students search the problem to learn more about it using PhET.	
4.Develop a solution	PhET Simulation	The students doing another problem using PhET.	

Components	Learning materials	Description of learning process	Examples of learning activity
5.Present the solution	Nearpod	The students present their solution to the class	
6.Reflect on the learning	Nearpod	The students apply their knowledge and reflect on the learning process	

4. Methodology

4.1 Participants

The participants in this study consisted of 25 primary students who are studying in the tenth grade, ranging in age from 9 to 10 years old, from a local public school located in the Northeastern part of Thailand. A majority of the students in the class, specifically 64%, demonstrated misconceptions regarding the concepts of addition and subtraction when applied to fractions. The students had already completed a unit on fractional concepts and were afterwards instructed on the operations of addition and subtraction using fractions. Furthermore, the participants possessed the capacity and had experience in utilizing technology for educational purposes on a consistent basis within the classroom setting prior to their involvement in this research.

4.2 Research Instruments

In this study, there are two research instruments as measuring tools of conceptual understanding and attitude toward using technology to learn mathematics. The first tool is a conceptual test involving the conception of addition and subtraction fractions. The test is designed with open-ended questions to measure the ability to understand the topic. It consists of 16 test items converting the concept of addition and subtraction fractions. It has four concepts. There is addition with the same denominator (4 items), addition with a different denominator (4 items), subtraction with the same denominator (4 items), and subtraction with a different denominator (4 items). The second tool is an attitude to learning mathematics with a technology questionnaire. It is a 5-point Likert-scale questionnaire to investigate the student attitude. It consists of 20 items covering mathematics confidence (MC) (4 items), confidence with technology (TC) (4 items), attitude towards the use of technology for learning mathematics (MT) (4 items), affective engagement (AE) (4 items) and behavioral engagement (BE) (4 items). Cronbach's alpha values indicate the following subscale reliability for MC, MT, TC, BE, and AE are 0.87, 0.89, 0.79, 0.72, and 0.65, respectively. The questionnaire was obtained from Pierce et al. (2007).

4.3 Data Collection and Analysis

Students took 30 minutes to complete a pre-test on fraction addition and subtraction. Then, spend another 20 minutes completing a questionnaire about pre-learning mathematics. After completing a pre-test, students received a simulation-based integrated learning arrangement. During data collection, students must discover solutions through PhET simulation, showcase how to solve problems with Nearpod and reflect on each other. The teacher explains how to use the simulation and the Nearpod application and how to find answers and share them with the class through discussion. The students received a post-test and a questionnaire. (See Figure 1)

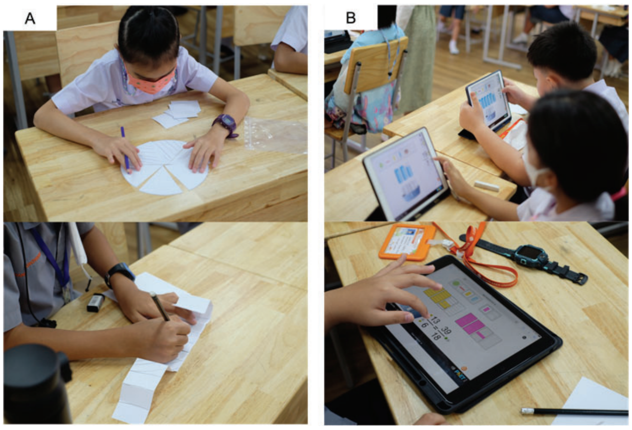


Figure 1. Examples of teaching materials: (A) is hands-on material, (B) is interactive PhET simulation.

The statistical data techniques selected for analyzing students' conception and attitude toward using technology for learning mathematics was Wilcoxon matched pairs signed-ranks test in SPSS 22.0.

4.4 Learning Materials

In the part of the learning activity, technology materials that support the learning process are interactive PhET simulation and interactive presentation from the Nearpod application. Students could also use all applications on their mobile devices. First, the simulation can easily visualize fractional transformations and increase understanding of fraction content meaning of fractions and comparing fractions as well. Moreover, it can change numbers immediately. Whether it's the numerator or the denominator, the picture will also change. This is good for students who want to use their understanding more. Second, the Nearpod application was an interactive classroom tool that enabled teachers to create engaging learning experiences by providing interactive presentations, collaboration, and real-time assessment tools into one integrated solution. Students joined writing solutions on fractions through the Nearpod application. Then, students shared each of the students' writing solutions on fractions with the rest of the class and discussed together along with a summary of mathematical concepts via a collaborative board as show in Figure 2.

Figure 2. Examples of teaching materials: (A) is PhET simulation, (B) and (C) are Nearpod applications show students' solution and discussion about the answer.

5. Result and Discussion

5.1 Student's Conceptual Understanding in Addition and Subtraction of Fraction

The present study employed nonparametric statistics analysis, specifically the Wilcoxon signed-ranks test, to examine the difference between pre-test and post-test conceptual understanding scores. The results showed a significant increase in students' post-test scores for conceptual understanding of addition and subtraction of fraction concepts compared to their pre-test scores ($Z=-4.385$, $p<.05$) as shown in Table 2.

