Lesson Exemplars in Electricity and Students' Epistemological Beliefs

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Abstract – *The study evaluated the effects of a developed lesson exemplars in electricity integrating computer simulations and constructivist approach on students' Epistemological Beliefs. Specifically, it sought to determine how computer simulations, constructivist approach and Formative Assessment Classroom Technique (FACT) can be integrated in the lesson exemplars in electricity; and evaluate the effects of the developed lesson exemplars in the students' Epistemological Beliefs.*

The investigation employed the pre-experimental single-group pretest and posttest study using the Epistemological Beliefs Assessment in Physical Sciences (EBAPS) questionnaire. The study was conducted among seventy-two (72) Grade 10 students of a laboratory high school from a state university in the Philippines. They were taught using Physics Educational Technology (PhET) and other web-based simulations, constructivist approach, and formative assessment classroom technique.

The results revealed that the over-all Epistemological Beliefs of the students did not change significantly; only along Nature of Knowing and Learning and Real-Life Applicability.

Generally, utilizing computer simulations and applying constructivist approach did not alter students' epistemological beliefs in its entirety. However, it can be engaging and effective in promoting students' understanding of Physics.

Keywords – *Computer Simulation, Conceptual Understanding, Electricity, Epistemological Beliefs, FACT, Motivation*

INTRODUCTION

Achieving quality education in the Philippines remains a knotty long-term task and continues to baffle all sectors of our society. Every level in Philippine education is crucial as it impacts the development of a nation that is capable of addressing the many problems that encompass the different agencies of the society, from social, political, economic, and cultural and others that in turn stall the development of the citizenry which primarily affect their productivity and global competitiveness. These challenges in turn translate into the mission of producing graduates who will possess the necessary scientific skills and well-founded epistemological beliefs while having the ethical and social consciousness in approaching every course of action; and competent enough to be able to respond to the increasing challenges of the new millennium.

Thus, it would require every aspect of the learning process, the capacity of providing a responsive focused-approach in addressing these pressing issues and concerns. The role of educators, therefore, even in the advent of ultra-modern age has never been more important as before. Educators must continue to find ways, devise methods, and employ their own critical-thinking skills to ensure that learning process is at its best and the goals of achieving quality education is held within the realm of reality and certainty.

Physics is 3D- Difficult, Dull and Dumb. This view often results to students being not motivated, uninterested and therefore performs and understands the subject poorly. Students of Physics find themselves to do multitasking and often realized they are not ready for it [1]. This perception, however, negatively impacts students' achievement and has serious implications for the technical and technological development of the country.

Traditional physics instruction coupled with the perception that physics is 3D, does not normally result in a coherent and consistent conceptual framework for students rather in gross misconceptions and lack of understanding [2]. The lack of understanding and motivation forced students to revert to their preconceptions even if it oftentimes conflicts with science concepts being taught in the classroom. In order to eliminate these preconceptions, constructivist learning theory suggests that students must be confronted with a discrepant event that conflicts with their world view or preconceptions.

Applying Constructivist Approach means that the learners were made to be active in the teaching-learning process and in developing new meaning and knowledge. This study adopts the 5 –E Learning cycle to exemplify constructivist learning. The 5E's represent the different phases of the learning process or model akin to scientific inquiry. This model provides a step-by-step procedure of providing the students a sequential yet meaningful learning experience to be able to link previous knowledge and the newly-acquired concepts. The teacher, therefore, facilitates the emergence of new knowledge based on scientific inquiry and sound decision-making. The 5E's represent: Engage, Explore, Explain, Elaborate, and Evaluate [3].

Computer simulation by itself is useless. In order to make it a powerful learning tool, instruction should be designed to promote scientific inquiry. In this way, the valuable educational potential of computer simulations will help students understand scientific concepts and assist in promoting conceptual change. In addition, computer simulations can provide conflicts on students' preconceptions that might eventually lead to meaningful learning. The study of Liu et al. [4] demonstrate how simulation can provide an experiential learning for students where they can also learn and practice other learning skills, both cognitive and psychomotor, in a safe, controlled environment. Using this approach is a deviation and was proven to be more effective in promoting science skills as compared to the orthodox instructional practices like lecture-based and textbook-based teaching approaches.

