Exploring the Effect of PhET® Interactive Simulation-Based Activities on Students' Performance and Learning Experiences in Electromagnetism

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Abstract. *This study focused on the development and finding the effect of PhET® Interactive Simulation-based Activities in electromagnetism on the performance and learning experiences of students following the steps of the Research and Development (R & D) methodology . A panel of evaluators validated the Physics Education Technology Interactive Simulation-based Activities (PhET®ISbA) and their ratings were analyzed using the mean. The developed PhET®ISbA were tried out to 200 Grade 10 students to determine their effectiveness in teaching concepts in Physics particularly Electromagnetism via a quasi experiment following a one-group pretest-posttest design. Test results gathered from the tryout were analyzed using frequency distribution, mean, standard deviation and t-test for correlated samples. Data gathered revealed that the developed PhET®ISbA are extremely valid in terms of learning outcomes, instructional characteristics and evaluation. Findings of the tryout show that there is a significant improvement of the Physics academic performance of the students. The answers in the informal interview and feedbacks in the scientific journal of the students revealed that when PhET®ISbA were used in teaching, they acquired significant learning experiences which are synthesized into three big themes: learning Physics is fun, learning Physics is real, and learning Physics is simple and easy. Hence, the developed PhET®ISbA are found to be effective instructional materials in teaching Physics particularly Electromagnetism. The indicated findings and favorable feedback of students only prove that the developed PhET®ISbA are valid, thus, these are recommended to be used for classroom instruction for understanding Physics concepts for diverse learners.*

Keywords*: Physics Education Technology (PhET®), Interactive Simulation, Activities, Performance, Significant Learning Experiences*

INTRODUCTION

The global community believes that everyone deserves access to quality education. Quality education is the highlight of the Sustainable Development Goals of 2030, that is, to ensure inclusive and equitable education and promote lifelong learning opportunities for all. The Philippine educational system, is likewise, geared toward attaining inclusive and quality education for all. Hence, Republic Act No. 10533 or Enhanced Basic Education Act 2013 was enacted to implement the K to 12 Curriculum improve competitiveness of Filipino learners and graduates.

Science and Technology foster the implementation of the sustainable development goals. As stated in the 2002 Basic Education Curriculum, Science aims to help every Filipino learner gain a functional understanding of scientific concepts and principles linked with real-life situations, acquire scientific skills, attitudes, and values necessary to analyze and solve day-to-day problems in the society. These scientific skills can be best acquired by learners through Information and Communication Technology (ICT) integration.

Integrating ICT in the teaching-learning process has become a great concern of many educators in K to 12 schools in the Philippines. In the pursuit of ICT in education, Republic Act 10844 prioritizes the provision of Wi-Fi access at no charge in selected public places including parks, plazas, public libraries, schools, government hospitals, train stations, airports, and seaports. This ICT-supported education will allow students to use learned skills in other academic content areas, motivate them to learn more, provide them opportunities to collaboratively learn with other

learners, and help them develop various intelligences [4].

However, empirical survey conducted revealed some problems today in Physics teaching. These are inadequate textbooks, lack of laboratory rooms and apparatus for actual experiments. Some teachers used virtual laboratories and simulations to carry out laboratory experiments that are difficult to accomplish due to the nature and the risks in performing them. They also pointed out that there are available simulations online that can be downloaded for free but there are no accompanying activity sheets. Likewise, careful scrutiny of the existing activities in Grade 10 Physics shows that there is a need to make activities that could bridge the gap between the topics taken in the previous grade levels and the present topics.

Studies show that lack of models or representations of the invisible concepts is one of the reasons why students hardly understand Science concepts. This is the real scenario in Physics classroom setting that needs to be addressed by educators. The great challenge to Science teachers is to devise or innovate ways to make teaching-learning interesting and meaningful. Simulation-based activities can be one of the strategies to increase students' interest resulting to higher level of their academic Science performance. As de Jhong (1998) pointed out, simulations are simplified versions of the natural world and these have potential to facilitate learning focusing on students' attention more directly on the targeted physical phenomena. However, ICT skills of teachers should be enhanced to be able to employ simulation-based instruction and other ICT resources in the teaching and learning process.

It is said that traditional instruction can be successfully enhanced by using computer simulations [19]. Physics Education Technology (PhET®) Interactive Simulation-based activities can be one way to increase visualizations of students leading to a deeper understanding of Physics concepts. Visualization is especially useful for helping students to see structure and processes that are traditionally invisible to students. Concepts can be invisible if it is too small, too big, too fast or too slow to be observed. These processes can be accessible so learners can see details or can repeat experiments for several times using simulation-based activities [13].

For Physics instruction to be effective, it must encourage the kind of learning that leads to conceptual understanding. It was pointed out that improving students' understanding of fundamental Physics concepts can only be achieved by active involvement of students in learning activities [20]. Thus, Physics educators should teach Physics through inquiry, discovery, demonstration, simulation, practical work, laboratory-based and other hands-on experiences. Since Physics is theoretical in nature, concrete, visual representation and models are needed in order to understand the concepts. In this study, PhET® Interactive simulation is the software used because of several advantages such as the following: it can be run online or downloaded for free, research-based, highly interactive, animated, easy to use, creates a game-like environment, and allows actions that would be difficult or impossible in the real world.

