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# INVESTIGATION OF UBIQUITOUS-PHYSICS APP WITH LEARNING GUIDED MAP TO FACILITATE PHYSICS LEARNING IN AUTHENTIC CONTEXTS

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## Abstract

Many studies have considered the use of mobile devices to support learning in different subjects such as English, math, and biology. However, there are not many studies which focus on facilitating physics learning with mobile device supports in authentic contexts. Taking this into account, we updated a mobile app called Ubiquitous-Physics (U-Physics) by adding a guide learning map (gMap) which helps students to explore inclined plane phenomena in authentic contexts. We aimed to investigate the effectiveness of U-Physics with gMap on students' learning achievements and to analyze students' perceptions based on interview results. Forty-five first-grade vocational high school students majoring in housekeeping management were participated in this quasi-experiment for seven weeks. The experimental group used U-Physics with gMap and the control group used U-Physics without gMap. Although there were no significant differences between the experimental group and the control group concerning learning achievements, we found that learning gain of both groups significantly improved. Additionally, students revealed that they enjoyed exploring and conducting physics experiments in authentic context environments such parks, playgrounds, and houses. These findings indicated that exploring and conducting physics phenomena in authentic contexts can enhance understanding of the physics phenomena and enriches experiential learning.

**Keywords**: Authentic contexts; guided learning Map (gMap); Ubiquitous-Physics (U-Physics).

**Abstrak**

Banyak penelitian telah mempertimbangkan penggunaan perangkat seluler untuk mendukung pembelajaran dalam berbagai mata pelajaran seperti bahasa Inggris, Matematika, dan Biologi. Namun, tidak banyak penelitian yang berfokus pada memfasilitasi pembelajaran Fisika dengan dukungan perangkat seluler dalam konteks otentik. Dengan mempertimbangkan hal ini, kami memperbarui aplikasi seluler bernama *Ubiquitous-Physics* (U-Physics) dengan menambahkan peta pembelajaran panduan (gMap) yang membantu siswa menjelajahi fenomena bidang miring dalam konteks otentik. Kami bertujuan untuk menyelidiki efektivitas U-Physics dengan gMap pada prestasi belajar siswa dan untuk menganalisis persepsi siswa berdasarkan hasil wawancara. Empat puluh lima siswa sekolah menengah kejuruan, kelas satu, jurusan manajemen rumah tangga berpartisipasi dalam percobaan semua ini selama tujuh minggu. Kelompok eksperimen menggunakan U-Physics dengan gMap dan kelompok kontrol menggunakan U-Physics tanpa gMap. Meskipun tidak ada perbedaan yang signifikan antara kelompok eksperimen dan kelompok kontrol mengenai prestasi belajar, kami menemukan bahwa perolehan pembelajaran kedua kelompok meningkat secara signifikan. Selain itu, siswa mengungkapkan bahwa mereka senang menjelajahi dan melakukan eksperimen Fisika di lingkungan konteks otentik seperti taman, taman bermain, dan rumah. Temuan ini menunjukkan bahwa mengeksplorasi dan melakukan fenomena Fisika dalam konteks otentik dapat meningkatkan pemahaman tentang fenomena Fisika dan memperkaya pembelajaran berdasarkan pengalaman.

**Kata kunci:** Konteks otentik; Peta pembelajaran terpandu (gMap); *Ubiquitous-Physics* (U-Physics).

## Introduction

The lack of physics theories and concepts, lack of experiences in connecting physics knowledge to real-world (Hirschfeld, 2012) and a lack of adequately equipped laboratories (Kibirige & Hodi, 2013) could be reason why most of students perceived that physics is a challenging subject (Saleh, 2011). Because students are unable to realize and understand that physics theories and concepts can be found easily in their daily life and surroundings, they usually believed that physics is an uninteresting, irrelevant to their daily lives, and an elite discipline which only suitable for people with unique talents and gifts (Erinosho, 2013). In fact, physics should link to daily phenomena. Teachers should involve students to do more authentic experiential activities that can help students construct their knowledge by using logical inquiry and psychomotor skills. The students were asked to learn by constructing meaning through interacting with and interpreting their environments (Jonassen et al., 1995), connecting and applying what they learned in school to daily life problems (Lombardi, 2007).