Simulations allow students to make connections with everyday life experiences [5]. Simulations promote deep learning and allow students to observe processes that are otherwise unobservable [6].

Simulations allow hypothesis testing via prediction of outcomes [7]. These all lead to improve learning outcomes [8].

However, the real teaching scenario reveals that in a traditional classroom-teaching process, science learning may not really happen. Unfortunately, with one's biases, the teacher may believe that in using his chosen strategy and class activity, or even id he already thinks that he is at his best, the actual learning process does not take place at all, and students may have little or no gain at all in science conceptual understanding. The truth is, the students may give their best and purposely learn science only to pass a test but without deeper comprehension, they will continue to be plagued with older misconceptions. According to Angelo and Cross [9], "Learning can and often does take place without the benefit of teaching— and sometimes even in spite of it—but there is no such thing as effective teaching in the absence of learning"

To address this problem, the teachers must be able to devise ways, particularly, improve he assessment process to determine the students predisposition of the subject and what they have actually gained after exposing to the instructional or learning process. The assessment process must be a two-way process wherein students must be actively engaged so that students does not only learn from the instruction lesson, but also, in the assessment process itself. When properly done, assessment provides more meaningful feedbacks on the students' performance as well as the teachers' effectiveness, including, the choices of pedagogies. Hence, the use of formative assessment techniques may lead to further interest to learn more about the subject develop newer ideas, encourage inquiry, and discourse among students to ensure that even the assessment strategies used also promote learning.

As pointed out by Baylon (2014), one way to develop the critical thinking skills of the students is through the art of questioning in both written and oral discourse. The development of critical thinking skills requires the development of an effective classroom assessment that is purposely chosen to target the development of certain skills. However, this can only be achieved when the teachers formulate questions both in written and oral along the different levels of critical thinking [10].

The use of formative assessment was found to significantly enhance the learning of the students by providing them with better conceptual understanding. The ultimate goal of formative assessment is to help students develop their own "learning to learn" skills.

Meanwhile, Conley [11] stated that science classrooms should include investigation of students' epistemological beliefs. Several studies have indicated that students' epistemological beliefs are related to their learning and content understanding.

Epistemological beliefs - beliefs about knowledge and knowing, are important for the development of students' learning as they present the person's views about a certain body of knowledge, how it can be acquired, its certainty, and the limitation and parameters to be considered in evaluating what the knowledge is all about [12]. It was found in numerous researches concerning epistemological beliefs that students with expert-like beliefs performing better in a school- set-up than those whose epistemological beliefs are naive.

In teaching sciences, particularly Physics there is a need for instructors to pay attention to the motivational factors of relevance and confidence [13], which can correlate strongly with student performance in both class and laboratory since they determine the amount and quality of effort that the students put forth. According to McDonough [14], the challenge for teachers is to design instructional strategies that can encourage, develop, and reward the factors that motivate students to learn. The use of computer simulations and formative assessment guided by constructivist approach can readily provide this requirement, hence, this study.

Specifically, the study determines the effects of the lesson exemplars that feature the use of computer simulations, constructivist approach and formative assessment classroom technique on Epistemological Beliefs before and after the use of computer simulation.

MATERIALS AND METHODS

The study used the pre-experimental single group pretest and posttest study. Four lessons were developed to provide the necessary intervention after the pretest and were implemented using the features; computer simulations, constructivist approach and formative assessment classroom technique.

The study was conducted to a group of high school students using a total enumeration of seventy-two (72) students of CBSUA-Laboratory High School. The respondents from these classes were chosen considering that they are taking Physics subject with the topics covered in the lesson exemplars The lessons used PhET and other web-based simulations and similar resources. Formative assessments used include: I Think-We Think; A&D Statements; Chain Note; First Word Last Word and Concept Cartoons. The developed lessons covered topics in electricity that consists of Pioneers in the Field of Electricity as Lesson 1; Electrostatics as Lesson 2; Electric Current as Lesson 3 and Electric Circuit as Lesson 4.