Table 2. *Statistics Of Wilcoxon Matched Pairs Signed-Ranks Test for Students' Conceptual Understanding Scores*

		N	Mean Rank	Sum of Ranks	Z	Asymp. Sig.(2-tails)
Post-Pre	Negative Ranks	0[a]	0	0		
	Positive Ranks	25[b]	13	325	-4.385	<.001*
	Equal	0[c]	-			

* p= <.05

The quantitative result indicates the post-test score of students' conceptual understanding of addition and subtraction fractions was significantly higher than the pre-test score. This finding revealed that the conceptual understanding of students who learn with blended learning with PhET simulation is better after learning. The results related to Arifin et al. (2022) studied the effectiveness of using PhET simulation in primary school students' mathematical understanding of fractions. The results showed that using simulation significantly improved students' mathematical understanding of fractions.

5.2 Student's Attitude toward Using Technology for Learning Mathematics

The Wilcoxon signed-rank test analysis found that there were significant differences between the pretest and post-test for attitude to learning mathematics with technology is mathematics confidence (MC) ($Z = -3.733$, $p < .001$), attitude towards the use of technology for learning mathematics (MT) ($Z = -4.121$, $p < .001$), confidence with technology (TC) ($Z = -3.907$, $p < .001$), affective engagement (AE) ($Z = -3.856$, $p < .001$) and behavioral engagement (BE) ($Z = -3.805$, $p < .001$) as shown in Table 3

Table 3. *Statistics of Wilcoxon matched pairs signed-ranks test for attitude to learning*

		N	Mean Rank	Sum of Ranks	Z	Asymp. Sig.(2-tails)
MC	Negative Ranks	3[a]	5.17	15.5		
	Positive Ranks	20[b]	13.03	260.5	-3.733	<.001*
	Equal	2[c]				
MT	Negative Ranks	1[d]	6	6		
	Positive Ranks	23[e]	12.78	294	-4.121	<.001*
	Equal	1[f]				
TC	Negative Ranks	2[g]	6.75	13.5		
	Positive Ranks	22[h]	13.02	286.5	-3.907	<.001*
	Equal	1[i]				

		N	Mean Rank	Sum of Ranks	Z	Asymp. Sig.(2-tails)
AE	Negative Ranks	2[j]	4	8		
	Positive Ranks	20[k]	12.25	245	-3.856	<.001*
	Equal	3[l]				
BE	Negative Ranks	3[m]	5.67			
	Positive Ranks	21[n]	13.48		-3.805	<.001*
	Equal	1[o]				

* p= <.05

From the study, the overall outcome was students' attitude toward using technology for learning mathematics. There are good results from using technology in mathematics classrooms, as simulations keep students excited, interested. The students liked it and gave it a lot of attention. As well as showing how to do the problem, students can write on iPads. Easy to write, edit the answer, present students' ideas, type, and write along with seeing classmates' answers for talk and discussion. In the meantime, Emata (2023) examined the relationship between math self-efficacy, technology attitude, and attitudes toward mathematics among students. The study found a moderate level of math self-efficacy and attitudes towards math among the students, while the level of technology attitude is high. So, from the study's results, technology should be adapted to teaching and learning.

5.3 Student's Interview on the Attitude toward Using Technology for Learning Mathematics

This study found that students' attitudes toward using technology for learning mathematics. The researchers chose to explain each of the five types of explanations with an example from a student.

5.3.1 Mathematics Confidence: Student A said:
"I'm not afraid to make a math problem. Because it's easy to edit from the iPad without a pencil and eraser."

5.3.2 Attitude Towards Use of Technology for Learning Mathematics: Student B said:
"I love to use apps for math. because normal learning is boring, I like math, but I don't like writing numbers and answers on books. I like math games and anything else that can't just be learned from books"

5.3.3 Confidence with Technology: Student C said:
"I like to use iPad because it's very easy to use, easy to write, easy to click. I want to use iPad in every class."

5.3.4 Affective Engagement: Student D said:
"I'm so excited to use iPad to learn math because I love to see and share my solution with my classmates through the app."

5.3.5 Behavioral Engagement: Student E said:
"I am very focused when studying math. Because I have to keep up with the teacher, I wish I had more time to do the problem. because the teacher gives little timer"

That means students are not worried about showing how to do or responding to answers through technology. Because technology makes it easy to write and answer, students do not enjoy learning solely from books. They enjoy using technology to learn, need to talk to their classmates about the answers they have received, and are determined to learn, making efforts to listen and focus on their studies to keep up with both the teacher and their classmates in the classroom. This qualitative study showed students' attitudes to learning mathematics with technology. The result indicated that many students described an attitude related to mathematics, confidence, attitude towards the use of technology for learning mathematics, confidence in technology, affective engagement, and behavioral engagement.

6. Conclusion and Limitation

Based on the research findings, it can be concluded that blended learning with technology can better resolve misconceptions about addition and subtraction of fractions. Furthermore, PhET simulations can help students visualize and increase their comprehension. Additionally, students interact through the Nearpod application that could exchange their ideas with classmates immediately. Moreover, students have positive attitude to learning mathematics with technology. It's implied that teaching mathematics with blended learning toward technologies had an effect on students' conceptual understanding and attitude toward technology in fraction concept in mathematics classroom.