A number of studies had used mobile devices as virtual laboratories to tackle the physics learning difficulties (Carlos Castro-Palacio et al., 2013; Purba & Hwang, 2017a, 2017b, 2018; Purba et al., 2019). The studies aimed to collect experimental data through the acceleration sensors of the tablet, and bring measurements and experiments that usually could only be done in the laboratory using multimedia tools. For example, a study used the “Accelerometer Monitor” to measure the period and frequency of the simple pendulum (Carlos Castro-Palacio et al., 2013). The other study utilized an app called U-Physics, which used acceleration sensors to measure the period and acceleration of the simple pendulum (Purba & Hwang, 2018). The study showed that U-Physics was accepted and perceived useful by the students during the experiment. However, the studies, as mentioned earlier, had not considered authentic explorations such as finding physics phenomena outside of school (e.g., public parks and houses) in their activities.

With the development of technology, nowadays, Google maps not only offers students an opportunity to benefit by using the map as a study tool, but also provide them the ease to be able to relocate and review, at their convenience, in person or online. Relocating could help students to find more and more inclined plane phenomena in their surroundings and reviewing the content of marks on the map help them to tackle technical and pedagogical problems during physics phenomena investigations (Shen & Huang, 2006). Students can easily create and view what they have discovered during their physics investigations into the map. Therefore, we integrated Google Maps into our developed app and named it as a learning guided map (gMap). It allows students to seek any example and comparison in solving physics phenomena. Providing an example for students during the learning process can build relevant knowledge and enhance students' problem-solving (Daluba, 2013). Students to check the details of the experimental result and the place of the experiment using gMap. The learning activities allowed students to use the tablets outside of school time, conduct physics experiments and access physics learning content anytime at anywhere. More specifically, the study addressed the following research questions.

1. What are the differences in learning achievements between students who use U-Physics app with gMap and those who use U-Physics app without gMap?
2. What are the differences in learning gains between students who use U-Physics app with gMap and those who use U-Physics app without gMap?
3. What are the students' perceptions of U-Physics with gMap?

## Literature review

### Physics Learning

In general, learning physics requires students to understand and solve related physics phenomena using experimental data, tables, graphs, pictures, and formulas. Learning physics is not only about memorizing formulas, but it is also about understanding the physics concepts being studied. When investigating physics phenomena, students are required to rely more on the ability to observe data and reason and to use their logical reasoning (Lee & Sulaiman, 2017). Ng and Nguyen (2006) said that teachers give students more opportunities to interact directly with the phenomena being studied and to evaluate their understanding by asking them to solve real-life problems. By doing so, the students can learn new concepts in the classroom and then use and apply new knowledge to solve real-life problems outside the classroom. Unfortunately, teachers often employ one-way teaching, where students sit, read, take notes and do homework (Ateş & Eryilmaz, 2011) because they lack experience in conducting physics experiments (Rauf et al., 2013), and some schools may not have the laboratories needed to conduct such experiments (Kibirige & Hodi, 2013). That is why only a few students choose physics as their major, why students become passive during the learning (Josiah, 2013), and why few teachers use experiments in the physics classroom.

## The Use of Real Experiments and Everyday Problem Solving in Physics Learning

Studying and solving everyday phenomena help students construct knowledge, enhance the logical, and explore the psychological sport skills (Hwang et al., 2017; Hwang et al., 2018; Hwang et al., 2019; Lee & Sulaiman, 2017; Purba & Hwang, 2017a, 2018). The use of real experiments and everyday problem-solving in physics learning can stimulate students' interest in the understanding of physics concepts (Purba & Hwang, 2017a, 2018), motivations, and achievements. It also helps students to gain more new experiences, excitements, a better understanding of physics, and cooperation with friends (Lee & Sulaiman, 2017).

Mobile devices such as smartphones are one of the solutions to eliminate buying expensive laboratory tools and difficulties of exploring physical phenomena in authentic environments. It supports learning in the classroom or outside the classroom (Golonka et al., 2014; Wang et al., 2015). In addition to being flexible and convenient, the use of mobile device-based sensors can collect a range of physics data more accurately than the naked eye and can immediately transform those data into graphs or tables. Some studies had explored the use of mobile devices to support student learning in various subjects that include science (Wang et al., 2015) and English as a foreign language (Golonka et al., 2014) and a few studies had used mobile device-based sensors to facilitate physics learning (Purba & Hwang, 2017a, 2017b, 2018). However, the studies generally tested the accuracy of the apps and only a few of them concerned about how to use the apps in authentic environments such as public parks and houses. Therefore, we integrated acceleration sensors, GPS, and Google Maps into our app and conducted experiments in both laboratory and authentic contexts (e.g., schools, house environments, and public parks).

