Effectiveness of a Constructivistic Multimedia-Learning Package on Shaping and Guiding Students' Attitudes Toward Physics

Divya C. Senan
Department of Physical Science Education, Sree Narayana Training College, University of Kerala, India
mail2divyacsenan@gmail.com

and

Matthew E. Edwards and **Salam Khan**
Department of Physics, Chemistry and Mathematics, Alabama A&M University,
Normal, AL 35762, USA
matthew.edwards@aamu.edu, salam.khan@aamu.edu

and

Asha J. Vilasini
Department of Education, University of Kerala, India.

ABSTRACT

Physics is considered by some to be the most perplexing area in the sciences and perceived as a hard subject for students from secondary school to the university to adult-graduate education. Educational research has provided evidence that attitudes towards physics change with exposure to it. When students have negative attitudes towards physics, they often do not "like" physics courses or the teachers of those courses. Based on this premise, numerous studies have been conducted to determine the factors that affect students' attitudes towards physics. A goal that is important to most if not all teachers of physics courses is to inspire students to have a positive attitude towards the subject. This goal encompasses an appreciation of how physicists think and how they incorporate the values that it provides, as well as, how it is applied to other areas or related fields, and its application in everyday life. In this regard, the aim of this investigation has been to explore how to impact more effectively positive students' attitudes in physics courses. To that end, we report the effectiveness of a constructivistic multimedia-learning package (MLP) in shaping and guiding students' attitudes towards physics.

Keywords: Constructivist, Multi-media Learning Package (MLP), Cognition, Bloom's Affective Domain

1. INTRODUCTION

For almost a century, the question that existed in educational technology research was that of which medium could most effectively deliver knowledge. Educators and researchers have worked hard to show that technology, as a tool, not only can assist the delivery of information in learning, but can improve learning as well. It was during the last few decades that these groups have begun to embrace the constructivist paradigm in contrast to using only objectivistic methods. It has been argued that constructivism can provide the foundation that guides the application of technology towards more intellectual instructions. Moreover, it provides a theory of learning based on the learner's processing of information and holds promise of achieving two perennial instructional goals: the differentiation of learning tasks and the shifting of the responsibility for learning to the learner.

In this regard, learning is not just a mechanical process, and for this reason, more care must be taken when designing and implementing technological teaching tools. The dominant missing feature in the vast majority of educational technology research is a lack of an appropriate theoretical foundation. Researchers have had the misconception that students could be receptors of knowledge rather than active learners. This led to studies that searched for a better vehicle for conveying knowledge, ignoring the affective and cognitive domains, as illustrated by Blooms' taxonomies [1]. In light of this fallacy, the goal of research is changing. Researchers are examining learning with technology from the ground up, seeking to understand the fundamental "active ingredients" to progress scientifically to "authentic educational learning technologies" [2]. In this context, the process of design and development of effective interactive multimedia learning materials, especially for engaging the learner, needs to be guided by an academic framework based on relevant theories. This matter could be tactfully addressed by applying a conceptual framework of principles of multimedia learning and constructivist learning theories to the pedagogical design of learning material.

Although many studies have stated that the Affective Domain is importance, it is the least studied, often being overlooked, and the most nebulous and the hardest to evaluate. The reason for this outcome is that research paradigms in social psychology and educational psychology, which influenced research in science education, shifted from a behavioral to a more cognitive orientation [3]. Usually, in classroom instruction, the teacher's efforts go immediately to this aspect of teaching and learning, and most of the classroom interaction is designed for strengthening cognition, which is more suitable to well prepared students [4]. Moreover, evaluating cognitive learning is straightforward, but assessing affective domain influences is less direct and more difficult to implement. A contemporary view is that the "affective dimension" is not just a simple catalyst, but it is a necessary condition for cognitive learning to occur [5]. Thus, there is significance in realizing the potential to increase student learning by tapping into the Affective Domain, especially regarding students' attitudes pertaining to valuing knowledge, and the process of receiving it.

