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Development of Student-Based Interactive Physics Activity (Sipa): Basis of Conceptual Change in Force and Motion

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ABSTRACT

This study aimed the following: (1) develop a Student-based Interactive Physics Activity (SIPA) app game and (2) determine the conceptual change in Force and Motion. The study employed a developmental research design with three phases: input, process, and output. The Physics activity was intended for classroom instruction, especially for grade 9 students. The evaluation of the SIPA app game was done by the in-service Physics teachers using the App Checklist for Educators (ACE). The readability of the Physics activity was administered using Flesch-Kincaid Test. The result of the evaluation was the basis for the enhancement of the app game and learning activity. The SIPA app game was commendable regarding student interest, design features, connection to curriculum, instruction features, and rating and review. The modified Physics activity was ascertained appropriate for Grade 9 learners. The leaners improved; thus, the SIPA app game was proven workable.

INTRODUCTION

The state of science education in the Philippines, particularly in the basic education level, lags behind other countries. The outcome of the Second International Science Study (SISS) and Third International Mathematics and Science Study (TIMSS) placed the Philippines in disadvantaged positions among participating nations (DepEd, et.al.,2000). In the SISS, the Philippines ranked almost at the bottom of seventeen (17) nations that took the large-scale evaluation of educational attainment. Related outcomes appeared in 2005, 2009, and 2013 TIMSS.

The study of Camarao (2017), "High School Students' Difficulties in Physics", assessed that the subject was hard to learn and to understand contributed to the students' difficulty, which had shown through poor performance in the issue. Sources of the problem in Physics included the content of the subject matter, learning materials, classroom environment, and teacher factor. Students revealed that they found the mechanics of the topic, which includes force and motion, challenging to understand. The topics force and motion were especially difficult for students who had not learned how to apply knowledge in novel and real-life situations. Students who were asked to remember the contributions of physicists found the task problematic because of the foreign names. For major topics, lack of mastery of underlying concepts made lessons challenging. The result of such a null hypothesis was rejected, implying that significant improvement occurred in the performance of the specific area or topic. Topics that were heavy on terminologies, formulas, and numbers were also listed as particularly demanding.

Objectives of the Study

This study used a student-based Interactive Physics Activity (SIPA), an android application-based game type that could boost learners' motivation in learning Force and Motion. Correctly, this study was guided by the following objectives:

1. Develop the Student-based Interactive Physics Activity (SIPA) App game, and
2. Determine the conceptual change in Force and Motion.

Scope and Limitation of the Study

The study was validated by the ten (10) in-service teachers and five (5) STEM experts. They validated the STEM teaching kit.

Statement of the Problem

This study was conducted to answer the following questions:

1. How is the Student-based Interactive Physics Activity (SIPA) App game developed?
2. How can the Student-based Interactive Physics Activity promote conceptual change in learners regarding Force and Motion?

METHODS

Subject of the Study

The participants of this study were the selected in-service Physics teachers of schools in Iligan City. The researcher chose them because of their teaching experience, and they daily deal with the ICT tools. They were asked to assess the SIPA App game to determine its workability, which became the basis for the enhancement of the app game.

Research Design

The study focused on developing the Student-based Interactive Physics Activity (SIPA) App game with the

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evaluation rating sheet, readability of the physics learning activity, and student activity that will help students better understand the lesson of force and motion. It shall also consider research and development and quantitative data in which it focuses on force and motion lessons.
The research also reviews the evaluation of the SIPA app game in terms of workability and Physics learning activity in terms of readability. Like the analysis, the researcher used a mathematical approach to evaluate numerical data collected by acquiring weighted average on the developed context and the quantitative method.

Instrument Used
In this study, SIPA app game, rating sheet was utilized for the workability of the app and base on the evaluation of the App Checklist for Educators (ACE). Evaluation rubric on the SIPA app game was done in terms of its app name, concepts involved, tools, code, preparation of materials, procedure, assembly, layout, and spelling and grammar. In testing the readability of the physics learning activity, Flesch-Kincaid test was applied.