Research findings proved that an interactive teaching strategy that stimulates students' interest can improve Physics teaching and learning. It was stressed that effective integration of technology into K to 12 classrooms supports Science as inquiry teaching [9]. The basis of effective teaching with technology requires three main components namely: understanding of how to use ICT tools in educational context, pedagogical approaches that use technologies to teach the content and appropriate technology that enables discovery of new content and representations of the content [11]. Furthermore, technology makes students' thinking visible and promotes critical listening, evaluation, and argumentation in the class [6]. The teacher is a facilitator, providing scaffolding if needed, clearing up points of confusion and misconceptions, and allowing students to figure out things and reach consensus on their own.

It has been observed that students are very much engaged in ICT in all aspects of their daily endeavor. Thus, they should be guided very well on how to use this in the teaching and learning process.

The situation of Science education in the Philippines stated above ignited the researchers' desire to develop and validate Physics Education Technology Interactive Simulation-based Activities (PhET®ISbA) as instructional material in teaching Physics concepts, specifically Electromagnetism, as well as to explore the effect of such material to their learning experiences in Physics. The fact that educators who implement instruction blended with technology that are based on students' interest, needs and learning preferences ensure high level of learning in each student, in the light of the findings of this research work, it is envisioned that to achieve meaningful learning, learner's needs and problems must be properly addressed by teachers.

It is in the researchers' minds that for teaching to be effective, learners must be involved actively in

scientific inquiry and knowledge construction. Hence, teachers must think of appropriate teaching and learning strategies or approaches to make learning meaningful. They must devise instructional materials that ignite students' interest to learn and improve academic performance. In lieu of this and guided by the theory of constructivism that calls for learner-centered instruction because learners are assumed to learn better when they are forced to explore and discover things by themselves, and supported by the theory of anchored instruction which a major paradigm for technology-based learning which recommends the use of video to make the anchored instruction as realistic as possible, the researchers conceptualized, as shown in Figure 1, that the developed PhET®ISbA can be used as instructional material to increase learner's mastery of Physics concepts, hence, their performance in Physics improved. The use of interactive simulations is intended to recreate interesting, engaging, and realistic content that encourage active learning among students. The teaching and learning approach allows learner to explore and discover concepts on a particular topic in a more interesting way, instead of merely reading about it or the information is just relayed from the instructor.

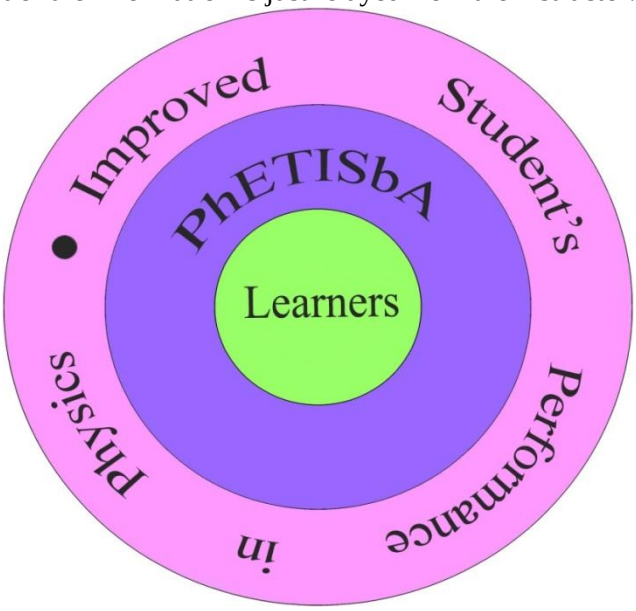

Figure 1. The research paradigm.

The results of the study may have significant contributions in enhancing the teaching-learning process. Students may have greater enthusiasm for learning when there are concrete representations of Physics concepts through the use of PhET®ISbA. They may also be provided more opportunities to explore things beyond the four walls of the classroom and develop their problem solving skills and supports for self-directed learning. For Science teachers, a tool such as PhET®ISbA may serve as aid in teaching students difficult topics or abstract concepts in Physics. With this, educators are encouraged to upgrade their ICT skills to be able to innovate or develop learning materials, hence, making teaching and learning meaningful. Furthermore, the results of the study may serve as a motivation to school administrators to equip teachers with in-service trainings in ICT to enhance their skills, may encourage them to develop ICT-based instructional materials like PhET®ISbA and other activities suited to the level of the learners and source out ICT tools for the school. Policy and curriculum makers may also be benefited with the results of the study by using ICT to inform, facilitate and enhance learning experience for the benefit of both the learners and the teachers across the curriculum. PhET®ISbA may serve as a new light to shape teaching and learning based on implementation of effective curriculum, efficient instruction, teacher development and authentic assessment. The results of the study could stimulate other researchers to conduct similar studies to investigate further the effectiveness of PhET®ISbA to other topics in Physics or to other fields of Sciences as well. ICT developers may also be encouraged to create, innovate, and design Interactive Simulations in different fields of Science intended for Filipino learners.