Based on the results of the research, technology plays an essential role in the correction of mathematical misconception. Technologies that facilitate learning, such as PhET and Nearpod, are widely available and compatible with various devices, including smartphones, tablets, and laptops. These technologies have the potential to enhance student achievement by improving teaching and learning processes. Conceptual understanding can be attained through all six stages, with the most pronounced expression occurring throughout the stage of Brainstorming possible solutions. This stage involves the utilization of physical materials, including the stage of Researching the problem and developing a solution, where the use of PhET is employed. Consequently, this process facilitates the formation of precise concepts. One potential limitation of this study is its reliance on a single sample, hence resulting in a limited sample size. Consequently, researchers are unable to make comparisons between scores, behaviors, and students' attitudes towards learning in relation to both traditional teaching methods and blended teaching incorporating simulation. The sample utilized in the study did not yield results that can be generalized to the general population. In future investigations, it is recommended that researchers conduct trials on a substantial cohort of students.

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Design and Development of a Personalized Recommender System of Student Question-Generation Exercises for Programming Courses

Chih-Hung LAI[a], Pham-Duc THO[b*]
[a]*Department of Computer Science and Information Engineering, National Dong Hwa University, Hualien, Taiwan, Republic of China*
[b]*International School, Vietnam National University, Hanoi, Vietnam*
*mrthoedu@gmail.com

Abstract: Computer programming courses often face the challenge of high dropout rates, prompting educators to seek effective solutions to improve student engagement and retention. Student Question-Generation (SQG) have been explored as potential remedy to this issue, enabling advancements in computer science education. However, the majority of existing SQG support systems lack personalized features to enhance student learning. In response to this gap, the study introduces a personal recommender system of SQG exercise tailored for programming courses. The system leverages individual student preferences and SQG exercise complexities to personalize learning experiences within SQG activities. This paper presents the design of the system and its user interface and delves into motivations and technical bases underlying its development.

Keywords: programming course, Student Generated Question, Recommender System, collaborative filtering

1. Introduction

Computer programming is a foundational part of computer science education, and many educational institutions are updating their curricula to address the challenges in programming courses. High student failure and dropout rates in traditional classrooms are attributed to factors like limited class time, resource constraints, and more. Scholars propose remedies, including collaborative learning, problem-solving techniques (Wang et al., 2017), visualization tools (Minjie, 2015), psychological analysis, visual programming environments (Minjie, 2015), and student-generated questions (Andrew et al., 2011; Hsu & Wang, 2018; Lai et al., 2017).

Among these solutions, SQG have emerged as a critical pedagogical strategy with long-standing recognition (Barak & Rafaeli, 2004). SQG has been noted to enhance comprehension of acquired knowledge, and cultivate skills in algorithmic thinking (Hsu & Wang, 2018), motivation, engagement and learning performance (Crogman & Crogman, 2018; Yeong et al., 2019). Through SQG, students are empowered to apply learned concepts to novel challenges and bridge newly acquired knowledge/skills with prior understanding (Lai et al., 2017). This approach encourages students to adopt an alternative cognitive mode and enhance their repertoire of learning strategies (Hsu & Wang, 2018; Yu & Chen, 2014).

Despite the positive outcomes observed, there were some noteworthy concerns surrounding the implementation of this approach. Specifically, it came to light that certain students expressed a lack of motivation when engaging with assignments involving SQG, as proposed by the instructor throughout the course. This lack of motivation was evident in cases where high-achieving students were presented with relatively straightforward SQG exercises, or conversely, where less experienced students were confronted with overly complex ones.

To address this challenge and fully capitalize on the advantages of SQG, this research introduces an innovative system known as PERS (Personalized Exercise Recommender System). PERS builds upon the SQG concept by incorporating a Recommender System (RS) that suggests appropriate SQG exercises or problem statements to individual students. Operating on the principles of collaborative filtering, PERS intelligently recommends SQG exercises based on students' interests and their assessed proficiency level.

2. Related work

2.1 Question generation and programming learning

Question Generation, also referred to as Question Posing, involves the active process wherein students formulate examination questions based on the content they have read. Even in the face of unfamiliar scenarios or exceptional circumstances, individuals, including children, naturally pose questions. Constructivist educational theories emphasize the significance of this innate curiosity as a driving force for learning and advocate for instructors to facilitate the emergence of such spontaneous inquiry. This facilitative role of the instructor is seen as pivotal in nurturing the inherent questioning process.

Question types span diverse formats, encompassing coding exercises, multiple-choice, matching, short-answer, true-false, fill-in-the-blank, and word puzzles (Barak & Rafaeli, 2004; Lai et al., 2017). When generating questions, students are required to engage deeply with the pertinent information in their texts and subsequently formulate correct answers and distractors (Lai et al., 2017). The ability of students to elucidate the reasoning behind their crafted answer options serves as an indicator of their grasp of the reading material (Lan & Lin, 2011;). Furthermore, question generation allows instructors to identify students' comprehension challenges, thereby enabling targeted instructional interventions (Lan & Lin, 2011; Yeh & Lai, 2012).

Numerous web-based learning systems have been developed to foster student question generation, including QPPA (Yu et al., 2002), Question-Authoring and Reasoning Knowledge System (QuARKS) (Yu, 2009), CodeWrite (Denny et al., 2011), StudySieve (Andrew et al., 2011), and PIPLS (Lai & Tho, 2016). While many of these systems are domain-agnostic, accommodating various question types and multimedia content, and supporting anonymous interactions, only a limited few are specifically tailored for programming courses (Denny et al., 2011; Lai & Tho, 2016; Reilly, 2012) and none of them incorporate automated methods to recommend SQG exercises to students.