Data Gathering Procedure
Phase I: Development of the SIPA App game
Stage I: Creation of the SIPA App game
The challenge of the researcher was to create the SIPA App game. It was one of the objectives of this study. The researcher developed the app game because of the versatility of the equipment in terms of concept and its appropriateness to the vital stage standards of the enhanced K-12 basic education curriculum. He was also inspired in teaching using the Physics Educational technology (PhET). The SIPA App game covered concepts on the topic of Force and Motion.

Stage II: Modification of the Physics Learning Activity
The researcher modified the Physics learning activity based on the developed App. The design of the activity was also based on the activity provided by PhET. The learning activity was a fundamental tool/instrument to test the workability of the SIPA App game.

Phase II: Evaluation of the SIPA App Game
Stage I: Evaluation of the SIPA App Game by the Physics Teachers
The developed SIPA app game was presented to the 16 in-service Physics teachers using an evaluation rating sheet to evaluate the developed App based on its app feature, ease of manipulation, efficiency, accuracy, safety, and appropriateness. After the evaluation, the comments were incorporated. The evaluators suggested adding a graph to show the movement of the object in the air which the purpose was being tossed the object and using a certain amount of force.

Stage II: Readability of the Physics Learning Activity
The Physics learning activity, which was based on the developed App and PhET, underwent a readability test using the Flesch-Kincaid test. The Flesch-Kincaid test assessed all the parts of the activity to determine their readability. In the Flesch Reading Ease test, higher scores indicated that the material was easier to read; lower numbers marked more difficult passages.

Stage III: Pilot Testing
The participants were purposively chosen in which only those with smartphones could participate. The SIPA App game was given to the participants through their smartphones. Afterward, the students tried out the Physics learning activity. Their responses on the activity regarding the conceptual understanding of the topic Force and Motion were considered.

Statistical Analysis
The mean is the average of the numbers summed up and divided by the count. This study used the mean to determine the average score of the App Evaluation for Educators Checklist (ACE). The weighted mean was employed in getting the participants' average response on the workability of the developed App.
The content analysis was done on the responses of the in-service physics teachers on the evaluation of the developed SIPA app game in terms of workability. It was also used to assess the designed physics learning activity in terms of readability.

RESULTS AND DISCUSSION
1. Development of Student-based Interactive Physics Activity (SIPA) App

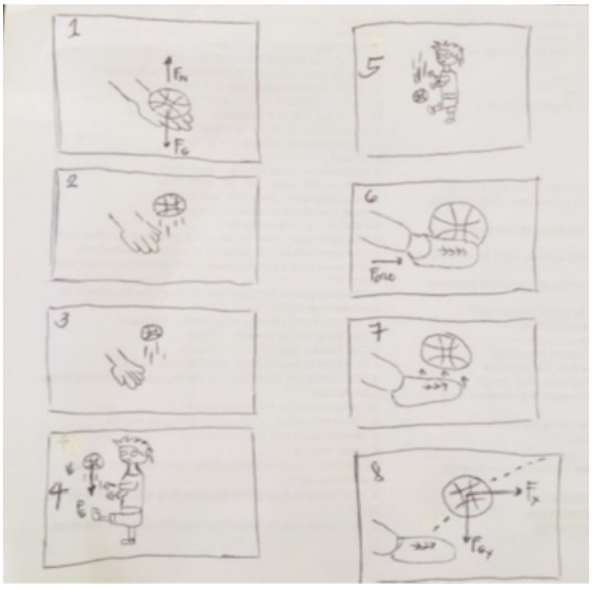

Figure 1: Storyboard for the making of SIPA App

Figure 1 shows the first draft of the SIPA app game, which was a sketch of the storyboard that focused on the game in the Philippines called "Sipa," the national sport of the country. The sport "Sipa" which literally means kick or to kick, is a homegrown national sport.