Lastly, findings of the study may generally make Science, specifically Physics teaching and learning realistic, engaging, more exciting, fun and productive.

OBJECTIVES OF THE STUDY

This study aimed to develop and validate laboratory activities in Electromagnetism for Grade 10 Physics based on Physics Education Technology (PhET®) Interactive Simulations. I also looked into the effect of this instructional material to the learning experiences of students in Physics.

Specifically, it sought to find out how valid are the developed Physics Education Technology Interactive Simulation-based Activities (PhET®ISbA) in terms of their learning outcomes, instructional characteristics, and assessment techniques; to determine how effective are the developed PhET®ISbA in teaching Physics; and to explore the learning experiences the students acquired in using the developed PhET®ISbA. The present study tested this hypothesis: There is a significant difference between the mean pretest and posttest scores of students who are exposed to Physics

Education Technology Interactive Simulation-based Activities (PhET®ISbA).

MATERIALS AND METHODS

This study used the Research and Development (R & D) methodology in developing and validating the PhET® Interactive Simulation-based activities for Grade 10, particularly on topics of Electromagnetism. It further used the one-group pretest-posttest design to determine the effectiveness of the developed PhET®ISbA in teaching Physics. The steps in the R & D method in the development of the PhET®ISbA are Planning Stage, Development Stage and Validation Stage.

Planning stage included the preliminary preparation that involved planning and development of the material and bibliographical survey that involved extensive reading, researching and analyzing information on relevant resources such as books and websites in the internet available pertaining to the preparation of instructional materials and learning theories that support the use of PhET® Interactive Simulation-based activities for classroom instruction.

The development stage included the designing of PhET®ISbA specification and writing of the material. The designing involved performing crucial processes to meet the standard characteristics of the instructional material like examining the K to 12 Curriculum Guide in Science, specifically, the Grade 10 learning competencies in the Physics where the topics in Electromagnetism were singled out for the study. The researchers also asked permission from the PhET® Interactive Simulations developer thru an email and upon the approval of the PhET® Team, required video player softwares (Java and flash players) were downloaded, after which, simulations were downloaded from the PhET® website (http:/phet.colorado.edu/) [16]–[18]. The PhET® Design Process which contained the guidelines in using the PhET® Interactive Simulations was thoroughly studied by the researchers. Simulations were chosen based from the Grade 10 learning competencies of the K to 12 curriculum required by the DepEd as determined during the planning process.

The researchers made the PhET®ISbA based on the following simulations: Balloons and Static Electricity; Charges and Fields; Electric Field of Dreams; Magnet and Compass; Faraday's Electromagnetic Lab which includes Bar Magnet, Electromagnet, Pick Coil, Transformer and Generator. These were selected because not only that these are abstract topics, they also require laboratory-based instructions, and usually materials needed are either available or there is scarcity inside the classroom. All the simulations were played and manipulated by the researchers before making the PhET®ISbA. The simulations were played for several times so as to simplify the tasks in the activities. Since the activities are simulation-based, all parts of the activities were anchored to a specific simulation and followed the DepEd standard format of a worksheet. Each PhET® Interactive Simulation activity has the following parts: overview of the activity, learning outcomes, materials, procedure, guide questions/exercises, generalization and application. In making the PhET®ISbA, the following steps were observed: 1) writing the overview of the activity, 2) formulating of learning outcomes, 3) establishing procedures based on PhET® design process, 4) preparing observation worksheets based on the simulation and evaluative items in the analysis and interpretation of data gathered, 5) construction of application questions and writing expected answers in the teacher's guide.

The validation stage included the validation of the PhET®ISbA by Physics experts, tryout, and modification and final production of the material. This stage was undertaken after all the letters of permission to conduct the study to respected authorities of the three Department of Education divisions in Ilocos Norte and of the school where the study is conducted were approved.

In the validation of the tests, learner's material (LM) and teacher's guide (TG), the researchers were guided by a table of specifications in the preparation of the Physics' pretest and posttest to evaluate learning outcomes and competencies to be tested. The test was content validated by Physics teachers and professors and was tried out to the Grade 11 students enrolled in the General Academic Strand (GAS) of Ilocos Norte Agricultural College. Item analysis was performed and test of reliability was done to further improve it. On the other hand, the PhET®ISbA were validated by a panel of Physics experts to establish internal validity in terms of the activities' learning outcomes, instructional characteristics and evaluation.