2.2 Recommender systems and learning environments

A RS is a software tool designed to discern and propose content that a specific user would find valuable (Ricci et al., 2011). It falls within the realm of information filtering systems, which exploit user data to predict ratings or preferences a user might assign to particular items. Consequently, the primary advantage of an RS is its ability to identify the most suitable array of items for a given user, optimizing rating predictions.

Ricci et al. (2011) delineated five types of RSs: content-based, knowledge-based, demographic, community-based, collaborative, and hybrid. Collaborative Filtering RSs (CFRSs) have seen extensive utilization (Elahi et al., 2016). CFRSs operate on the premise that users may favor items endorsed by other users with similar preferences in the past. This principle underpins the RS employed in this study. CFRSs consist of two main approaches: user-user and item-item (Elahi et al., 2016), both commonly employing the Nearest Neighbors algorithm (Nikolakopoulos et al., 2021).

RSs have found broad application in e-learning environments within the scope of Technology-Enhanced Learning (TEL) to enhance students' self-directed learning (Manouselis et al., 2011). In e-commerce, RSs suggest products; in e-learning, they recommend educational resources (such as papers, books, or courses) to participants like students and teachers (Liu et al., 2022).

RSs have been analyzed for their application in e-learning systems (Santos & Boticario, 2011), presenting three technological prerequisites for developing semantic education RSs.

Enhancing RSs in collaborative learning environments, Anaya et al. (2013) introduced an influence diagram employing machine learning to assess user collaboration, leading to the development of an automatic RS with a pedagogical decision tree. A cloud-based architecture for recommending learning elements based on the learner's emotional state was also proposed (Leony Arreaga et al., 2013).

An extensive survey on RS evaluation in the context of TEL highlighted the need for better evaluation strategies (Erdt et al., 2015). In conclusion, the review underscores the popularity of RS in education, especially technology-driven approaches for enhancing learning. Furthermore, it notes the absence of RSs supporting programming learning with SQG, which forms the rationale for the proposed system.

3. PERS: An integrated approach

In the traditional SQG approach, instructors utilize classroom lectures and student-created SQGs, which are added to a shared Question Bank. Challenges involve overseeing student interaction and addressing dissatisfaction, especially among advanced students who may find exercises too simple. Another approach is more lab practice with instructor oversight, offering better control over SQG exercise interaction. Yet, it risks overemphasizing formal learning, conflicting with broader goals. The challenge is enhancing the current method while reducing direct instructor involvement, maintaining its advantages.

In response to these considerations, this study introduces PERS, a web application that integrates SQG as a teaching tool along with a RS for peer exercises. It is important to note that this proposal not only facilitates interactions similar to the existing approach but also personalizes students' learning journeys through SQG exercises. This empowers the instructor to guide students' learning paths by creating exercises integrated into the system. Moreover, students are afforded the opportunity to evaluate and indicate their preferences for SQG exercises, enabling the system to gain insights into their individual preferences. Using this feedback, the system generates suggestions for new SQG exercises tailored to each student, capitalizing on the notion that students with shared preferences and perceptions of exercise complexity are prime sources for recommendations.

From an educational perspective, this proposition emerges as a novel intermediary between instructors and students. In the ensuing section, the proposal is presented in meticulous detail, outlining the developed Web Application's principal modules and features. Subsequently, the technical elements of the implemented RS are elucidated.

The primary interaction workflow between students and the proposed system is illustrated in Figure 1. Upon logging in, the system assesses whether the student has previously encountered SQG exercises. If they have, the system employs a collaborative filtering approach to recommend 10 SQG exercises. If not, the system selects the most approachable and engaging SQG exercises from the available pool. Additionally, the system assembles a list of 10 SQG exercises intended for presentation to students.

The subsequent stages can be readily comprehended by referring to the diagram. However, it's noteworthy that following the submission of evaluations for the SQG exercises, the system employs collaborative filtering to furnish the student with a fresh set of recommended SQG exercises. As a result, students may engage with varied SQG exercises based on their individual interactions.

Consequently, the student profile is developed based on their evaluations (Favorites and Complexity) of the completed SQG exercises. The current version of PERS was crafted using Python and employs the PostgreSQL Server as its underlying database system.

Among its noteworthy features, PERS encompasses:

- User Authentication Area: This area permits the entry of previously registered students and teachers.
- Student Interface: Students benefit from an informative panel (as depicted in the right panel of Figure 2), which empowers them to manage their profiles,

access a summary of their completed SQG exercises, and review the evaluations of those exercises.