## Ubiquitous-Physics (U-Physics)

We designed and developed a mobile app called Ubiquitous-Physics (U-Physics) to facilitate physics learning inside and outside of classrooms. We activated the embedded acceleration sensor of smartphone to collect physical data when students slid the smartphone on a ramp. To access the app, students inserted their student numbers and passwords into a login system. Once they logged in, U-Physics wall appeared (Figure 1). The main wall of U-Physics hosts some tabs such as recent posts, my posts, and popular posts. Clicking the top right corner of the wall will show more functions of U-Physics including angle measurement function, gMap function, experiment function, ranking function, and log out function. The angle measurement is to measure the angle of inclined plane and an essential step before they measure acceleration and velocity values of sliding smartphone on the inclined plane. The example of measuring angle of inclined plane is shown in Figure 2.

To activate and start experimental measurement of inclined plane, student need to click the experiment button. Once the students clicks the experiment button, a new interface will appear as shown in Figure 3 and U-Physics will automatically record the location of student using GPS. Figure 3 hosts several buttons such as start, stop, graph, table, and whiteboard.

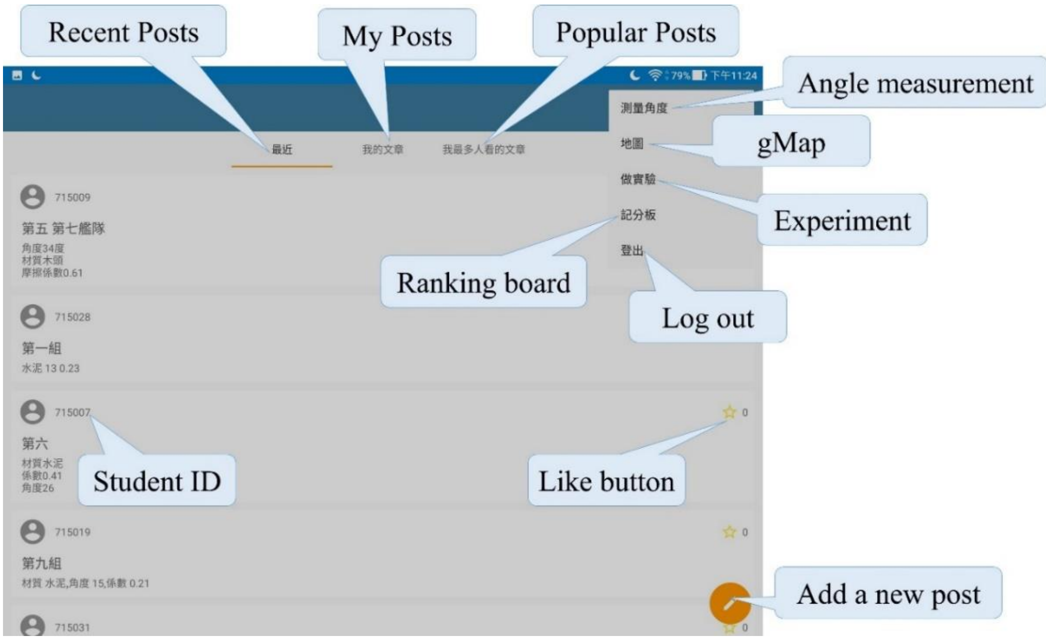


***Figure 1.*** The interface of U-Physics discussion board.

***Figure 2.*** Angle measurement of inclined plane.

The start button is to record acceleration, velocity, and time data of sliding smartphone on the inclined plane and the stop button is to end the recording. The graph button is used to display a graph and the table button is used to display table data.