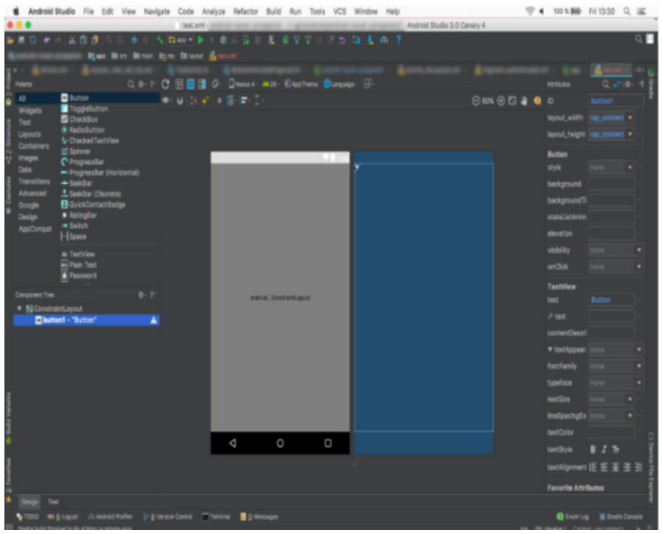

Figure 2: Mock-ups for the making of SIPA app

Figure 2 shows the mock-ups for the making of SIPA app game. Sketching up the frames of the app was a great way to make it a bit more realistic. This was the step that could not be avoided in creating any kind of application. The efficient way to test the assumptions about the app also provided detailed instructions for developers. Abdelhamid et al. (2020) found that the experimental results show, the effectiveness of the proposed approach in generating a visually appealing android GUI from hand-drawn mock-ups with a recognition accuracy of 98.54% when tested on various hand-drawn GUI structures designed.

Figure 3: Design of the developed SIPA app

Figure 3 shows the SIPA app game before the pilot testing. Comments and suggestions of the thesis advisers and panel members were already incorporated in this presentation of the app game. At this point, the SIPA app game had to undergo evaluation by the in-service Physics teachers and ICT experts.

Modification of the Physics Learning Activity

The Physics activity entitled "Ramp Forces and Motion Investigation" from PhET, authored by Bruce Palmquist at Central Washington University. Here the students would write a testable hypothesis and design an experiment about the relationship between either object's mass or ramp's angle and the distance traveled by an object sliding down a ramp. The researcher used this activity as the basis of the Physics learning activity for the SIPA app game. Modifications were made on the activity to fit the SIPA app game and meet the study's objectives.

Evaluation of the SIPA App Game

Sixteen Physics validators evaluated the SIPA app game to determine its appropriateness and consistency based on the App Checklist for Educators (ACE) assessment criteria. Areas included in the ACE are Student Interest, Design Features, Connection to Curriculum, Instruction Features, and Rating and Review.

Table 1. Based on the evaluation of the SIPA app game in terms of student interest, most of the in-service Physics teachers agreed that the SIPA app game was easy to use, entertaining to the students, could increase student interest in the topic, and students could want or ask to use the app again. According to Sivan (2005), found that when active learning is carried out, simulations, discussions, student presentations, games, role-plays, flip charts and handouts are basic elements of physics lessons.

Table 1: Evaluation of the SIPA App Game in terms of Student Interest

Student Interest	**Yes**	**No**	**Some what**	**N/A**
Is it easy to use?	14	0	2	0
Would students find this app entertaining?	13	0	3	0
Does it increase student interest in the topic?	14	0	2	0
Do students want or ask to use this App again?	11	0	5	0

Table 2: Evaluation of the SIPA App Game in terms of Design Features

Design Features	Yes	No	Somewhat	N/A
Is the layout clear and consistent?	13	0	3	0
Does the app include graphics and/or animations?	15	0	1	0
Do visual features enhance student learning? (e.g., pictures or animation)	13	0	3	0
Do the auditory features enhance student learning? (e.g., music or reading aloud)	8	0	8	0
Is it compatible with other technology devices?	12	0	4	0
Is technology support available?	12	0	3	1
Is content prepared in a culturally inclusive manner?	13	1	2	0
Does it provide students' performance feedback?	11	3	2	0
Do educators have access to student performance data?	8	1	6	1
Does it collect data over multiple uses?	8	0	7	1
Is it reasonably priced?	4	0	10	2

Table 2. Based on the evaluation of the SIPA app game in terms of design features, most of the in-service Physics teachers agreed that the layout was clear and consistent; the app included graphics and animations; instead of, the visual features could enhance student learning; the app was compatible with other technology devices; technology support was available; the content was prepared in a culturally inclusive manner; and the app provided students' performance feedback. Some of the in-service Physics teachers somewhat agreed that the auditory features enhanced student learning; educators could have access to student performance data; and the app could collect data over multiple uses. Most in-service Physics teachers agreed that the app was reasonably priced. Studies on mobile learning focus on how learners on the move gain new knowledge, skills and experiences (Sharples et al., 2009).