As far as we can determine, no ready-made courseware designed in a constructivistic environment exists in the Indian Education System. This is a critical feature since India is the initial location of this investigation. In India, the observed courseware, provided by various governmental and non-governmental agencies, is generally based on the objectivistic model. There might be some constructivistic elements embedded within a given courseware, but for the most part, it is designed in an objectivist manner. In this regard, since classroom teachers typically do not have the resources, time or expertise to prepare their own courseware based on the constructivistic methods, it has become imperative to ensure that ready-made courseware is available to schools to assist teachers in implementing teaching and learning processes in this manner. Upon realizing this need, we have ventured into the challenging process of developing a Multimedia-Learning Package (MLP) that uses both constructivism and multimedia learning principles. From envisaging the scope and the importance of MLP, the first author of this study has designed and developed such a package, under the name **"Opto Quest,"** which is based on integrated design principles as derived from Mayer's multimedia learning principles [6].

2. THE DESIGN AND DEVELOPMENT OF OPTO QUEST

The impact of constructivism on classroom practices has been studied by many researchers [7-9], and others have suggested that constructivist strategies can exploit technologies for the greatest impact in learning [10]. To that extent, a symbiotic relationship appears to exist between computer technologies and constructivism.

Although constructivist theory has been implemented with several instructional models, the most commonly used model has been the 5E model, with 5E expressing *engagement, exploration, explanation, elaboration and evaluation*. This model was developed by a team led by Roger Bybee [11], and was designed primarily by science educators for secondary science teaching when using a classic constructivist structure with a convenient format. In their study, Keser and Akdeniz [12] stated that the 5E model was one of the best-known models among the ones that were recommended for constructivist learning theory. The model encourages students to formulate their own concepts, and provides a tangible reference for teachers to use their expertise in structuring a learning environment, which will facilitate students' interaction within a learning context in a critical, reflective and analytical way [13, 14].

Based on the three themes, which were multimedia-learning principles, constructivist perspective and 5E instructional model, we have integrated a conceptual framework for this MLP. This learning package, with a specific instructional content based upon the theme "Colors of light" from a Physics subject, has been designed using Mayer's multimedia-learning principles and developed with the Constructivist BSCS 5E Instructional Model. Thus, we have integrated technological and constructivist principles into a pedagogically suited MLP.

3. PURPOSE OF THE STUDY AND RESEARCH QUESTION

For decades, science educators have been interested in understanding how students achieve in academia. Such research has revealed that there is a strong association between science achievement and attitude towards science [15, 16]. In TIMSS 1999 (Trends In International Mathematics and Science Study 1999) and the International Science Report [13], students' attitude towards science was one of the ways to elicit information that could provide an educational context for interpreting science achievement results. According to educational psychologists, the attitudes of students play an important role in their systematic and scientific training. While Gardner has described science-related attitudes as learned tendencies to evaluate objects, people, events, and situations in a specific way or a set of propositions related to science, Martinez, in his studies that were aimed at determining the effects of attitudes on science education, has put forward the notion that students' attitudes towards science lessons affect their academic achievement and the tendency to continue in the sciences [17]. Moreover, the measurement procedure of students' attitudes towards physics should take into account their attitudes toward the learning environment [18]. The affective aspect of students' attitude toward science is incredibly significant, since problem solving requires patience, persistence, and a willingness to accept risks [19], which are innately associated with attitude. Hence, in this study, it is important to monitor students' attitude and ascertain whether or not the constructive MLP has the desired effect.

Since in this study, which was intended to answer the basic question of evaluating the effectiveness of a developed constructivist multimedia-learning package on students' attitude towards physics, we have addressed the following question:

In applying the constructivist multimedia-learning package in the given instructional context to secondary students, will Opto Quest affect the students' attitudes towards Physics?

4. METHODOLOGY

The purpose of this study was to explore the effects of a constructivist MLP for secondary students. A Pre-test/Post-test Non-equivalent experimental-control group design was used in this study, and it was conducted with non-equivalent intact classroom groups. The experimental and control groups can be described as non-randomized. Both groups took the pre-test and the post-test, but only the experimental group received the instructional treatment. The sample for the study consisted of 168 students of secondary schools in India. In each school, the selected students were divided into two groups as Control group and Experimental group.