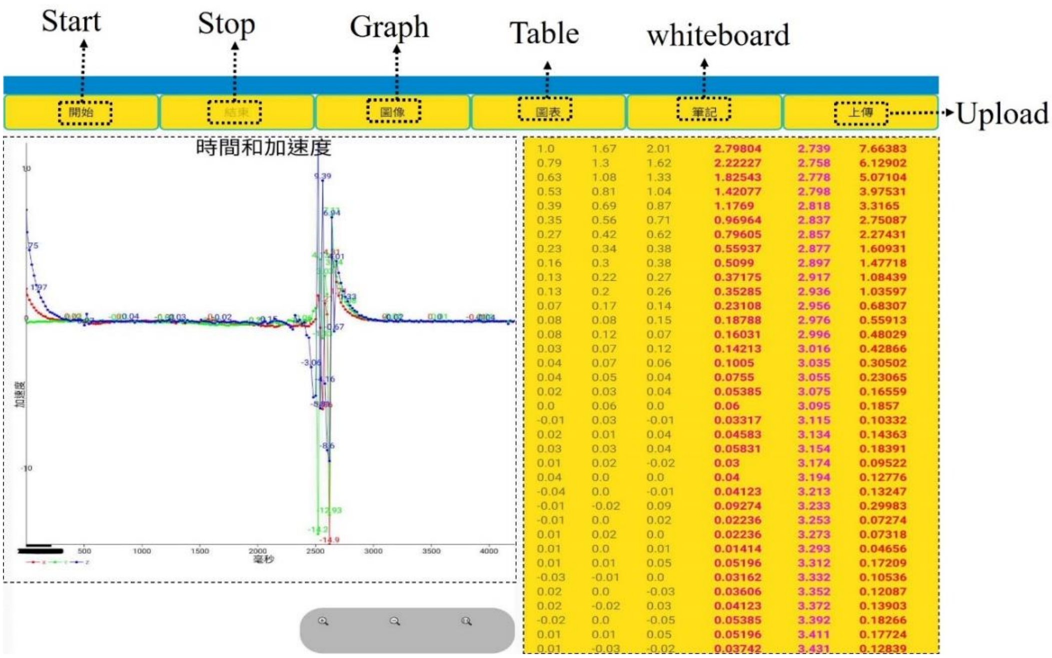


***Figure 3.*** The interface of experiment button.

The student then marks the start time, the sliding period, and the stop time on the graphs using whiteboard button (Figure 4). The graphs and tables then were uploaded by the student to an online database using the upload button.

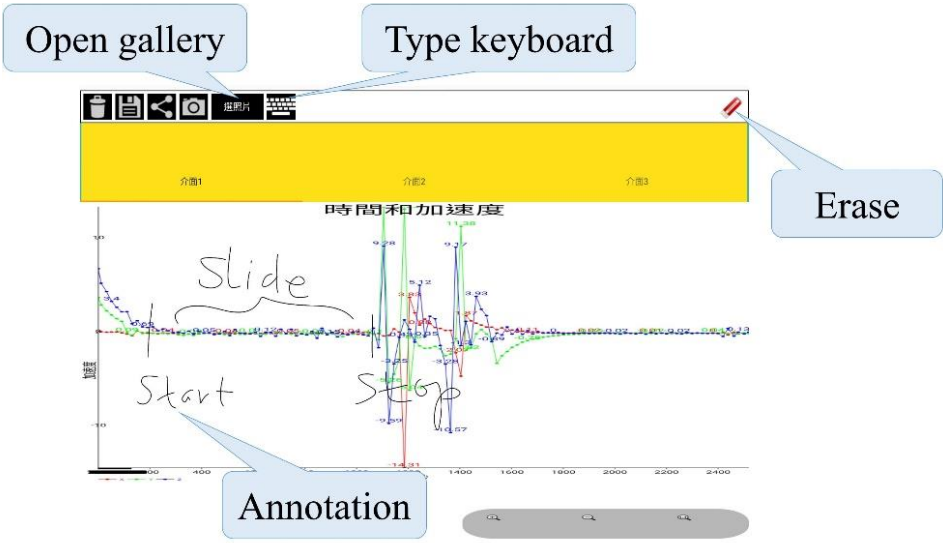


***Figure 4.*** The interface of whiteboard button.

Each experiment done by the student is marked as a location on the gMap, allowing the student to access results by clicking the corresponding marker (Figure 5). The gMap is to help the student to find recommended places, based on other students' markers.