Table 3. Based on the evaluation of the SIPA app game in terms of connection to curriculum, most of the in-service Physics teachers agreed that the content of the app could relate to the common core standards; the content could match the student skill level; it could align with the IEP goals; it could be applied to the real-world situations; and the app could improve academic and critical thinking skills of the students. Studies on mobile learning focus on how learners on the move gain new knowledge, skills and experiences (Sharples et al., 2009). Rapid development of mobile technologies also brings some disadvantages to researchers and learners. Learners devote time to get used to the characteristics of the new device.

Table 3: Evaluation of the SIPA App game in terms of Connection to Curriculum

Connection to Curriculum	Yes	No	Somewhat	N/A
Does the content relate to Common Core Standards?	16	0	0	0
Can the content match the student skill level?	14	0	1	1
Can it align with IEP goals?	14	0	2	0
Can it be applied to real-world situations?	14	0	2	0
Will it improve students' academic skills?	14	1	1	0
Will it improve students' critical thinking skills?	13	1	2	0

Researchers face challenges carrying out longitudinal studies. People, who have mobile devices, desire to use these devices in mobile learning settings for their personal needs, which poses challenges to researchers on having control over variables (Pancher, 2009).

Table 4. Based on the SIPA app game evaluation in terms of instruction features, most of the in-service Physics teachers agreed that the app could require students to memorize basic facts, explain ideas and concepts, apply information to various situations, and make connections among concepts. Most of the in-service Physics teachers somewhat agreed that the app could require students

Table 4: Evaluation of the SIPA App Game in terms of Instructions Features

Instruction Features	Yes	No	Somewhat	N/A
Does it require students to memorize basic facts?	9	2	5	0
Does is require students to explain ideas and /or concepts?	11	1	2	2
Does it require students to apply information to various situations?	13	0	2	1
Does it require students to make connections among concepts?	14	0	2	0
Does it require students to create original work?	5	1	10	0

to create original work. According to Evans (2008), emphasized that mobile learning is more effective and instructive than books, and more supportive in learning.
Table 5. Based on the evaluation of the SIPA App game in terms of rating and review, all in-service Physics teachers agreed that the app could be recommended to other professionals and to families.
The results of the study implied that the students could have positive learning gains on force and motion with the use of SIPA app compared to the traditional teaching method. The educational use of mobile devices in and outside of the classroom helps students develop positive attitudes towards courses (Ozdamar, 2011).

Assessment of the Physics Learning Activity with the SIPA App Game

Table 5: Evaluation of the SIPA App Game in terms of Rating and Review

Rating and Review	**Yes**	**No**	**Somewhat**	**N/A**
Would you recommend this app to other professionals?	16	0	0	0
Would you recommend this app to families?	16	0	0	0

Table 6: Assessment of the Physics learning activity

Results	
1.Flesch-Kincaid Grade Level:	6.2
2.Flesch Reading Ease Score:	63.9
3.Reading Level:	8th and 9th (Plain English)
4. Average Words per Sentence:	7.5
5.Average Syllables per Word:	1.5
6.Sentence:	27
7.Words:	202
Score	Estimated Reading Grading Level
90 to 100	5th Grade
80 to 90	6th Grade
70 to 80	7th Grade
60 to 70	8th and 9th Grade
50 to 60	10th ad 12th Grade (high school)
30 to 50	College
0 to 30	College Graduate