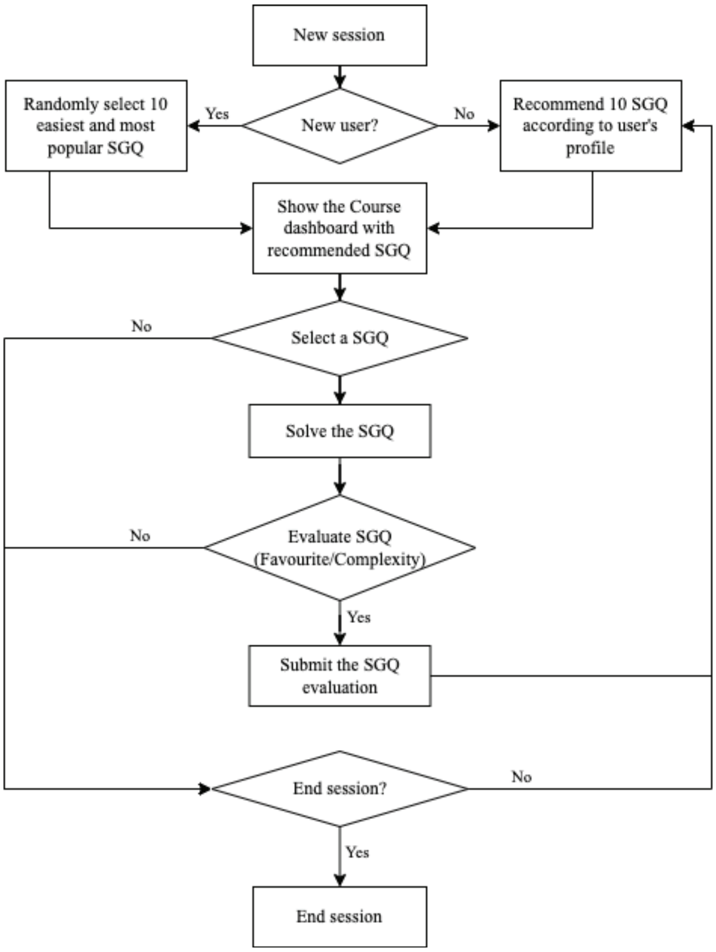

Figure 1. The main workflow of the interaction between the student and the proposed system

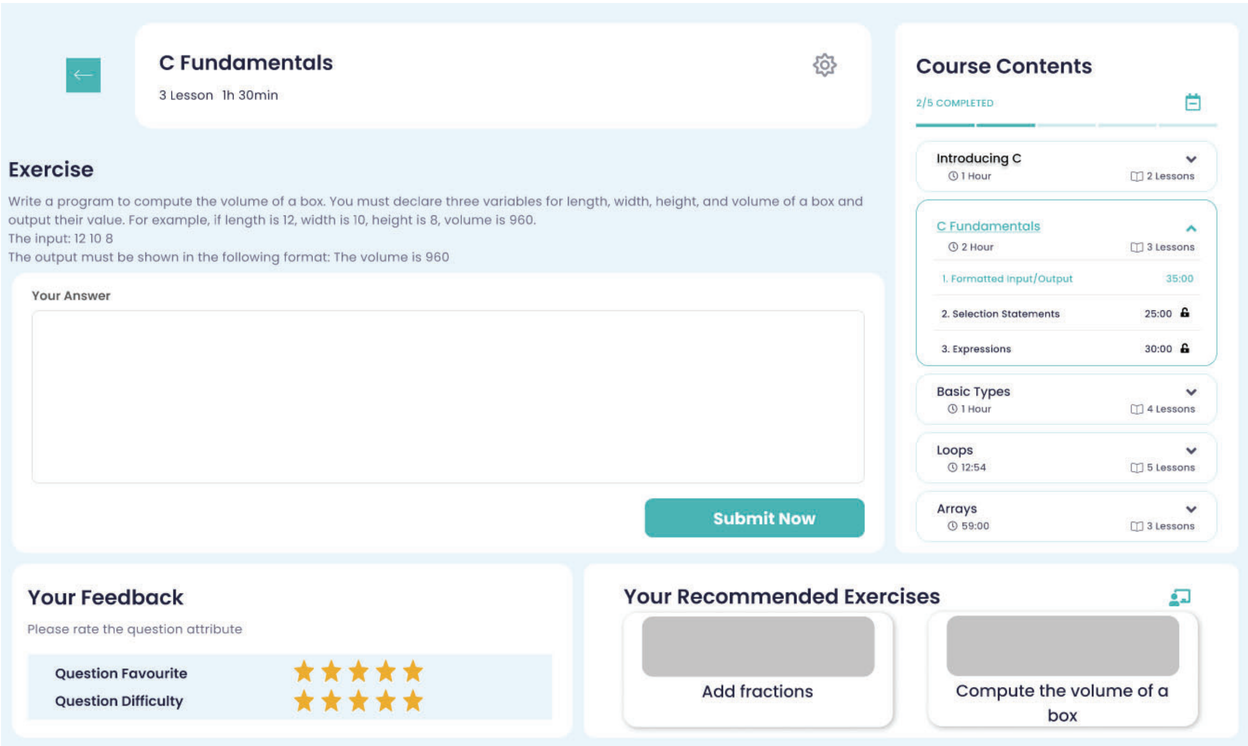

Figure 2: PERS front-end

- Central Display Area: The central region (as shown in Figure 2) is tailored to exhibit the description of the chosen SQG exercise along with its evaluation criteria.
- Bottom-Right Area: The section located at the bottom-right (depicted in Figure 2) provides either a roster of recommended SQG exercises or an exhaustive list of all SQG exercises.
- Teacher Profile: In the teacher's profile, educators can seamlessly integrate new SQG exercises and gain access to statistical insights regarding both the SQG exercises and student interactions.

Importantly, the inclusion of the RS within PERS was realized through the utilization of Surprise. This Python Scikit, abbreviated as SciPy Toolkits, facilitates the creation and evaluation of recommender systems, underscoring PERS's technological foundation.