The researcher started from developing lesson exemplars on the topics based on the approved syllabus and the budget of work of the laboratory high school. The topic on Electricity formed part of the third grading period in the laboratory high school. In the beginning of the grading period, Epistemological Beliefs Assessment for Physical Science (EBAPS) was given to the students. This was important in determining student's initial epistemological beliefs. This formed the foundation of this study and served as the basis of comparison when the posttest was finally given. Their answers were recorded and analyzed. The developed lesson exemplars were taught for six weeks as per calendar of the school. After this period, posttest using the same questionnaire used in the pre-test was administered.

Over the course of the study there were a total of 9 computer simulations and additional interactive applications used by the students. They were carefully picked to correlate with the objectives set for the chosen lessons. Using these simulations students' were asked to either collect or analyze data, construct circuits, identify conductors and insulators and other interactive activities. Computer simulations were integrated mostly in the Exploration Phase of the 5-E Learning Cycle used in the developed-lesson exemplars.

The pretest and posttest scores were administered to evaluate the sophistication of students' Epistemological Beliefs. The corresponding t-test analysis was used to determine the significant effects of the lesson exemplars integrating computer simulations and constructivist approach.

The instrument used in the study was the Epistemological Beliefs Assessment for Physical Science (EBAPS) [15] as shown in Table 1.

Table 1. Non-orthogonal Dimensions of EBAPS

EBAPS Dimensions	Sophisticated Beliefs	Naïve Beliefs
Structure of scientific knowledge	Single Coherent System	Collection of isolated Pieces
Nature of knowing and learning	Self – Constructed	Propagated from Authority
Real-life applicability	Applicable to the Modern World	Not-applicable to the Modern World
Evolving knowledge	Knowledge changes with time	Knowledge does not change with time
Source of ability to learn	Acquired	Innate

To quantify students' epistemologies, the following scale was used: Extremely Sophisticated 3.5–4.0; Highly Sophisticated 3.4–3.0; Moderately Sophisticated 2.9–2.4; Poorly Sophisticated 2.3–1.6; and Unsophisticated 1.5 – 0.

At the onset, the objectives of the study were carefully explained in oral and written forms to the intended sample population. It generally includes terms to explain why they were chosen as the respondents of the study, and the possibility of its publication in a scientific or education journal. The students were advised to read the form thoroughly, and encourage them to ask any questions that they may have before agreeing to be part of the study. The form was given together with the questionnaires to apprise the respondents of the extent of its coverage and the extent of the assessment that will be conducted.

The form also explains the procedures and tasks including, the length of time for participation, and the frequency and duration of procedures. The benefits of participation were also explained, particularly, in an opportunity to be exposed to a new approach of learning.

Further, the students were given the option to write or not to write their names in the actual survey questionnaire. However, for reference purposes while maintaining anonymity, survey questionnaires were labeled and controlled using codes. On the other hand, for those who will opt to identify themselves, guarantee were given that the researcher will not collect or retain any information as regards to their identities, as the records of the study will be kept in strict confidence including information in any report or article which later on may be published.

Finally, to indicate that they voluntarily agree to be a research participant in the study, and that they have read and understood the information provided above, they have to sign two copies of the form in which one copy was kept by the researcher while the other was given to the respondent.]

RESULTS AND DISCUSSION

A. Developed Lesson Exemplars in Electricity

The development of the lesson exemplars which utilized ICT and Computer Simulation Instructional Material involves the following steps: (a) identification of the least learned topics based on the curricular program or syllabus for the fourth grading period of the fourth year high school students; (b) among the topics identified in the first step, the topics were further selected to suit the lessons in; (c) and integration of the features in the developed-lesson exemplars in Electricity with the following features: Use of ICT and Computer Simulation; Use of Constructivist Approaches; Integration of Formative Assessment Classroom Technique. These topics were also based from the Philippine Secondary Science Learning Competencies (PSSLC).

a. Use of Computer Simulation

In this study, computer simulations were integrated mostly in the Exploration Phase of the 5E Learning Cycle used in the developed-lesson exemplars.