The tryout of the developed and validated PhET®ISbA was done to the 7 (seven) sections of the Grade 10 students of the Ilocos Norte Agricultural College INAC, Pasuquin, and Ilocos Norte during the last quarter of School Year 2016-2017 wherein one-group pretest-posttest design was used to determine the effectiveness of the materials. The posttest was first

administered then the PhET®ISbA were used as instructional materials in teaching Physics concepts particularly Electromagnetism in addition to the traditional chalk-talk and laboratory method. Since it was conducted inside the computer laboratory, the students were allowed to repeat the simulations while answering the PhET®ISbA. Students' answers in the activities were checked and the results were shown to them. The researchers also required the students to make a daily journal to record their learning experiences, observations and comments about the encountered PhET®ISbA. After the tryout, the posttest was administered. The results of the pretest and posttest were analyzed to validate if the material is effective. Prior to the conduct of the study, it was explained fully and meaningfully to the participants the purpose of the study and that all data gathered were highly confidential. Moreover, students have no identities in the journal entries presented in the results of the study.

Weighted mean was used to analyze the ratings of the panel of evaluators regarding the validity of the PhET®ISbA. The students' scores in the pretest and posttest in Physics were analyzed and interpreted using frequency distribution, mean and standard deviation. The t-test for correlated samples was used to determine whether there is a significant difference between the pretest and posttest mean scores of the students. In testing the hypothesis, the level of significance was set at the 0.05 probability level. All data were organized using Microsoft Excel 2007 and analyzed via IBM SPSS Statistics 20.

To confirm the results of the test, the researchers checked the students' journals and conducted semi-structured interviews to some students to gather feedbacks pertaining to the use of the developed PhET®ISbA. Interviews were transcribed and analyzed together with students' journal outputs. Their feedbacks which reflect their learning experiences during the tryout were grouped into themes.

The last part of the validation stage is the modification and production of the PhET®ISbA which was done after the material was proven as effective tool in teaching Physics concepts. The mean ratings of the validation were interpreted using the following scales: 4.51-5.00 for Extremely Valid (EV), 3.51-4.50 for Highly Valid (HV), 2.51-3.50 for Moderately Valid (MV), 1.51-2.50 for Slightly Valid (SV), and 1.00-1.50 for Not Valid (NV).

RESULTS AND DISCUSSION

Validity of the PhET®ISbA

Findings reveal that the developed PhET®ISbA were valid in terms of their features namely learning outcomes, instructional characteristics and assessment techniques making it as a good learning material in teaching Physics, particularly Electromagnetism. This can also be proven by the computed overall mean rating of *4.66* with a descriptive interpretation of *extremely valid* as shown in Table 1.

Table 1. Results of the validation made by the panel of evaluators on the features of the PhET®ISbA (N=10).

Features of the PhET®ISbA	**Mean Rating**	**Descriptive Interpretation**
Learning Outcomes		
The learning outcomes of the PhET® Interactive Simulation-basedActivities (PhET®ISbA) are:		
1.1 specific.	4.70	Extremely Valid
1.2 measurable.	4.60	Extremely Valid
1.3 attainable/achievable.	4.70	Extremely Valid
1.4 realistic/relevant.	4.70	Extremely Valid
1.5 time-bound.	4.30	Highly Valid
Weighted Mean	**4.60**	**Extremely Valid**
Instructional Characteristics	**Mean Rating**	**Descriptive Interpretation**
The PhET®ISbA		
develop critical thinking skills and analyzing skills of students at their present grade level.	4.80	Extremely Valid
present real life situations.	4.50	Highly Valid
give appropriate and relevant information for the development of Physics concepts.	4.90	Extremely Valid
have exercises aligned to the learning competencies of electromagnetism.	4.70	Extremely Valid
focus on specific skill and concepts.	4.50	Highly Valid
are useful in understanding invisible concepts or concepts that is hard to observe in actual setting.	4.50	Highly Valid

Table 1 (cont). Results of the validation made by the panel of evaluators on the features of the PhET®ISbA (N=10).

Instructional Characteristics The PhET®ISbA	**Mean Rating**	**Descriptive Interpretation**
provide immediate feedback	4.70	Extremely Valid
develop creativity and ignite curiosity of the students.	4.60	Extremely Valid
simplify the task to make it more manageable and achievable to a learner.	4.50	Highly Valid
provide some direction in order to help the student focus on the learning outcome.	4.60	Extremely Valid
model and clearly state activities to be performed.	4.70	Extremely Valid
promote active learning.	4.90	Extremely Valid
introduce ideas/concepts in logical learning sequence.	4.40	Highly Valid
are learner-centered.	4.80	Extremely Valid
allow students to engage and motivate students to a greater degree.	4.60	Extremely Valid
provide more opportunities for independent, self-directed learning.	4.70	Extremely Valid
Weighted Mean	**4.68**	**Extremely Valid**
. Assessment Techniques		
The questions/tasks in the PhET®ISbA		
are clearly stated and consistent with the learning outcomes	4.70	Extremely Valid
are engaging and challenging	4.60	Extremely Valid
appropriate to the knowledge and skills intended to be measured	4.80	Extremely Valid
require higher-order-thinking skills of the students	4.80	Extremely Valid
are relevant to everyday life situations	4.60	Extremely Valid
use technology in accessing and analyzing information	4.70	Extremely Valid
Weighted Mean	**4.70**	**Extremely Valid**
Overall Mean	**4.66**	**Extremely Valid**

Effectiveness of PhET®ISbA

The following discussions show comparison of the results of the pretest administered prior to the tryout and posttest administered after the tryout which was used to determine the effectiveness of the developed PhET®ISbA. Table 2 presents the distribution of the pretest and posttest scores of the students.

