CONSTRUCTIVE ALIGNMENT IN TEACHING ELECTRICITY AND MAGNETISM: EFFECTS ON STUDENTS' CONCEPTUAL UNDERSTANDING AND ATTITUDES

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ABSTRACT

This study aimed to determine the effects of constructive alignment in teaching College Physics on the students' conceptual understanding of Electricity and Magnetism and their attitudes towards learning. The teaching method ensured the alignment of the intended learning outcomes, constructivist teaching strategy, and assessment tasks. Specifically, the intervention incorporated outcomes-based instruction in Driver and Oldham's Orientation-Elicitation-Restructuring-Application and Review constructivist teaching sequence, which allowed the students to use a validated set of learning guides. The study utilized a pretest-posttest experimental design with a sample class of 24 students. Results show that the students progressed from a "poor" level before the treatment period to a "very good" level of conceptual understanding after the intervention as indicated by the posttest scores of the students which were statistically higher than their pretest scores. The intervention with the set of learning guides is highly recommended for use in the teaching of physics.

Keywords: *Constructive Alignment, Electricity, Magnetism, Conceptual Understanding, Attitudes*

1. INTRODUCTION

Outcomes-Based Education (OBE) has been emphasized as part of the educational reforms in the Philippines. This innovation aims to address the need to equip learners with 21st-Century skills and to develop them holistically. The new curriculum aims to produce critical problem solvers, innovative and creative citizens, informed decision makers and effective communicators. OBE develops among students lifelong learning to make them useful citizens in a competitive world. Specifically, the new science curriculum framework for basic education is focused on the improvement of the teaching and learning process and the learning environment that promotes the construction of acceptable scientific knowledge.

In the tertiary level, the Commission on Higher Education released CHED Memorandum Order 46 s. 2012, called "Policy Standards to Enhance Quality Assurance in Philippine Higher Education through an Outcomes-Based and Typology-Based Quality Assurance," which describes OBE initiatives. As the term implies, OBE focuses on the outcomes of learning in the form of competencies acquired and developed by students, and how these skills become concrete and measurable to be applied in the future. In planning for the desired learning experiences of the students under OBE, teachers should create their course syllabi with the end in mind. Course intended outcomes should be set appropriately instead of teaching objectives. Course syllabi should be aligned on how teachers teach with the intended learning outcomes and that they should be fully consistent with each other. The quality of teaching is evaluated by the quality of learning. In the model of Biggs (1996), outcomes-based education and constructivism are combined in what he termed as constructive alignment. The model requires that the intended learning outcomes need to be aligned with the constructivist teaching strategy to support student learning, and the methods to assess the learning.

1.1 Purpose of the Study

This study was conducted to use constructive alignment in teaching College Physics particularly Electricity and Magnetism using a validated set of learning guides. Specifically, it aimed to measure the conceptual understanding of Electricity and Magnetism of the students through the pretest and posttest; test for significant difference between the pretest and posttest scores of the students; determine the levels of attitude of students towards learning before and after instruction; and test for significant difference in the attitudes of the students before and after instruction.

1.2 Theoretical Framework

A number of constructivist teaching strategies can be applied in Outcomes-Based Education. Anderson (2009) emphasized two constructivist learning methods - cooperative learning and problem-based learning. The 5E (Engage-Explore-Explain-Extend-Evaluate) Model developed by the Biological Sciences Curriculum Study Science Educators in 1987 was expanded and improved by Eisenkraft in 2003 and became the 7E (Elicit-Engage-Explore-Explain-Elaborate-Evaluate-Extend) learning cycle.

Earlier, Driver and Oldham (1986) formulated a four-phased constructivist teaching-learning sequence. The first phase, called Orientation, directs students' attention to the essential concepts to be learned and the tasks to be undertaken. It gathers the students' prior knowledge. In the second phase, Elicitation, the students, divided into small cooperative groups, perform practical activities or experiments. They hold group discussions to clear out their prior concepts. In the third phase, Restructuring, the whole class is convened for the sharing period. The cooperative groups present and defend their own outputs to the whole class. The instructor encourages each student to challenge others' conceptualization of ideas. After the students' presentation, argumentation and agreement on the concepts presented, the instructor deepens their understanding. The instructor formally discusses mathematical formulations and numerical applications of the concepts learned. The fourth stage is called Application and Review. In this phase, the students, again in cooperative groups, are exposed to more complex learning activities, which include problem-solving and designing and constructing improvised apparatuses. The members of each group share and explain their outputs to the whole class. Finally, the instructor facilitates the review of the students' conceptions, ending with acceptable knowledge.