Primarily, computer simulation is a mode of representing the reality in instances where the learning process does not allow it to be represented or cannot be shown in concrete terms. For instance, the difficulty or danger of manipulating harmful substances in a classroom setting; manipulation of electric charges or materials to handle the functional purposes of these particles can be safely studied using simulations. The different difficulties encountered in imitating an activity, computational, financial, the time-frame required and amount of material and human resources result to an improbability of doing the actual process in a classroom set-up. The used of simulation has also evolved from actual classroom instruction to simulation games which are now increasingly utilized in a number of learning domains considering that this approach allow the students to be more engaged in the learning process, from discover to practical learning experiences.

b. Use of Constructivist Approach

The used of constructivist approach to learning emanates from the belief that learning takes place when students actively participates in the process. Learners are the makers of meaning and knowledge. This approach promotes critical-thinking, and actuates students to learn on their own. Researches on constructivism found that when students are allowed to conduct experiments and to test hypotheses conceptual understanding and wards off misconceptions. Notably, the change that occurs in the conceptual understanding of the stands is not only fast but also long-lasting.

In this study, Inquiry as a tool for constructivist learning is used. The 5E Learning cycle is adopted to exemplify constructivist learning. Each phase in this learning cycle or model promotes scientific inquiry in a varying extent or degree. Since the phases were logically arranged it helps students organize their learning experience to interlink previous knowledge and new concepts. The main role of the teacher, which is ought to be, is a facilitator of learning or, in this case, the process developing newer ideas and concepts based on scientific inquiry and in turn a sound scientific decision.

The 5E's stands for Engage, Explore, Explain, Elaborate, and Evaluate. In the **Engage** phase, activities must be designed to link past and present learning experiences; the students must also anticipate and focus students' mental process on the learning outcomes of the activities at hand. Activities must be designed in such a way that students will be engaged mentally to learn concept, process, or skill. In the **Explore** phase, students are provided with a common base of experiences. They are allowed to actively explore their environment or manipulate materials to develop concepts and skills and understand the process. The **Explain** phase provides an opportunity for the students to explain the results of their exploration, including the concepts, process and skills. Students are given the chance to communicate their conceptual understanding or to showcase the newly-acquired skills and behaviors. This also allows the facilitator to define, present formal terms and bring in the necessary explanations. In the **Elaborate** phase, the students are allowed to extend conceptual understanding and to practice skills and behaviors learned through the process. The new experiences of the students result to a deeper and wider appreciation of major concepts enhanced their knowledge and interests and hone their skills. Finally, in **Evaluate** phase, the learning cycle, the learners are encouraged to actively participate in the assessment of their understanding and abilities, as well as teachers' own take in the assessment process is also done in this stage.

B. Effect of the Developed Lesson Exemplars in Electricity in the Epistemological Beliefs of the Students

A teacher made test was administered to the students and their scores were analyzed to determine the effect of the Developed Lesson Exemplars in Electricity in the Epistemological Beliefs of the students. Earlier researches, confirmed the clear relations between epistemological beliefs and student learning. It is clear that in learning physics' concepts, students' epistemological beliefs are important.

Table 2 shows that, the pre-test epistemology of students was categorized as Poorly Sophisticated with a mean of 2.22. Nonetheless, the Source of Ability to Learn is interpreted as Highly Sophisticated.

After exposure to the developed lessons, the Epistemological Beliefs of the students improved with an overall mean of 2.53, which is Moderately Sophisticated. This change represents student's recognition that they can construct ideas from what they do. There were two dimensions where changes have been observed, Nature of knowing and learning and Real-life applicability.