Table 2. Frequency distribution of the pretest scores of the students (N= 200).

Range of Scores	**Descriptive Interpretation**	**Pretest**		**Post test**	
		f	**%**	**f**	**%**
33-40	Outstanding	-	-	43	21.50
25-32	Very Satisfactory	-	-	157	78.50
17-24	Satisfactory (S)	25	12.50		
9-16	Fair(F)	149	74.50		
0-8	Needs Improvement	26	13.00		
Mean		**12.17 (Fair)**		32.14 (VS)	
Standard Deviation		12.30		4.96	

It can be gleaned from Table 2 that the pretest scores of the students are within the score ranges 0-8, 9-16; 17-24 with descriptive interpretations *needs improvement*, *fair* and *satisfactory*, respectively. It can also be noted that majority (74.50% or 149) of the total respondents performed *fairly.* Twenty-five students (12.50%) scored with *satisfactory* and twenty-six students (13%) have *needs improvement scores*. Further, the mean score in the pretest is *12.17.* On the other hand, the posttest scores are within the score ranges 25-32, and 33-40, with descriptive interpretation of *very satisfactory* and *outstanding*, respectively. Out of the 200 respondents, forty-three students (21.50%) got *outstanding scores.* Majority (78.50% or 157) of the respondents got scores within the range of 25-32 with a descriptive interpretation of *very satisfactory*. Generally, the students' posttests mean score of *32.14* falls under a descriptive rating of *very satisfactory.*

To find out if the use of PhET®ISbA resulted to a notable increase in the students' performance, Table 3 below is presented. The validity of the developed PhET®ISbA is supported by the indicated gain score between the mean of the students' pretest (12.17) and that of the mean of their posttest (32.14). The computed t-value of *79.09* is higher than the critical value of *1.392* at 0.01 level of significance with 199 degrees of freedom. This signifies that there is a significant improvement on the academic performance of students after using the PhET®ISbA. It was evident that during the conduct of the study, students were very active, highly motivated, had fun and challenged while doing the activities in class. Students were also observed to have intensive brainstorming with their classmates as

regards the concepts included in the activities. These results signify that ICT integration with the use of PhET®ISbA made the teaching –learning process meaningful to learners.

The above findings agree with this statement that when used appropriately, different ICTs are said to help expand access to education, strengthen the relevance of education to the increasingly digital workplace, and raise educational quality by, among others, helping make teaching and learning into an engaging and active process connected to real life [24].

Significant Learning Experiences of the Students in Using PhET®ISbA

Table 3. Comparison between the pretest and posttest mean scores (N = 200).

	Pretest	Posttest
Mean	12.17	32.14
Standard Deviation	12.30	4.96
Mean Difference	19.97	
t-value	79.09**	

** Significant at the .01 probability level
Critical Values: (2-tailed, α =.01, df=199) = 1.392
(2-tailed, α =.05, df=199)= 1.233

Learning Physics is Fun. Learners can be said to be enjoying what they are doing when they participate, can relate/associate immediately the concepts with real-life experiences, and discover things on their own. During the tryout, the students were observed to be active, very much interested and had enjoyed the lessons that were presented. The following journal entries of the students in using the developed PhET®ISbA exhibit active learning:

Student A - *Ang mga activities ay nakakakuha ng atensyo nng mga mag-aaral at maganda ang topic. Kaaya-ayaang talakayan at marami akong natutunan.* [The activities are attention compelling to students and nice topic. We had an interactive discussion and I've learned many things about it.]

Student B - Wow! It's so interesting! I'm thankful that we have this kind of activities. I learn something about it.

Student C - The lessons are hard but if you are interested with the lesson, you will definitely understand it.

Physics as a subject has always been perceived as difficult and boring because it involves a lot of formulas, analyses, problem solving activities and abstract concepts. This is one of the main reasons why any Physics-related course has not been attractive to prospective takers- the students.

The above scenario has been the main subject of Physics researches which include this study. It is notable that the use of PhET®ISbA shed new light on how the respondents view Physics as a subject as indicated by the learning experiences they gained.

Learning experiences represent an attempt to update concepts of how, when, and where learning can take place. Designing learning interventions in such a way that learning activities and resources are aligned with learning outcomes may contribute in shaping an individual's learning experiences.

Below are the learning experiences students had with the use of PhET®ISbA in learning Physics. Analysis of the results of the interviews and the journal entries of the students shows significant learning experiences that the students acquired. The interviews and feedbacks were analyzed and synthesized into three big themes.