Obrero, M. M. and Obrero, M. P. (2015) exposed a class composed of college students enrolled in Thermodynamics to a constructivist classroom environment, in which the students' preconceptions about heat and thermodynamics were determined and the students were engaged instructional activities in small groups. The study revealed that most of the students' misconceptions were changed to scientifically accepted conceptions after the intervention as indicated by their posttest scores that were found to be significantly higher than their pretest scores, and the concept maps relating correctly the various Thermodynamic concepts after the treatment period. The students liked the constructivist nature of their learning because of the meaningful learning they experienced. The extent of conceptual change the students achieved was significantly influenced by their attitudes towards constructivism, small-group learning, and physics.

Another study was conducted to determine the effects of constructivist learning approach on students on their academic achievements in science (Ayaz & Sekerci, 2015). They found out that constructivist learning approach on students' academic achievement makes more significant contributions to learners' academic achievement than does the traditional learning method. They suggested that the use of a constructivist learning approach should be used to improve students' achievement.

The model of constructive alignment formulated by Biggs (2014) combines constructivism with outcomes-based education. It suggests that intended learning outcomes should be properly defined before instruction. The teaching strategy and activities and the appropriate assessment methods and tools are then designed to ensure the attainment of the outcomes. According to Biggs, constructive alignment can be employed to enhance the quality of teaching and learning.

1.3 Conceptual Framework

The research paradigm of this study is shown in Figure 1. The attitude survey towards learning and the Conceptual Survey on Electricity and Magnetism were administered before and after the treatment period. The treatment used was the constructive alignment of learning outcomes, constructivist teaching sequence with the use of validated learning guides in Electricity and Magnetism, and assessment tasks. This allowed the students to learn by constructing their own meanings out of their experiences, and later acceptable knowledge, and by demonstrating creative, critical thinking, problem-solving, and improvisation skills.