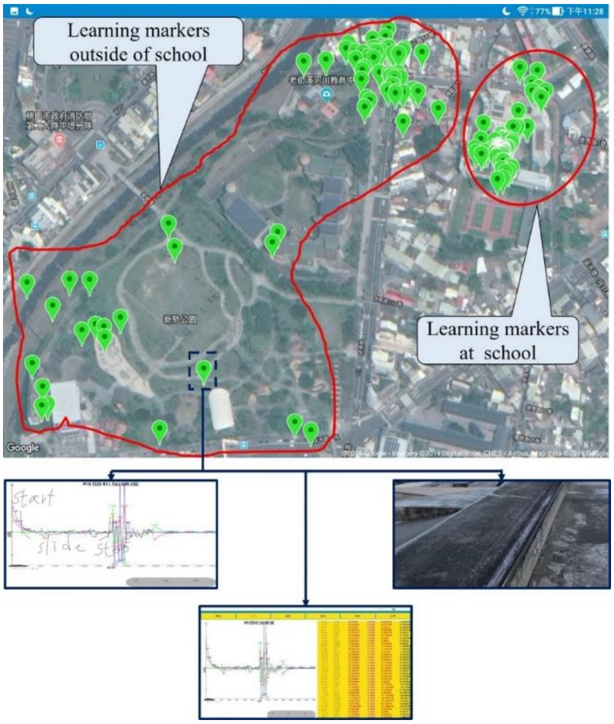


***Figure 5.*** The interface of learning markers on gMap.

The student can check the total of complete activities and the ranks by clicking the ranking board (Figure 6). The student then can share the experimental findings with classmates by posting the experimental data on U-Physics wall (Figure 7). The classmates can give feedback such as comments and suggestions on the posts and the students can also respond to the feedback on the posts. The student needs to click the post to see the detail of someone post. The comments can be in the form of texts and pictures. The discussion threads are organized as threads similar to Facebook (Figure 7).

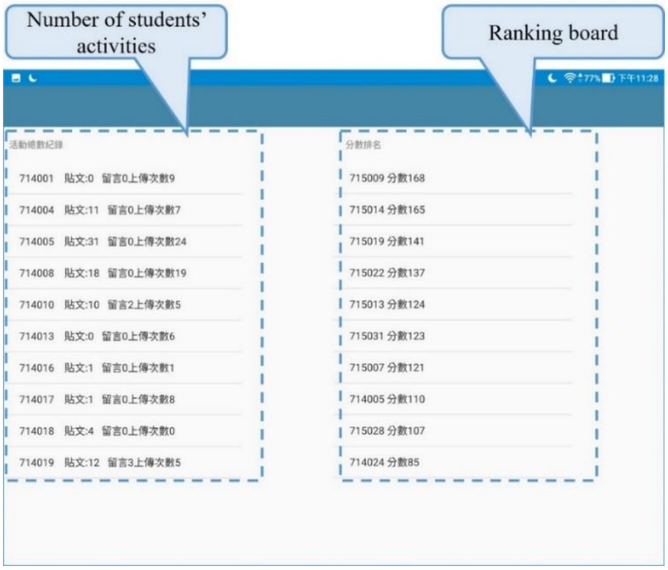


***Figure 6.*** The ranking board of student.

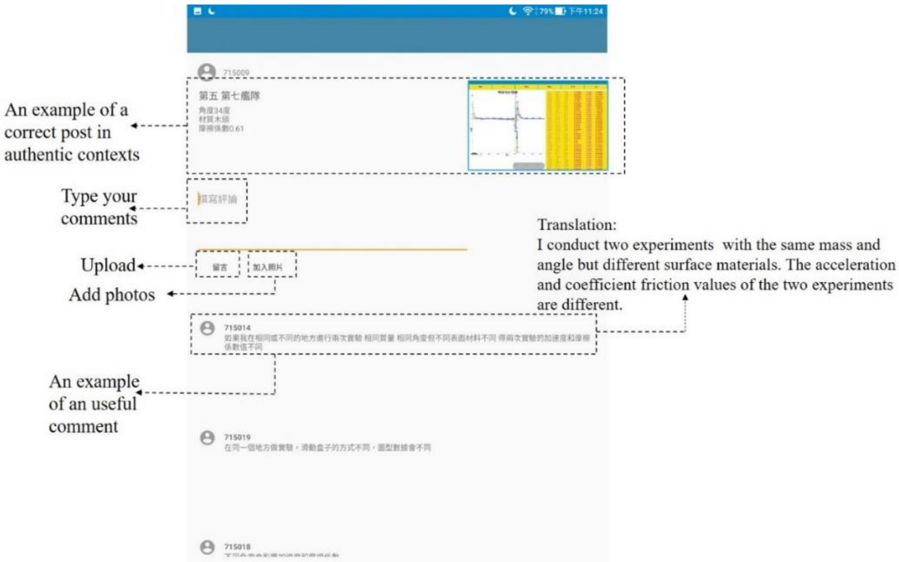


***Figure 7.*** The interface of discussion threads.

## Research Method

### Research Participants

A total of forty-five first grade vocational senior high school students majoring in housekeeping management was volunteered and participated in this study quasi-experiment. They were divided into experimental group (EG; n = 20) and control group (CG; n = 25); each group was further divided into eleven and four-teen smaller groups, respectively. They were taught by an experienced teacher with the same learning materials and time. The EG students used the U-Physics app with gMap and the CG students used U-Physics without gMap.