5. INSTRUMENT

In this study, a Physics Attitude Scale was developed and applied to identify students' attitudes towards physics. After reviewing many related studies about students' attitudes towards physics, selected dimensions, as they have been labeled, have been used, such as real-world connections, personal interest, sense making**,** conceptual understanding**,** and problem solving. The scale was constructed by making use of Likert's methods [20] of summation to obtain a five-point judgment on each item. Against each statement, five alternative responses, namely, "Strongly Agree" (SA), "Agree" (A), "Undecided" (U), "Disagree" (D) and "Strongly Disagree" (SD) were provided, with weights of 5, 4, 3, 2, 1, respectively in the order of their favorable to unfavorable statements, in a reversed scoring manner. Both positive as well as negative questions were included. Approximately six questions were related to real world connections, which included questions, such as, "I feel surprised while learning physical phenomena." Similarly, an equal number of questions were included under personal interest, such as, "I feel helpless while studying Physics." The questions like "I try to find the answers of natural phenomena related to properties of light," are included for focusing problem solving. Both positive as well as negative questions were included. About six questions were related to real world connections, which included questions, such as, "I feel surprised while learning physical phenomena." Moreover, an equal number of questions were included under personal interest, such as, "I feel helpless while studying Physics." Questions like "I try to find the answers of natural phenomena related to properties of light," are included for focusing problem solving.

After constructing the Physics attitude scale, a pilot test was conducted. Items analyzed were executed by calculating the discrimination index. The final draft of the Physics attitude scale consisted of thirty items covering five dimensions. The scale contained 30 statements, which represented the universe of items with content validity. The study employed split-half method to determine the coefficient of internal consistency, of which the reliability of the split-half test was found to be 0.78 using Spearman – Brown prophecy formula [21].

6. DATA ANALYSIS PROCEDURES

To analyse the research question, data were considered using Analysis of Covariance. The research question examined the effect of constructivist multimedia-learning strategy with the help of 'Opto Quest' on students' attitudes towards physics. The following hypothesis was suggested:

H_1: *The attitude of students towards Physics taught using Opto Quest is significantly higher than that of students taught without Opto Quest.*

The relationship between the physics attitude score of the experimental group for whom the lesson was treated with the help of constructivist multimedia-learning package and the control group of students where it was not used is shown below. Specifically, the pre-test and post-test Physics attitude scores of the students in the experimental and control groups are shown in the Figure 1.