4. Conclusion and future work

In this study, PERS, a user-friendly Web App is introduced seamlessly combining SQG with a robust recommender system to support students in learning Programming more effectively compared to other systems. In the forthcoming stages, this study will improve the functionalities of the existing systems and assessing the impact of the system on students' academic performance. The insights gleaned from this study will stimulate heightened interest among researchers in this domain.

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A Chatbot for Image Recommendation in Mobile Language Learning

Mohammad Nehal HASNINE[a*], Huyen T. T. BUI[a] & Hiroshi UEDA[a]
[a]*Research Center for Computing and Multimedia Studies, Hosei University, Japan*
*nehal.hasnine.79@hosei.ac.jp

Abstract: Mobile language learning applications have already shown great promise and have played a significant role in how language learners learn foreign vocabulary. Many mobile language learning applications such as mobile apps, computer programs, chatbots, and electronic dictionaries are developed to support vocabulary learning. Finding images to represent a word, considering the learning contexts, is challenging. Therefore, this article describes the development of a chatbot to provide foreign language learners with images to represent a word to memorize using Telegram messenger platforms. Using Python, Microsoft Azure services, and the Telegram API, this chatbot has been designed to provide five relevant still images from the image search engine to get the images to represent a word immediately. This minimizes learners' time spent searching images and optimizes the planning for their learning activities. This chatbot, AIVAS-iBOT (Appropriate Image-based Vocabulary Acquisition System- Image BOT), was also deployed in Skype and hence could be accessed from Telegram and Skype.

Keywords: AIVAS-iBOT, chatbot for language learner, image recommendation, vocabulary acquisition

1. Introduction

Mobile language learning, known under the umbrella terms mobile learning or ubiquitous learning, has shown promise in delivering close integration of language learning with learners' communication needs and cultural experiences. Because of this, learners can use smartphone functionalities to record experiences and listen to audio at any time, which encourages spontaneous interaction.

Foreign vocabulary learning using mobile language learning has been prevalent in recent years, especially in Asian countries such as Japan, China, Hong Kong, Thailand, and Taiwan. Vocabulary learning research indicated that foreign words are easy to memorize when it is represented with an image. It is because images have a significant role to play in our memory. Hence it is said that a picture is worth a thousand words. Many language learning textbooks extensively use images to create the learning content. Many language teachers and language learning apps use a combination of images to improve language learning. However, finding relevant images for a word that could be used as educational resources takes time and effort for the learners.

Educational chatbots have gained interest in the past years due to the advanced artificial intelligence algorithms used in searching content and recommending relevant content to learners. Typically, a chatbot is a program supporting user interaction via conversation in natural language, and it is accessible through the web or social networks (Pérez-Soler et al., 2021).

This paper aims to develop an intelligent chatbot, AIVAS-iBOT (Appropriate Image-based Vocabulary Acquisition System- Image BOT), for mobile language learners using natural language processing and Telegram. This chatbot is also deployed on Skype and can be downloaded from Skype. This research aims to assist foreign language learners in getting familiar with an educational chatbot environment and minimize image search time.

2. Literature Review

2.1 Chatbots in Education

In education, chatbots are becoming an increasingly popular option to interact with learners, and their popularity and adoption are rapidly spreading (Smutny & Schreiberova, 2020). For example, a review article by (Smutny & Schreiberova, 2020) listed 47 educational chatbots using the Facebook Messenger platform. Consequently, a systematic review by (Kuhail et al., 2023) reported 36 papers to understand, compare, and reflect on recent attempts to utilize chatbots in education. The main emphasis of using chatbots in education is to improve learners' learning experiences and learning outcomes. Some examples of educational chatbots are ELIZA, ALICE, and SmartChild. At the Botlist directory, over 2000 chatbots built and deployed on various platforms (e.g. Amazon Echo, Skype, and Slack) could be found.

2.2 Image Recommendation Research in Language Learning

Image recommendation systems have became popular in various domains, such as e-commerce and product recommendation. However, few research studies have examined the scope of image recommendation for language learning. One research by (Hasnine et al., 2018) built an image recommendation environment for language learners. This study proposed a model for Feature-based Context-specific Appropriate Image (FCAI) recommendation to mobile language learners. However, this model has yet to be implemented in a chatbot environment. Also, a few chatbots are built to support image recommendation for word memorization.

Therefore, we introduce AIBAS-iBOT, a chatbot for image search and recommendation to mobile language learners in this study. This educational tool can be downloaded from Telegram and Skype messages.

3. AIRS-iBOT

3.1 Design Process and Methods

Figure 1 shows the flowchart of the AIVAS-iBOT.