Table 6. Based on the assessment of the activity using the Flesch-Kincaid test, the learning activity had a score of 6.2. It means that the readability of the learning activity was understandable. The reading level of the activity revealed plain English and was appropriate for 8th and 9th graders, which means that the activity could be easily understood by 13- to 15-year-old students. According to Ozan (2013), have found that mobile technologies positively affect performance of students. Animations, which were developed by mobile learning group, were found more qualified in this research
Figure 4 presents the final design of the SIPA app game. Comments and suggestions of the in-service Physics teachers were already incorporated in this design. The researcher also made some adjustments to really improve the design of the app game. The app's graphic design included pixel-perfect visual details, graphic effects, image assets, and to some extent, even animations and motion design.
The android development platform, which was the Android Studio, was used to create input codes, edit, analyze, emulate, and preview the android app before release and to add some higher concepts of the game in designing the SIPA app game. According to Skoloff et.al (1998) , when simulations are applied in laboratory experiments and on tough concepts related to teaching physics, straightforward teaching can be achieved easily.

Figure 4: Final Design of the SIPA app

Conceptual Understanding of the Respondents

Table 7: Conceptual Understanding of the Respondents

Code	Before	After
S1	Force push or pull of an object. Motion the speed of the object or its owner.	Force pull or push of an object. Motion is the change in the position of an object over time
S2	Force is a kind of work that you can apply the real life that you can treat energy. Motion is an acceleration of objects that you can apply a distance and a velocity.	Force is a kind of object that you can apply in real life. Motion that can create an acceleration, force, energy of objects.
S3	Force object is on the direction of the object motion. Motion more friction it can move the object.	Force is any interaction that, when you paused will change the motion of an object. Motion is the change in the position of an object over time.
S4	Force is an acting of an objects. Motion is transferred by a force moving an object through a distance.	A force is any interaction that, when unopposed will change the motion of an object. Motion the act or process of moving or a particular action or movement.
S5	Force push or pull of an object. Motion is a moving an object.	Force pull or push of an object. Motion is the change in the position of an object over time

Conceptual Understanding Before the Activity

The researcher did a qualitative inspection of the answers of the students. In this way, he could better see the SIPA app results on the students' conceptual understanding. The two (2) open-ended questions in the pretest and posttest were sorted separately.

1. What do you think is the definition for the following:
   A. Force
   B. Motion

The most common concept answered by the students was " Force push or pull an object. Motion the speed of the object or its own." (S1, S5, S9, S11, and S19) and also with the same thought "(Force the amount of matter in an object. Motion is transferred by force moving an object through a distance." (S4, S7, S12, S14, S17, S22, S23, S24, S25, S28, S31, S33, S34, S37, S38, and S40).

This was because the respondents relied on their common knowledge or sense in answering. Common knowledge pointed to what they have known since on Grade 7 that force is a push or pull on an object, and for the motion, they have proven that it involves moving from one place or another. Their concepts were almost correct but lack the complete thought of it. In physics, motion is the change in the position of an object over time. Motion is mathematically described in terms of displacement, distance, velocity, acceleration, speed, and time. Moreover, in physics, a force is any interaction or any movement that, when unopposed, would change the motion of an object. The force can cause an object with mass to change its velocity (which includes beginning moving from a state of rest), i.e., accelerating. Force can also be described naturally as a push or a pull.

Conceptual Change After the Activity

After the activity with the SIPA App, a conceptual change was observed among of the students. In posttest, the most common concept answered by the students was a force is anything that can push or pull on an object. Forces influence objects that are at rest or that are already in motion.

This concept was found in 27 respondents, where previously there were none. This finding was promising since this was the correct concept. The activity using the SIPA App revealed to them that they were wrong in the pretest. It made a slow time in simulation and see whether a force is a push or pull on an object. In addition, most of the respondents were already familiar with force in the pretest, and this finding was changed in the posttest. This means that their understanding on force and motion was changed due to the SIPA-App game.

CONCLUSION

The following conclusions were drawn from the findings of this study:

1.The researcher-developed Student-based Interactive Physics Activity (SIPA) app game, which was based on the concept of Force and Motion, was commendable in terms of student interest, design features, connection to curriculum, instruction features, and rating and review. The SIPA App game was workable based on its evaluation by the in-service Physics teachers.

2. According to the Flesch-Kincaid test, the modified Physics learning activity was
appropriate for Grade 8 or Grade 9 learners. The learners' conceptual understanding
improved; thus, the SIPA App game fit the physics learning activity, and the App
game was also proven workable.

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