Student D - Sa una mahirap maintindihan, pero kung talagang makikinig ka sa guro, maintindihan mo. [At first, seemed too difficult to understand but you can easily understand if youlisten carefully to the teacher's discussion.

Student E - The activities were very interesting to learn, and I learned more knowledge about Physics.

The favorable remarks of the students conform to the findings that improving students' understanding of fundamental Physics concepts can only be achieved by the active involvement of students in learning activities [20]. Thus, participation of students in the classroom increases with the use of PhET®ISbA. The results also agree with the findings that performing experiments through computer simulations is enjoyable, interesting, and free from physical harm [22]. It is also in consonance with the result of the study conducted in 2003 by BECTA [3], that exploring new opportunities for improving classroom practices when using ICT, in particular, make lessons more stimulating and enjoyable.

Strengthening student's engagement is a key to effective and meaningful learning. In education,

students are said to be engaged when they strive to meet the learning goals, their motivation increases to a higher degree and they invest their time to learn the concepts even how hard it is. The following feedbacks prove that the use of PhET®ISbA enhanced students' engagement in learning Physics:

Student F - Every activity intends me to try on the computer. I was really amazed from what I observed and I learned a lot from it.

Student G - I feel that I need to work more activities like PhET®ISbA to sharpen my mind and to learn more about it.

Student H - It is so exciting, enjoyable, and the only limit is your imagination!

The feedbacks of the students are in harmony with the results of the study of Wang and Woo (2007), that ICT's when used appropriately, can help make teaching and learning engaging, and be an active process connected to real-life situations.

Learning Physics is Real. Concept retention is a teacher's main goal whenever a class is conducted. With PhET®ISbA, students claimed that they found learning and understanding Physics concepts better because they can already see the applications of the concepts and they can repeat the PhET® simulations to verify their results or answers in the worksheets. The following remarks indicated in the students' journals support these observations.

Student I - It provides a method for checking our understanding of the world around us and helps us produce better and faster results.

Student J - *Good, dahil ginamit natin ang advance technology para matuto. At ipinapaliwanag niya iton gmaayos at nakakatulong din ito.*[Good, because we used advance technology in learning. It explains the lessons well and it is also helpful.]

Student K - This helps our teacher to discuss the lessons because of its high quality and interesting which enhance the topic. It will also help us to easily find out what is being asked and what will be the answer.

The comments of the students agree with the findings that technology makes students' thinking visible and promotes critical listening, evaluation, and argumentation in the class that provides way to clear up points of confusion and misconceptions and allowing students to figure out things and reach consensus on their own [5]. One has gained in-depth knowledge when a person has a clear view of the concepts and when he is able to generate questions, and formulate and test hypotheses and making multiple strategies and procedural decisions as new information is processed [25].

With PhET®ISbA, students had a deeper understanding about the lesson presented and able to apply later to real life situations as indicated by the following remarks.

Student L - Wow! Amazing! The PhET®ISbA changed my expectations and I learnedsomething that I don't know before.

Student M - Overwhelming! The PhET®Interactive Simulation Activities are awesome! These make the topics simple and easier for students to understand. They are fun and entertaining too. It is helpful to students because we're not only havin' fun but learning too.

The findings of the study are in consonance with the results of a study that students gain in-depth knowledge that can be used for practical applications [8]. The PhET® Interactive Simulation-based Activities provided some direction that help students to focus on a specific learning outcome. It also ignited the curiosity of the students, made them more engaged and motivated to a greater degree. These are indicated by some of their reactions during the hands-on activity.

Student N - Ma'am how can we start this? I want to do it already.

Student O - It is so nice and I was amazed because I learn how Magnetism works.

Critical thinking and analyzing skills are just two of the Science process skills every Physics/Science teacher need to incorporate and instill into his students. Desirable feedbacks of the students that PhET®ISbA may help them to develop critical thinking skills and analyzing skills are reflected in their journals. Two of which are as follows:

Student P – Ang PhET®ISbA *ay isang kagamitan na sobrang nakakatulong sa pag*-analyze *ng mg*a lesson *sa Physics*.[PhET®ISbA is an important tool that helps us analyze our Physics lessons.]

Student Q - In every simulation-based activity, we need to analyze; there are cause and effect being showed before and after the activity.

The above findings corroborate with the results of a study that through careful analysis of the simulations showing the invisible with the use of analogy help students build a conceptual understanding of the Science concepts [1].

During the tryout, it is also evident that PhET®ISbA stimulated creative thinking. In using the PhET®ISbA, the following are the given reactions of the students:

Student R - I gain insight and the activities stimulate creative thinking.

Student S - We are able to enhance our understanding about the topic.

Student T - I was really surprised when I understand the topic because of its entertaining concept. I am learning, really learning!

Learning Physics is Simple and Easy.

Oftentimes, students view learning Physics as difficult. However, during the tryout, it was observed that besides being fun, learning Physics was simple and easy.