This experiment conducted within seven weeks and each week has one session for one hour. The experimental procedure is shown in Figure 8. A pre-test was conducted to evaluate students' prior knowledge in the first session. At the same time, a physics teacher lectured and demonstrated an inclined plane experiment to the students in both groups. Both groups conducted inclined plane experiments in a classroom setting in the second week. This classroom activity was to familiarize students with U-Physics and to train them of how to conduct inclined phenomena. In the classroom activity, an inclined plane was made up and configured with boxes and boards. Most of the time, students had to follow teacher choices and instructions to conduct the experiments. In the next four weeks, the students then explored inclined plane phenomena surrounding their schools and a nearby park. These outdoor activities was to improve students' understanding by applying newly learned knowledge to the real world. The students needed to find and explore inclined plane phenomena such as sliders, disable ramps, and stairs with configuring the experimental setting in the outdoor activities. They must be more independent, empowered to learn on their own and discuss for themselves.

Each week, after the class session, the students were asked to complete homework by finding inclined phenomena and investigating the phenomena surrounding their house and nearby their house. To explore more physics phenomena and compare the experimental results, the EG students can click the markers on gMap. By doing so, the students can easily find more physics phenomena at different places.

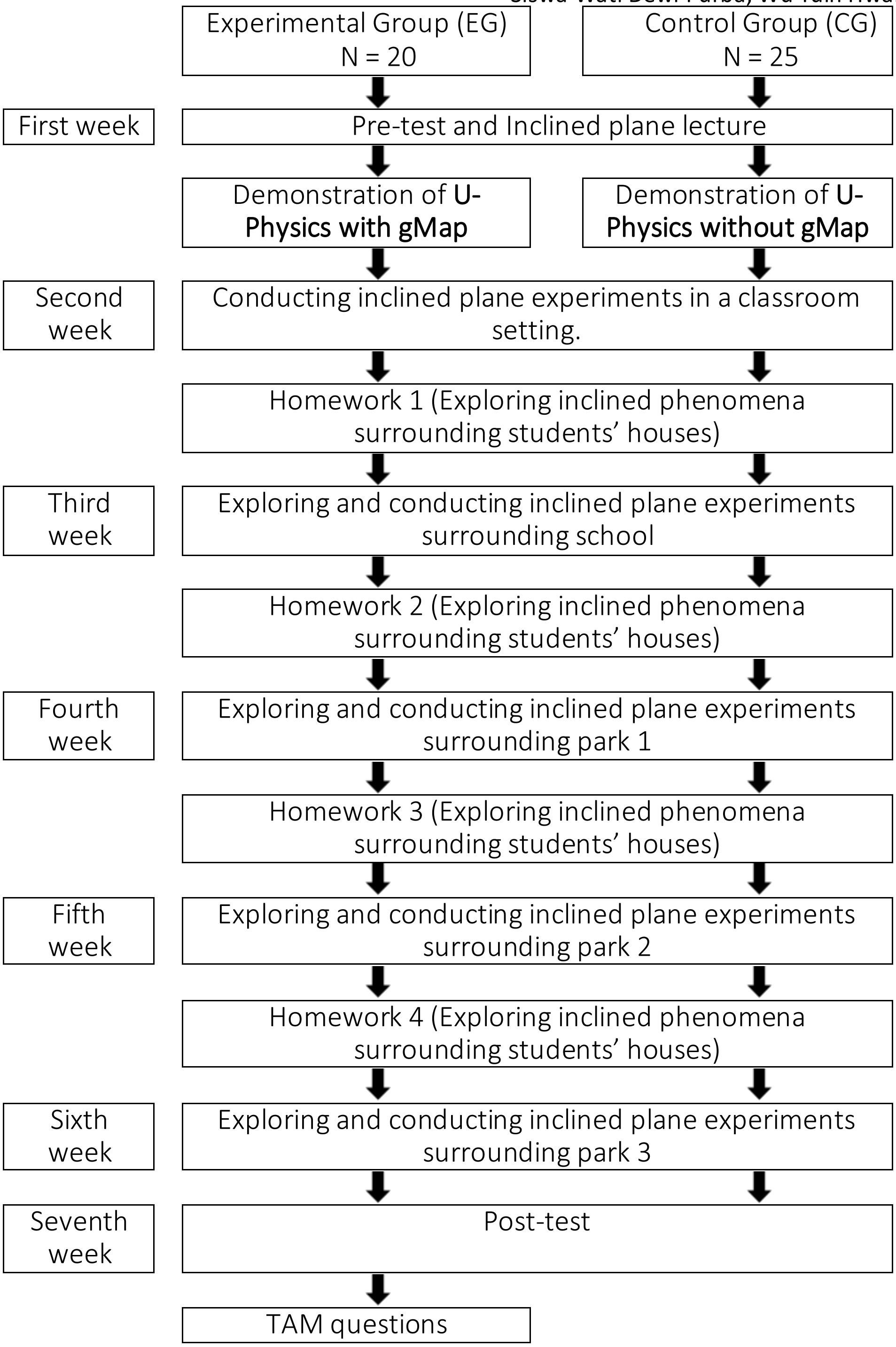


**Figure 8.** Research procedure.

Meanwhile, the CG had to explore and find more physics phenomena by themselves without gMap. Finally, in the seventh week, we distributed a post-test for both groups; the EG students further completed TAM questionnaires.

**Research Instruments and Tools**

U-Physics app was used as a measurement tool of inclined plane experiments and a social platform to share and discuss the phenomena. Students were provided with boxes, boards, tablets and three different surface materials (wood, baking paper, and aluminum foil) for experimental physics settings. A total of ten multiple-choice questions in a pre-test and a total of ten multiple-choice questions in a post-test were adopted from (Purba et al., 2019). The reliability of the pre-test and post-test was 0.902 and 0.841, respectively. Researchers worked together with a physics teacher to design learning assignments such as homework assignments, classroom assignments, exploring school assignments and exploring park assignments. We then adopted TAM questionnaires from Davis et al. (1989) to collect students' perception of U-Physics during the experiment.

**Data Collection and Analysis**

Students' learning achievements were collected using pre-and post-tests and analyzed t- test analysis. Students' perceptions were further collected using a Google form and analyzed using descriptive analysis.