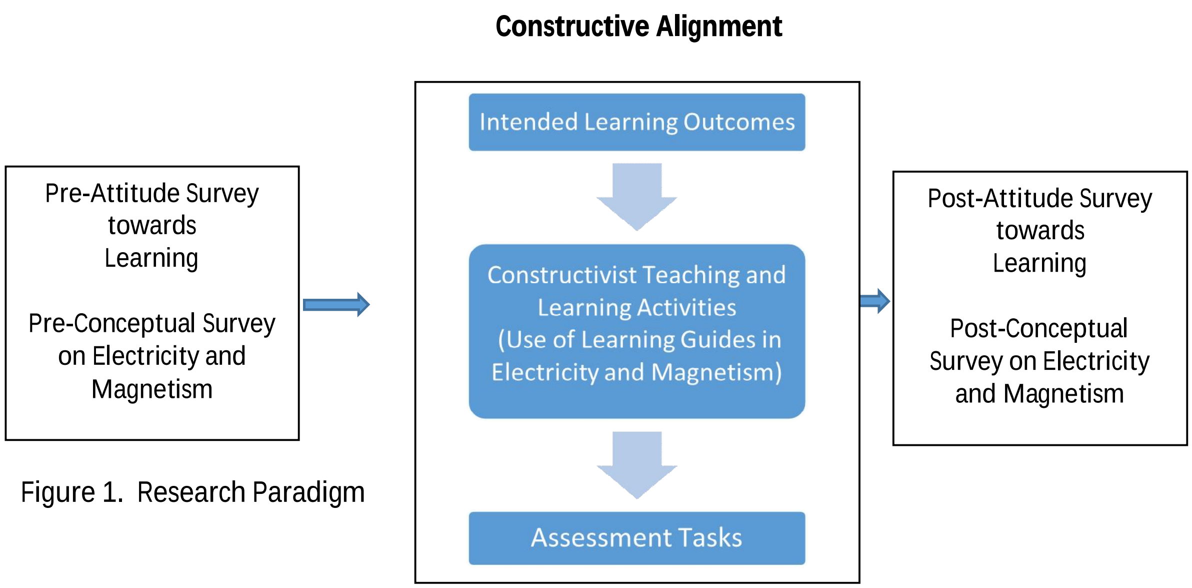

Figure 1. Research Paradigm

2. METHODOLOGY

The research design incorporated both the descriptive and the experimental methods involving a class of 24 college physics students in the College of Teacher Education, University of Northern Philippines, Vigan City, Ilocos Sur, Philippines during the Second Semester of School Year 2016-2017.

Prior to the conduct of the study, a set of learning guides in Electricity and Magnetism was developed by the researchers. Five experts on the field evaluated the instructional materials in terms of learning outcomes, content, structure and organization, learning activities and evaluative activities using an instrument with a five-point scale. Results of the validation showed that the learning guides are very highly valid as instruments for the implementation of a constructivist and outcomes-based instruction. The set of learning guides covered Electrostatics, Electrical Conductivity, Series and Parallel Circuits, Electric Field Measurement, and Magnetism.

Table 1. Summary of Evaluation of the Learning Guides

Area of Evaluation	Mean	Descriptive Rating
Learning Outcomes	4.90	Very Highly Attainable
Content	4.90	Very Highly Valid
Structure and Organization	4.93	Outstanding
Learning Activities	4.80	Very Highly Appropriate
Evaluative Activities	4.76	Very Highly Appropriate
Overall Mean	4.85	Very Highly Valid

Before and after the students were exposed to the intervention, the Attitude Survey towards Learning and the Conceptual Survey on Electricity and Magnetism (CSEM) were administered. The attitude survey instrument is composed of fifty-six items adapted from Nix, Fraser, and Ledbetter (2005). It is a questionnaire that measures how the students feel and act in a constructivist learning environment. The CSEM was developed by Maloney, O'Kuma, Hieggelke and Van Heuvelen (2001). It is a 32-question, multiple-choice test covering the topics on Conductors and Insulators, Circuits in Parallel and Series, Coulomb's Law, Electric Force, Induced Charge and Magnetic Field.

During the six-week treatment period, the Driver and Oldham's teaching sequence, consisting of four phases, namely: Orientation, Elicitation, Restructuring, and Application and Review was followed. Each student was given a set of learning guides. The intended learning outcomes were clearly identified in the orientation phase. Assessment of learning was done through reflection journals, formative tests, and the CSEM as the summative test. Statistical tools used included the mean and t-test for correlated samples.

3. RESULTS AND DISCUSSION

3.1 Levels of Performance of the Students in the Conceptual Survey on Electricity and Magnetism

The results of the pretest and the posttest are given in Table 2. The students got low performance during the pretest as indicated by the mean score of 5.00. Their performance in the posttest was higher than the pretest as shown by the mean score of 23.96. The very satisfactory performance of the students during the posttest is accounted to their exposure to the constructive alignment in teaching using learning guides. The students progressed from a "poor" level before the treatment period to a "very good" level of conceptual understanding after the intervention. They gained a better understanding of the various concepts related to conductors and insulators, Coulomb's Law, force and field superposition, work and electric potential, magnetic force, Faraday's law, and Newton's third law.

Table 2. Performance of the Students in the Conceptual Survey on Electricity and Magnetism

Test	Mean	Descriptive Rating
Pretest	5.00	Poor
Posttest	23.96	Very Good

Range of Scores
27-32 Excellent
20-26 Very Good
12-19 Good
6-11 Fair
0-5 Poor

3.2 Difference between the Pretest and Posttest Performances of the Students

The results of the test for significant difference between the pretest and posttest scores of the students are revealed in Table 3. The mean of posttest scores is 18.9 higher than the mean of the pretest scores. The t-value obtained was 27.364 which is significant at the .01 probability level. This result shows that the posttest performance of the students is statistically better than their pretest performance. The significance of the mean difference is explained by the students' exposure to constructive alignment with the use of learning guides. This means that the students gained from the constructivist nature of the teaching-learning method implemented which emphasized outcomes-based learning. The result proves that the treatment was able to improve the understanding of the students of the various topics of Electricity and Magnetism.