Scientific journal entries of the students proved that PhET®ISbA simplified the tasks making these more manageable and achievable to the learners.

Student U - I didn't expect that these kinds of activities are possible. They are very interesting and made our lesson easier and faster.

Student V - The PhET®ISbA is very effective for us students.We are able to learn faster and more efficient.

Student W - At first, hindi ko maintindihan pero ganun pala. [At first, it seemed complicated but it turned out to be so simple.] It's really amazing! I enjoyed the activities for it was very impressive.

These findings of the study are in harmony with the findings emphasized in a study that visualization is especially useful for helping students to see structure and processes that are traditionally invisible to students [13]. It is a teacher's vital role to select ICT resources appropriate for the teaching learning process suited to the needs and present level of the students. To realize this goal, PhET®ISbA was used to facilitate multimedia learning by integrating technology or multimedia resources into the teaching learning process.

The following remarks of the students are manifestations that PhET®ISbA can facilitate learning with the use of multimedia/technology.

Student X - Cool! Awesome! It is because we use our advance technology to learn and also help us to understand on how things work.

Student Y - Good! It's because we utilize advance technology in studying Physics concepts and it explains everything.

Student Z - So great! That was very interesting, we learned a lot with the use of technology.

Student AB - Today, gadgets are high-tech and it's easy to learn a lesson. It's fun and entertaining.

Most of the students' feedbacks in their scientific journal agree with the results of a study that the use ICT resources offers great opportunities for students to easily find relationships among variables with the use of variety of representations like pictures, animations, graphs, vectors, and numerical data displays [10]. The feedbacks of the students are also consistent with what was revealed in the findings of [14] that using multimedia-based instruction, the brain does not only interpret a multimedia presentation of words, pictures, and auditory information in a mutually exclusive fashion; rather, these elements are selected and organized dynamically to produce logical mental constructs.

All the findings stated above broadly support the Theory of Constructivism which emphasizes that learning occurs when learners are actively involved in scientific inquiry and knowledge construction. In light with this, PhET®ISbA are developed since the activities involve require learners to construct visual models and multiple representations of Physics concepts.

Overall, based on these findings and the favorable feedbacks of the students and panel of evaluators, the

PhET®ISbA are found to be *valid* in terms of their learning outcomes, instructional characteristics and evaluation. Moreover, desirable comments of the students exposed to PhET®ISbA affirm that they encountered significant learning experiences. These new learning experiences are synthesized into three big themes which are learning Physics is fun, learning Physics is real and learning Physics is simple and easy. With all the results, PhET®ISbA use is found to be effective in teaching Physics concepts, particularly Electromagnetism.

CONCLUSION AND RECOMMENDATION

Based on the preceding findings of the study, the researcher concluded that Physics Education Technology Interactive Simulation-based Activities (PhET®ISbA) are very good instructional materials in teaching Physics for these are valid in improving the achievement of Grade 10 students.

The developed PhET®ISbA are extremely valid in terms of their learning outcomes, instructional characteristics and evaluation making them appropriate and relevant for the development of Physics concepts. It can also be concluded that of PhET®ISbA's interactive feature, enables students to participate actively in learning Physics. Student engagement when enhanced tend them to try more, work more and learn more about the assigned tasks in the activities. Thus, their concept that Physics is a hard subject is changed to be an interesting, exciting and enjoyable subject to learn.

Effective teaching and learning involves learners actively in scientific inquiry and knowledge construction. The use of appropriate ICT resources and effective learning strategies and approaches make learning meaningful to learners. Interactive nature and technology-driven activities make students apply directly to real-life situations and appreciate the importance of scientific ideas.

It can further be concluded that learning experiences gained by the students with the use of PhET®ISbA can be deduced into three big themes: learning Physics is fun, learning Physics is real, and learning Physics is simple and easy. The PhET®ISbA as instructional materials increase learners' understanding and mastery of Physics concepts, lead them to explore and discover topics in a more interesting way, encourage active learning, ignite their interest to learn, and improve their academic performance.

Significant learning experiences of the students conform with the constructivist's view that simulation-based activities are enjoyable, interesting, free from harm, and offer oppurtunities to look for relationships among variables and promote critical thinking to a great extent.

As a whole, it is concluded that the findings in this research work enables the students to have greater enthusiasm in the classroom activities and participate actively in classroom discussions.

Based on the foregoing findings of the study, the researchers highly recommend that the PhET®ISbA should be used in classroom teaching to further enhance the activities. The PhET®ISbA are recommended to be employed for classroom instruction on other areas of Physics. ICT experts should design more computer-based tools that can be used for classroom instruction. Also, ICT developers should seek feedbacks from users to further improve interactive software that they will use in making more interactive simulations and other computer-based tools for teaching and learning.

Finally, researchers should consider some of the limitations of the study for future investigations. The developed PhET®ISbA are ICT-based designed for Filipino learners and limited to Grade 10 learning competencies of the K to 12 Curriculum prescribed by the Department of Education in the Philippines.