**Results and Discussion**

**Analysis of Learning Achievements**

Although the descriptive statistics of the pre-test shows that the EG (M = 6.25, SD = 2.35) scored higher than the CG (M = 5.72, SD = 1.64), Table 1 shows no significant difference between the groups (t =.886, p = .380) in terms of prior knowledge. It indicates that before receiving different learning treatments, the learning ability of students in both groups were not significantly different. After the learning treatments, similarly, the descriptive statistics of the post-test shows that the EG (M = 8.25, SD = 1.29) also scored higher than the CG (M = 7.84, SD = 2.01). However, Table 1 shows that both groups were not significantly different concerning the post-test scores (t = .789, p = .435). Although the EG students tried their best to engage themselves much in exploring and experimenting using U-

Physics with gMap in authentic contexts, their post-test scores were not significantly different with those of the CG. It might happen because a total of five hours within the five weeks of the experiment is insufficient to show positive effects on students' learning achievements. Therefore, the allocation of learning time to use U-Physics to explore physics phenomena should be extended to be a little bit longer. In addition, students are majoring in housekeeping management, and therefore they did not spend much time to focus on this activity.

**Table 1.** Analysis of pre-test and post-test.

| | Control Group | | | | Experiment Group | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | t | Sig | Mean | SD | t | Sig |
| Pre-test | 5.72 | 1.64 | .886 | .380 | 6.25 | 2.359 | .886 | .380 |
| Post-test | 7.84 | 2.01 | .789 | .435 | 8.25 | 1.293 | .789 | .435 |

**Analysis of Learning Gains**

Although no significant difference was found between the groups in the analysis of post-test scores, learning gain (post-test – pre-test) of both groups significantly improved within the five weeks (Table 2). More specifically, the EG significantly improved their learning ($t = 3.62$, $p = .002$) and the CG significantly enhanced their learning ($t = 4.53$, $p = .000$). The learning activities that allow students to explore and conduct physics phenomena outside of the classroom can enhance students' understanding of the physics phenomena. This kind of experience can enrich students' authentic experiential learning by connecting students' knowledge with daily life environments, enriching their scientific understanding, and stimulating their motivation to learn Physics anytime at anywhere. It leads students to be more independent in creating their own learning content, empowered to learn on their own and discuss for themselves with fewer teachers' interventions during the activity and the discussion process in the discussion board of U-Physics. Students can notice, remember, and recall their physics learning when they connect with related phenomena in their surroundings.