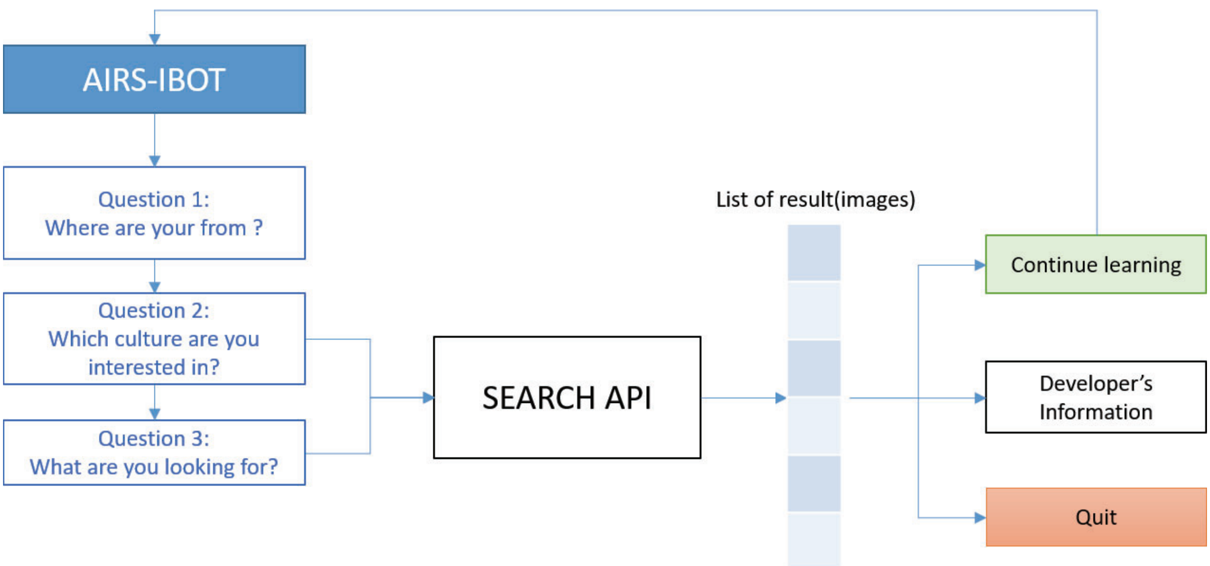

Figure 1. Flowchart of the AIVAS-iBOT.

In the design process, Question 1 defines the language for the chatbot's user interface. Question 2 indicates the country where the results come from, and Question 3 indicates what you want to search for. Each question has some button to guide user action; it enhances the user experience by selecting the available button or directly entering the question/answer.

After getting a list of results, AIRS-IBOT will give the information on the next step. Here a learner will have some choices for continuing using the chatbot. They are:

- Continue Learning: It will go back to the first question, and you will continue to use the chatbot
- Developer's Information: It gives the information of the developer of this chatbot.
- Quit: Quit the operation of the chatbot

3.2 Integration with Telegram and Skype

Telegram (https://telegram.org) and Skype (https://www.skype.com/en/) are popular instant messaging platforms. According to the Telegram website (https://telegram.org/apps), Telegram apps are open source and support reproducible builds. Anyone can independently verify that the Telegram apps you download from the App Store or Google Play were built using the same code that we publish. Skype website (https://www.skype.com/en/features/) suggests that hosting a video or an audio conference with up to 100 people, recording your calls, enabling live captions and subtitles or just simply talking over their smart chat platform is possible at Skype.

Due to these benefits, many apps and chatbots are built and integrated into Telegram and Skype. Telegram and Skype have 550 million and 2.1 billion users, respectively. Many of them use these platforms for educational purposes. Therefore, we aimed to integrate AIVAS-iBOT with Telegram and Skype. Figure 1 shows the integration.

3.3 Deploy in Telegram

At first, we created a Telegram account to create our chatbot onTelegram Bot. To start a new chatbot in Telegram, search for "BotFather" – a bot for managing all Telegram Bots and start registering the new bot.

- Send /start to start a new conversation
- Send /newbot to create a new Telegram bot.
- Configure Telegram in the Azure portal with an access token field

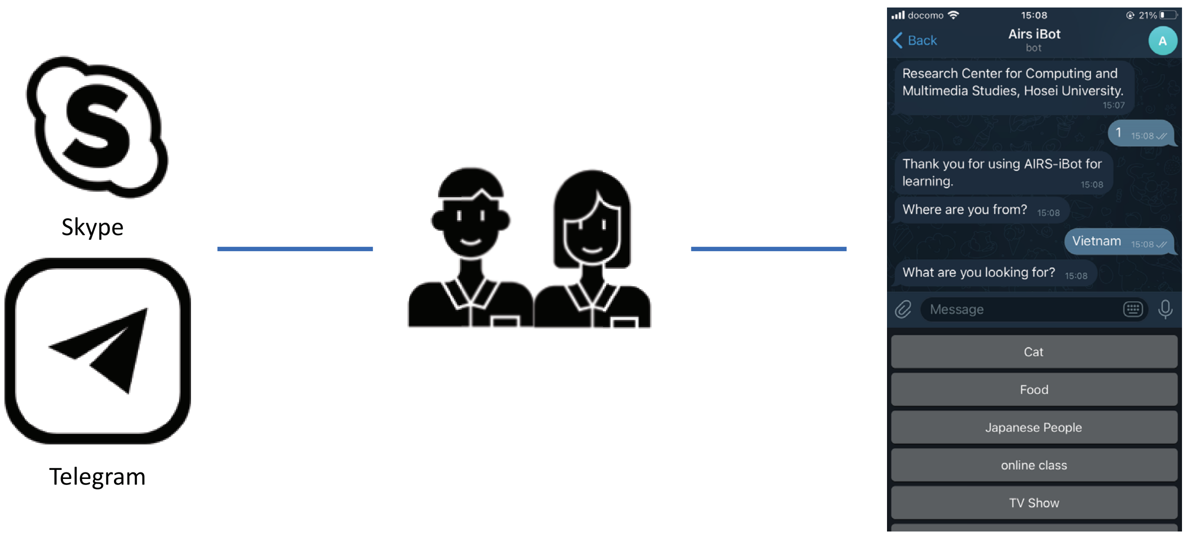

Figure 1. AIVAS-iBOT Integration with Telegram and Skype.