REFERENCES

[1] Adam, W.K. (2010). *Student engagement and learning with PhET interactive simulations*. Department of Physics University of Colorado –Boulder, CO 80309, US.

[2] Antonio, V. V. (2015*). Adoption and use of ICT in the management of public secondary schools* (Unpublished dissertation). Mariano Marcos State University, Laoag City.

[3] BECTA (2003). *What the research says about ICT and motivation - Digital literacy.* Retrieved online on January 27, 2017 from www.ictliteracy.info/rf.pdf/Research_Motivation.pdf

[4] Bonifacio, A.L. (2013). *Developing Information Communication Technology (ICT) Curriculum Standards for K-12 Schools in the Philippines*. Retrieved online on February 14, 2017 from https://linc.mit.edu/linc2013/proceedings/Session7/Session7Bonifacio.pdf

[5] Bransford, J.D. & The Cognitive & Technology Group at Vanderbilt (CTGV)(1990). *Anchored instruction: Why we need it and how technology can help.* Retrieved online on January 25, 2017fromhttp://web.cortland.edu/frieda/id/idtheories/41.html.

[6] Bransford, J. D., Brown, A. L. & Cocking, R.R. (1999). *How people learn: Brain, Mind, Experiences, and School.* National Academy Press: Washington, DC.

[7] deJhong T. & van Joolingen, W. R. (1998). *Scientific learning with computer simulation of conceptual domains.*

[8] Francisco, W. B. (2003).*Web-based instruction on selected topics in electromagnetism*. (Unpublished master's thesis). Mariano Marcos State University, Laoag City.

[9] Guzey, S.S. &Roehrig, G. H. (2009). Teaching *science with technology. Case studies of science teachers' development technology, pedagogy and content knowledge*. Contemporary Issues in technology and Teacher Education. Retrieved online on January 19, 2017 from https://goo.gl/D52Bta.

[10] Habibi, A. & Habibi, Z. (2014). *The effect of information technology in teaching physics courses.* Retrieved online on January 1, 2017 from http://wwwrtu.academia.edu/ALIHABIBI

[11] Koehler and Mishra, 2008. *Framework of TPCK*. Retrieved on January 16, 2017. url: https://goo.gl/a4M7Fh

[12] *K to 12 curriculum guide in science.* Retrieved online on December 26, 2016 from https://goo.gl/H1TtTL

[13] Lindgren, R. (2009). *Spatial Learning and ComputerSimulations in Science.* Retrieved online on December 26, 2016 from https://goo.gl/SpXD3T

[14] Mayer, R. E. (2001) Multi-media learning. 2nd Edition. Cambridge University Press.

[15] National Science Foundation (2000). Inquiry and National Science Education Standards. The National Academies Press. Retrieved online on September 20, 2017 from https://www.nap.edu/read/9596/chapter/1

[16] Perkins, K. (2013). *Teaching Physics with PhET simulations: Free, researched, web-based resources.* Retrieved online on August 30, 2016 from https://goo.gl/sNgNRg

[17] Perkins, K., Adams, W., Dubson, M., Finkelstein, N., Reid, S., and Wieman, C. (2004). *PhET interactive simulations for teaching and learning Physics.* University of Colorado Boulder.

[18] Perkins, K., Adams, W., Dubson, M., Finkelstein, N., Reid, S., Wieman, C., &LeMaster, R. (2006). PhET: Interactive simulations for teaching and learning physics. *The Physics Teacher*, *44*(1), 18-23.

[19] Rutten, N.P.G. (2014). *Teaching with Simulations.* Retrieved online on December 23, 2016 from doc.utwente.nl/93718/1/thesis_N_Rutten.pdf.

[20] Stern, D. & Huber G. L. (1997). *Active learning for Students and Teachers.* Retrieved online on January 2, 2017 from https://goo.gl/qQmg8h

[21] Tutaan, R.B. (2014).Make Me Genius e-learning materials in teaching Science concepts. (Unpublished master's thesis). Mariano Marcos State University, Laoag City.

[22] Ubiña, T. D. (2002). *Validated computer simulated projectile motion experiments (C-SPEX).*(Unpublished master's thesis). Mariano Marcos State University, Laoag City.

[23] Villa, V. C. (2010*). Indigenous game-based activities for teaching Physics*. S & T Journal (Special Issue) ISSN 20120060. Mariano Marcos State University Press, City of Batac, Philippines.

[24] Wang, Q. & Woo, H. L. (2007). *Systematic planning for ICT integration in topic learningeducational technology & society.* Retrieved online on January 17, 2017 from https://goo.gl/oiWfqA.

[25] Webb, N. (2014). Using Webb's Depth of Knowledge to Increase Rigor. Retrieved online on February 25, 2017 from https://goo.gl/BVhjr1.

[26] Wieman, C.E. (2001)PhET Interactive Simulations-*University of Colorado Foundation*. Retrieved online on August 30, 2016 fromhttps://goo.gl/Q1HUVQ.