**Table 2.** Analysis of paired t-test (post-test – pre-test) of groups.

| | Paired t-test of control group | | | | Paired t-test of experiment group | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | t | Sig | Mean | SD | t | Sig |
| Pre-test | 5.72 | 1.646 | 4.53 | .000 | 6.25 | 2.359 | 3.62 | .002 |
| Post-test | 7.84 | 2.014 | | | 8.25 | 1.293 | | |

**Analysis of TAM Questionnaires**

According to Table 3, the mean values of TAM is considered highly reliable (Cronbach alpha = 0.881). Most of students perceived that U-Physics with gMap was useful and easy to use to help them in investigating physics phenomena surrounding their daily lives. This finding is consistent with the findings of Purba et al. (2019). In addition, most of students further said that the post and gMap functions were very useful when sharing, reviewing, and clarifying their own findings and peers' findings. The students felt that more and more reflections and feedbacks built among students because of the post and gMap functions. The conveniences to check the details of the experimental results and the experimental locations using gMap could motivate students to explore more physics phenomena and to create more experiment records, thereby sharpening students' authentic-experiential (Wilson & Miller, 2015). Therefore, they are willing to use the U-Physics with gMap in their future experiments. The interview results also showed that gMap has great potentials to help students in their learning investigations.

**Interviewer:** "How do you think about the U-Physics with gMap app in your learning?"

**Student 01:** "It was easy for me to check on my previous experiments using gMap feature."

**Student 02:** "U-Physics with gMap motivates me to explore more different experiments and places."

**Student 03:** "I appreciate the opportunity to use U-Physics with gMap in my class. Previously, I used to feel boring in my class and was very passive. However, when I am using U-Physics with gMap, I am interest and eager to know more about science by finding and conducting physics experiments in different places."

**Table 3.** Descriptive of TAM questionnaires.

| Dimension | Item | Mean |
|---|---|---|
| PEU | I found that it was very easy to operate U-Physics with gMap and to achieve the goals I want. | 3.50 |
| | I had a clear interaction with U-Physics with gMap. | 3.50 |
| | It is very simple to use U-Physics with gMap. | 3.68 |
| | It takes some time to work on U-Physics with gMap. | 3.41 |
| | Using the posts feature of U-Physics can help me to have a good impression on this experiment. | 3.59 |
| | Using the posts feature of U-Physics can help me to compare my results with others' results. | 3.73 |
| | Using comment feature can help me to compare my results with others' results. | 3.59 |
| | I can get and give appropriate feedback to others groups using comment feature. | 3.59 |
| | It is easy to heck on my previous experiments using gMap. | 3.95 |
| | Using gMap makes me willing to explore different experimental places. | 3.82 |
| | Discussion board makes me be more competitive with others. | 3.55 |
| | Discussion board helped me know where others conducted experiments. | 3.68 |

| | | |
|---|---|---|
| | U-Physics with gMap can help me to improve my confidence in physics learning. | 3.14 |
| PU | I used U-Physics with gMap to improve my performance in physics class. | 3.27 |
| | I used U-Physics with gMap to improve my efficiency in physics class. | 3.27 |
| | In physics class, I found that U-Physics with gMap was very useful. | 3.32 |
| | Using U-Physics with gMap in physics class can increase my efficiency. | 3.41 |
| IU | If I had U-Physics with gMap, I would like to use it. | 3.23 |
| | If the teacher gave me U-Physics with gMap, I would use it. | 3.41 |
| | Eventually, I am satisfied with the experiences of using U-Physics with gMap to learn physics. | 3.36 |
| | I am eager to use U-Physics with gMap when studying physics. | 3.41 |
| Attitude | Overall, it is a good idea to use U-Physics with gMap in my physics class | 3.68 |
| | Overall, it is very smart for me to use U-Physics with gMap in my physics class. | 3.59 |
| | I like the idea of U-Physics with gMap. | 3.50 |
| | It is a pleasure for me to use U-Physics with gMap. | 3.05 |
| PP | I like to use U-Physics with gMap to learn Physics around school and park. | 3.59 |
| | I found that U-Physics with gMap was very interesting | 3.94 |
| | Using U-Physics with gMap makes me feel the time flies so fast. | 3.68 |

## Conclusion

This study found that although the post-test score of the EG and the CG were not statically different, both EG and CG significantly improved in terms of learning gains (post-test – pre-test). It might happen due to a short time of the experiment and the major of participants. Exploring and conducting physics phenomena outside of the classroom enhances students' understanding of the physics phenomena being studied and enrich their authentic experiences. The last but not the least, U-Physics is easy to use and useful for learning and the students showed positive attitudes to U-Physics and the learning activities. Since this study involved a small sample and a short learning activity, the results and their interpretation cannot be generalized.

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