Table 2. Epistemological Beliefs of the Students

AREAS	Pre test		Post test	
	M	I	M	I
Structure of scientific knowledge	1.81	Poorly Sophisticated	1.9	Poorly Sophisticated
Nature of knowing and learning	2.23	Poorly Sophisticated	2.77	Moderately Sophisticated
Real-life applicability	2.28	Poorly Sophisticated	2.51	Moderately Sophisticated
Evolving knowledge	2.15	Poorly Sophisticated	2.31	Poorly Sophisticated
Source of ability to learn	3.13	Highly Sophisticated	3.15	Highly Sophisticated
All questions equally weighted	2.22	Poorly Sophisticated	2.53	Moderately Sophisticated

Table 2 also shows that after teaching the Developed Lesson Exemplars in Electricity, the Epistemological Beliefs of the students improved with an overall mean score of 2.53, which is Moderately Sophisticated, but with Nature of Knowing and Learning and Real-life Applicability changed from Poorly Sophisticated to Moderately Sophisticated. On the other hand, Table 3 shows the test of significant difference of the Pre-Test and Post-Test on the effect of the lesson exemplars to the Epistemological Beliefs of the students.

Table 3. Significant difference in the Epistemological Beliefs of the students

AREAS	t-value	p-value	Analysis
Structure of scientific knowledge	-1.459	0.149	Not Significant
Nature of knowing and learning	-6.484	0.001	Significant
Real-life applicability	-2.090	0.040	Significant
Evolving knowledge	-1.438	0.155	Not Significant
Source of ability to learn	0.819	0.416	Not Significant

The results revealed that the Epistemological Beliefs of the students along Nature of knowing and Real-life applicability significantly improved after using the Developed Lesson Exemplars in Electricity, with p-values of 0.001 and 0.040, respectively.

Using computer simulation in a constructivist approach actively exposes their pre-conceptions against

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science concepts being presented. This discrepant event transformed their experience into a meaningful learning. Giving them new ideas and the realization that they can learn if they are involve.

In a classroom that utilizes constructivist approach, the key actors in the learning process, the teacher and the students actively take part in exploring and expounding their understanding of the world within, and the world beyond. Using this approach, the students use their critical-thinking in analyzing the given information and situation and developing the necessary judgment or conclusion.

These slight significant shifts although not the entire dimensions can be attributed to how physics lessons were delivered. These students studied science concepts with a method that does not give them pioneer roles and active participation in most cases. The use of the developed lessons helped them transformed their experiences into meaningful learning. This result is the same with the study of Mamolo [16] that showed no significant change in the Epistemological Beliefs of the students studied, except in the Real Life Applicability. His conclusion was, even a full science course may not significantly alter students' epistemological beliefs.

CONCLUSIONS AND RECOMMENDATIONS

The developed-lessons that feature the use of computer simulations, constructivist approach and formative assessment classroom technique did not entirely change or altered students epistemological beliefs, however, significant changes were observed along Nature of Knowing and Learning and Real Life Applicability. [This study provides researched-based insights on how the students of the laboratory high school responded to the use of constructivist method in describing and in turn changing some aspects of their epistemological beliefs. This provides the academic planners an opportunity in analyzing interrelationships between epistemological beliefs and approaches in order to explain how the latter influence the performance of the students. With this methodology, the classroom has become a haven of practical experiences that harmonize a myriad of different backgrounds and information which when properly organize would result to newer ideas which later on can be translated into scientific and technological advances.

The developed lessons, even one that uses computer simulation and recent pedagogies, may not significantly alter students' views of epistemological beliefs about physical science in a short period of time. The development of the epistemological beliefs is a long-term process. Therefore, to determine how computer simulations and the use of other teaching approaches affect epistemological beliefs, it requires a prolonged educational experience and therefore a long-term study is necessary.

However, to determine further the effect of computer simulation or other approaches in the epistemological beliefs of the students, considerations must be given to the scope and limitation. In this study, the lessons and the approach were only designed for grade 10 students. The study determined the effects of the developed lesson exemplar with computer simulation as the main teaching and learning tool, on students Epistemological Beliefs. The study was conducted during the third grading period which utilized a complete enumeration of 72 students from the fourth year classes of the laboratory high school, and the subject was taught by the school's own science teacher.

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