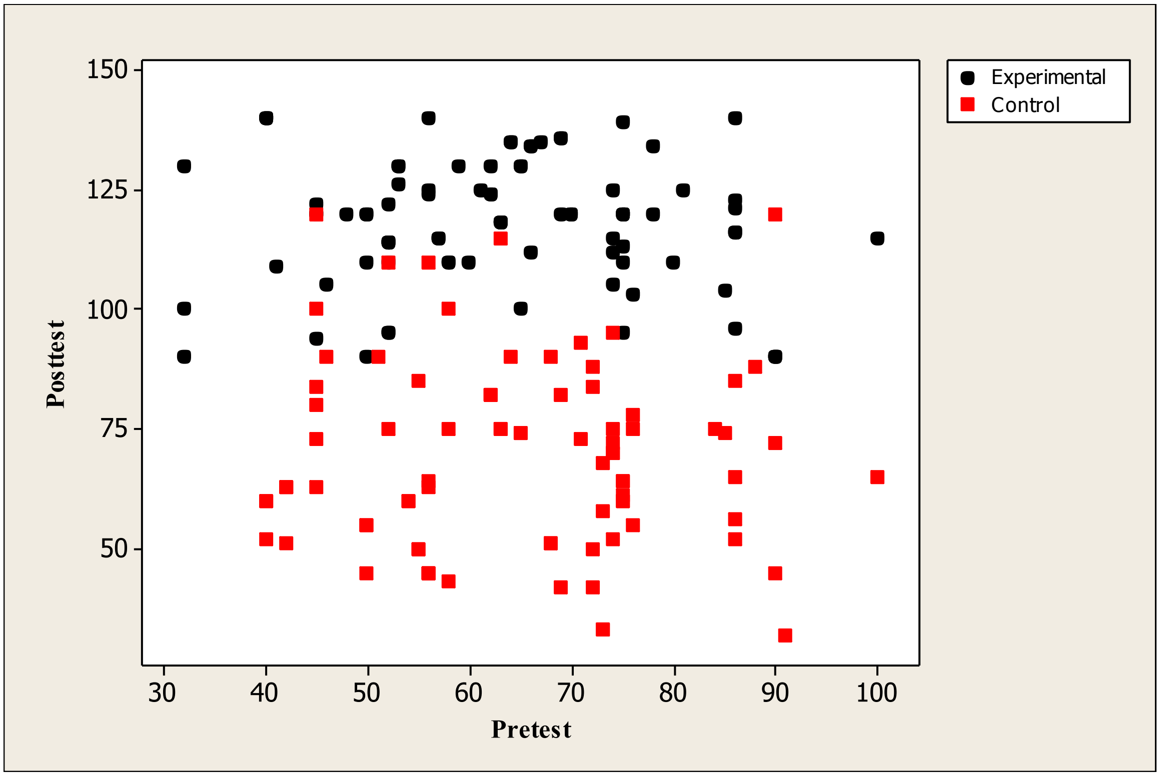

Figure 1: Scatterplot of Experimental Versus Control Group.

Figure 1 shows a bivariate distribution in the pre-test and post-test Physics attitude scores of the students in the experimental and control group study. From the graph, we can observe that attitude of students towards Physics taught using Opto Quest is significantly higher than that of students taught without Opto Quest. The experimental group consistently scored better on the post-test than the control group. Even though the control group had a 1.6 points pre-test advantage on the average, the experimental group scored 48.5 points higher on the post-test. Thus, applying the constructivist multimedia-learning package in the given instructional context improved students' attitudes toward Physics in this regard.

Figure 2 displays the pre-post means of the experimental group joined with a blue line (upper line) and the pre-post means of the control group joined with a yellow line (lower line). In this bivariate plot, given below, we observe quite clearly the original pre-test difference of 1.6 points, and the larger 48.5 point post-test difference. The plot gives a "cross-over" pattern. Here, the control group doesn't appear to change from pre-test to post-test, but the experimental group does, starting out lower than the control group and ending higher. This is the clearest pattern of evidence for the effectiveness of applying the constructivist multimedia-learning package in the given instructional context.

Analysis of Covariance (ANCOVA) has been used to analyze the pre-test and post-test physics attitude scores. In this analysis, we considered three scores for each student: a pre-test score (X), a post-test score (Y) and either a 0 or 1 to indicate whether the student was in the experimental (Z=1) or control (Z=0) group. In the statistical analysis of the non-equivalent group design, we needed to adjust the pre-test distribution for measurement error. The adjusted pre-test scores were given by:

$$X_{adj} = \bar{X} + r(X - \bar{X})$$

where, X_{adj} = adjusted pre-test value

$\bar{X}$ = original mean pre-test value

X = original pre-test value

r = reliability

The reliability analysis showed that the Cronbach's Alpha was 0.495, i.e., r = 0.495. The ANCOVA model is given by:

$$y_i = \beta_0 + \beta_1 X_{i-adj} + \beta_2 Z_i + \varepsilon_i$$

where, y_i = post-test score for the i^{th} unit

β_0 = Intercept coefficient

β_1 = Pre-test coefficient

β_2 = Group coefficient

$X_{i\text{-adj}}$ = Adjusted pre-test score

Z_i = Dummy variable for group and ε_i = error for i^{th} unit

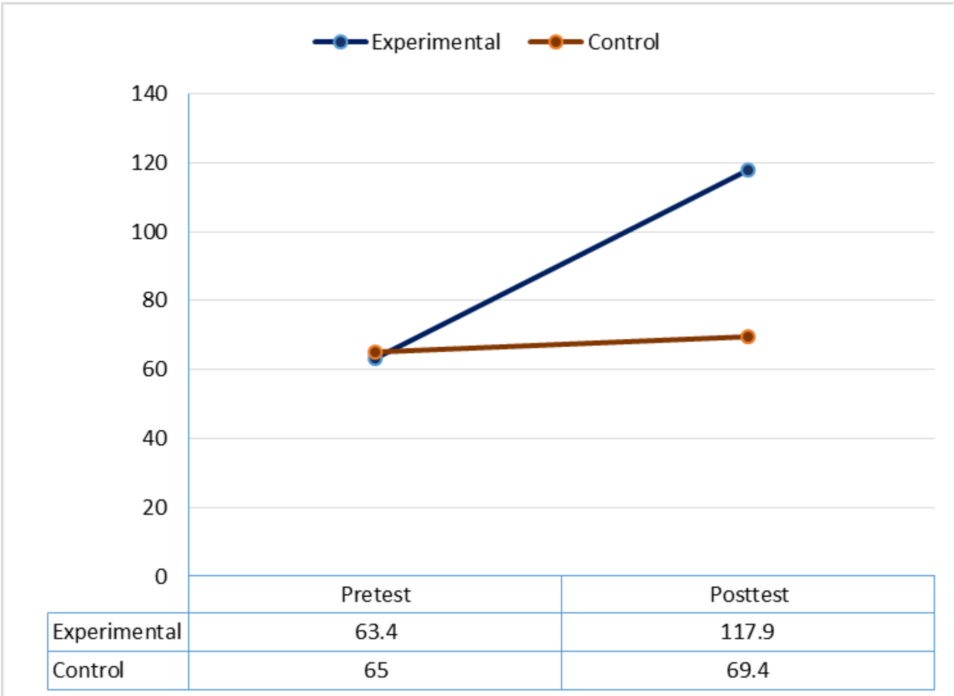

Figure 2: Pre-Post Means Of Experimental and Control Groups.

Tables 1, 2 and 3 give the ANCOVA analysis and parameter estimates for this model. From the analysis, we can observe that the procedure had a significant effect on the average experimental group, being 48.283 points, which is significantly higher than the control group. Thus from the statistical analysis, we conclude that teaching with constructivist multimedia learning package is more effective for enhancing students' attitudes towards Physics in this study.

Table 1: Levene's Test of Equality of Error Variances

Dependent Variable: Post-test

F	df1	df2	Sig.
11.695	1	166	.001

7. DISCUSSION & CONCLUSION

Our research question examined the effect of Opto Quest in enhancing students' attitudes towards Physics. Results showed a significant enhancement in the attitudes towards Physics for the students who were taught with the use of Opto Quest. The result describes some helpful approaches to the incorporation of computer-based multimedia teaching by utilizing constructivist design principles to facilitate the students' understanding and their attitudes towards learning physics.

The results of this study support the use of a constructivist multimedia-learning design in enhancing students' attitudes towards physics and hence can provide an increased academic performance in physics at the secondary level in India. It shows that a pedagogically well-designed constructivist multimedia-learning package can enhance attitudes towards physics, thus increasing problem-solving and collaborative skills as well as creative and critical-thinking abilities.

The limitations of the study and the researchers' reflections yield a suggestion for performing a replication of this study in the USA and using this approach in General Studies Level college courses, such as in Physical Science I, II, and the use of constructivism can have positives impacts in computer technology supplemental learning, through DVDs and Webcast learning.

Table 2: Tests of Between-Subjects Effects

Dependent Variable: Post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	98710.065[a]	2	49355.033	171.957	.000	.676
Intercept	23381.568	1	23381.568	81.463	.000	.331
Pretest-adj	254.774	1	254.774	.888	.347	.005
Group	97628.111	1	97628.111	340.145	.000	.673
Error	47358.214	165	287.019			
Total	1619445.000	168				
Corrected Total	146068.280	167				

a. R Squared = .676 (Adjusted R Squared = .672)

Table 3: Parameter Estimates

Dependent Variable: Post-test

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	80.344	11.720	6.855	.000	57.204	103.484	.222
Pre-test-adj	-.169	.179	-.942	.347	-.522	.185	.005
Group	48.283	2.618	18.443	.000	43.114	53.452	.673

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