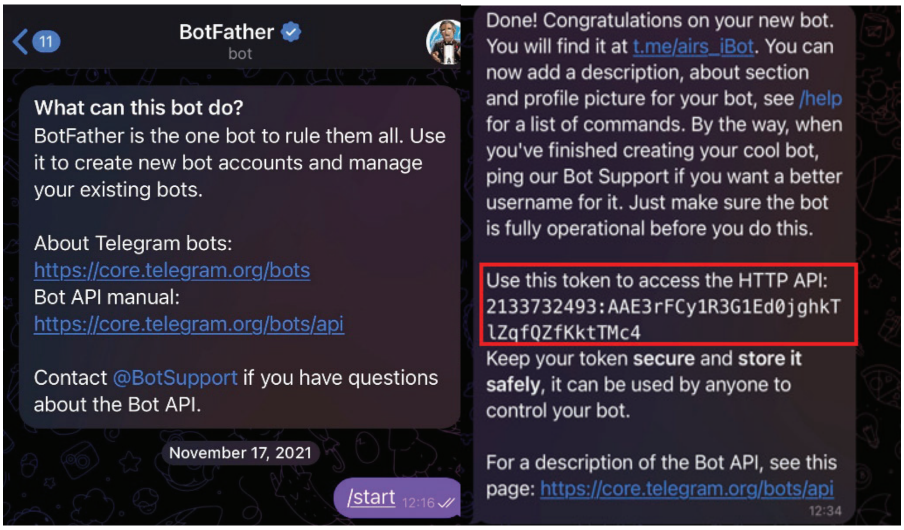

Figure 2. Access Token to Configure Telegram in Azure portal.

3.4 Image Recommendation

AIVAS-iBOT generates results upon answers to three questions by a learner, as follows:

First, *Where are you from?* Answers to this question give the chatbot an idea of a learner's cultural background.
Second, *Which culture are you interested in?* Answers to this question give the chatbot an idea about the language the learner is interested in.
Third, *What are you looking for?* Answers to this question give the chatbot an idea about the topic the learner is looking for.

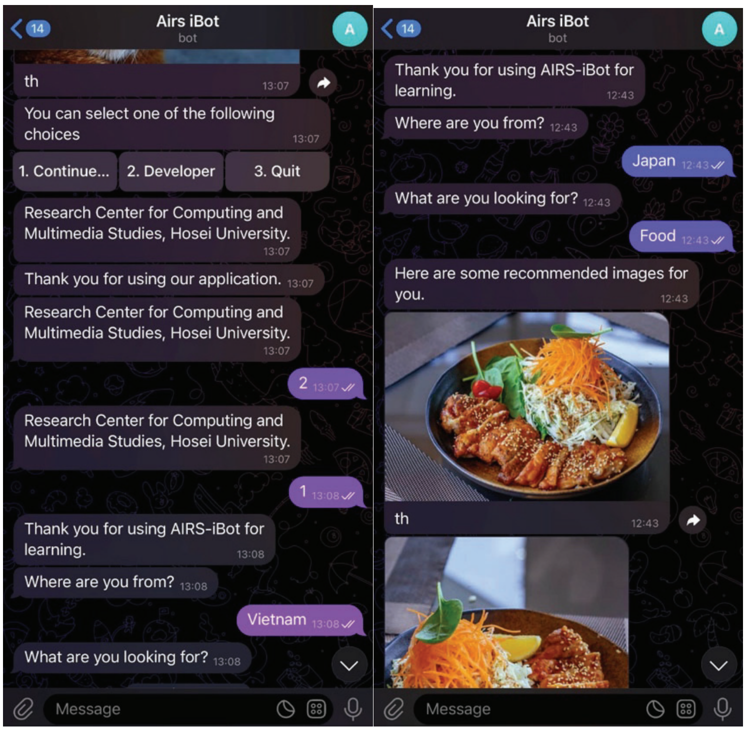

Figure 3. Image Recommendation in AIVAS-iBOT.

For each question, the AIVAS-iBOT suggests some options. So, a learner can choose from those options without typing his/her option if there answer matches with AIVAS-iBOT suggested options.

4. Summary

In this project, we developed a chatbot that returns appropriate images relevant to the language learners' search query. We use the Azure CLI to create AIRS-iBOT and use Bing Search API v7 as the function for searching images. For developing this Chatbot, we used Python as the programming language and Bot Framework Emulator to test and debug the bot. With Bing Search API, we can: AnswerCount. This means we can set the number of answers that we want the response to include. Also, we can Count Code. This means understanding the country where the results come from. In addition, Bing Search API can support many languages, the language to use for user interface strings.

Using AIVAS-iBOT, a mobile language learner gets appropriate images to represent a word he/she intends to memorize. The search and ranking result is swift in our chatbot. This chatbot is a new development to our image recommendation reseach for foreign vocabulary acquisition (Hasnine et al., 2017, 2019).

Future work will address the efficacy of this chatbot. We aim to investigate how learners interact with this chatbot environment, whether the recommended images help learners in short- and long-term memory retention, and what image properties are essential to recommend images for abstract nouns or adjectives. We also aim to investigate where generative AI could be used in improving the performance of AIVAS-iBOT.

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