Table 3. Test of Significant Difference in the Performance of the Students in the Pretest and Posttest

Mean Difference	t-value	p-value
18.9	27.364	$p<.01$

3.3 Pre- Attitudes and Post-Attitudes of Students towards Learning

Students' attitudes towards learning were determined before and after the treatment period. Most of the item means measuring pre-attitude and post-attitude fall within the "often" level which implies that the students had positive attitudes towards constructivist learning. The means after exposure to a constructivist learning environment are higher than those prior to exposure. Although both overall means indicate "often" level, the attitudes of the students towards learning were improved. The overall results of the attitude survey are presented in Table 4.

Table 4. Students' Overall Pre-Attitudes and Post-Attitudes towards Learning

Attitudes towards Learning	Mean	Descriptive Rating
Pre-Attitude	3.50	Often
Post-Attitude	3.73	Often

Range of Ratings

4.21 – 5.00	*Always*
3.41 – 4.20	*Often*
2.61 – 3.40	*Sometimes*
1.81 – 2.60	*Seldom*
1.00 – 1.80	*Never*

There are ten items in the attitude survey test in which the level was improved. Results for the first of these show that it was okay for them to ask their instructor why they have to learn a certain topic. The item mean rose from "sometimes" level to "often" level. The means for three items, which indicate whether the students asked questions the way the instructor ask them, whether they complain if they perceived the lesson as confusing, and whether they were given opportunity to plan with the instructor on what should they learn, increased from "seldom" to "sometimes" level.

Four more items had means which became higher after the students were exposed to the constructivist approach. For these items, the original "sometimes" level became "often" level. The students admitted that they like asking questions and leading their fellow students to ask questions too, presenting work before the teacher, and other students and other teachers, and making projects in which they apply what they have learned, and revealed that their prior knowledge was acknowledged in the class.

Further, the students appreciated that they were free to express their opinions as the item mean rose from "often" to "always" level. The same result was observed for the item which shows that they enjoyed performing experiments or activities with their classmates. Finally, in the tenth item, the students claimed that they were encouraged to construct their own ideas; however, the mean indicated a change from "always" level to "often" level.

3.4 Difference between the Pre-Attitudes and Post-Attitudes of the Students

As shown in Table 5, the post-attitude mean rating is 0.23 higher than the pre-attitude mean rating. The t-value obtained was 3.947 which is significant at the .01 probability level. This result shows that the post-attitude level of the students is statistically higher than their pre-attitude level. The significance of the mean difference is due to the students' exposure to constructive alignment in teaching Electricity and Magnetism. This result implies that the students appreciated the constructivist nature of the teaching-learning method implemented and the emphasis of intended learning outcomes at the beginning of the intervention. They had positive attitudes towards the intervention used because the learning environment was student-centered.

Table 5. Test of Significant Difference between the Pre- and Post-Attitudes of the Students

Mean Difference	t-value	p-value
0.23	3.947	$p<.01$

4. CONCLUSIONS AND RECOMMENDATIONS

Constructive alignment in teaching Electricity and Magnetism with the use of a set of validated learning guides in Electricity and Magnetism is very highly suited for college physics students. The intervention was also able to increase the levels of performance of the students in understanding conceptually the topics of Electricity and Magnetism. The model was effective in bringing out transformation in students' performance and attitudes because of their exposure to constructivist and outcomes-based instruction. There was a slight enhancement of the attitude of the students after the intervention. The students appreciated the constructivist and outcomes-based nature of the teaching-learning method implemented. The significant difference between the pre-attitude and post-attitude of the students towards constructivism is due to their exposure to the treatment.

Constructive alignment of the intended learning outcomes with the teaching strategy and the assessment tasks is recommended to be employed in physics teaching to improve students' learning. Physics instructors are encouraged to develop learning guides and other intervention materials with a constructivist and outcomes-based framework. Further studies may be conducted to determine the effectiveness of the intervention in other fields of physics.

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