Communications in Applied Sciences
ISSN 2201-7372
Volume 5, Number 1, 2017, 14-27

INFINITY PRESS
www.infinitypress.info

Comparative Study between Computer Simulated and Hands-on Physics11 (Electricity and Magnetism) Experiments

Rosemarie W. Ceniza[1], Maristel B. Cornez[1], Billbryan N. Lagbas[1], Luigi P. Orinay[1], Shaira Marie N. Tayo[1], and Van Ryan Kristopher R. Galarpe[2,*]

[1]BS Applied Physical Sciences, Department of Physics, College of Science and Mathematics, University of Science and Technology of Southern Philippines, Cagayan de Oro Philippines

[2]Faculty, Department of Physics, College of Science and Mathematics, University of Science and Technology of Southern Philippines, Cagayan de Oro Philippines

*Corresponding author: vanryangalarpe@gmail.com

Comparative Study between Computer Simulated and Hands-on Physics11 (Electricity and Magnetism) Experiments

Abstract

A major research domain in physics education is focused on studying the effects of various types of teaching interventions aiming to help student's alternative conception transformation. The purpose of this study was to compare the changes of conceptual understanding of Physics 11 (electricity and magnetism) laboratory in Computer simulated laboratory application (CSL) and Hands-on laboratory application (HLE) in the University of Science and Technology of Southern Philippines (USTP), formerly Mindanao University of Science and Technology (MUST). In this study, a total of 194 students were randomly selected. Two parameters were set for this study: (1) gender of the respondent; and (2) college the respondents were enrolled. The result presented that CSL with 54% was the most preferred applications as alternative instructional tool in understanding the concepts of physics. Sparingly, about 46% of the surveyed respondents favored HLE. However, no apparent differences appeared with respect to the questions on the conceptual understanding learning objectives. Overall, there was no significant difference between CSL and HLE regardless of the gender (p=0.81, p=0.90, and p=0.90).

Keywords: Computer simulated, Hands-on laboratory, Physics experiment.

1. Introduction

Effective use of laboratory can help the students in manipulative skills, gain necessary experience, share information and ideas, and turned theoretical knowledge into practical knowledge [1]. Hands-on laboratory helps the students to develop problem solving and critical thinking skills. Exposure to materials and equipment in a laboratory setting similarly may enhance learning. It is important that students have a contact in laboratory apparatuses and materials, improving problem solving ability.

Several studies showed that hands-on activities help students to outperform students who follow traditional, text-based programs [2] [3] [4] [5] [6] [7] [8] to enhance their understanding and replace their misconceptions with the scientific ones [9] to develop attitudes toward science positively [10] [11] [12] [13] [14] and to encourage their creativity in problem solving, promote student independence, improves skills such as specifically reading, arithmetic computation, and communication [6] [15]. The reference [16] emphasizes that children learn better when they can touch, feel, measure, manipulate, drawing, making charts, record data and when they find answers for themselves rather than being given the answer in a textbook or lecture.

While laboratory application may enhance learning, several factors may restrict effective use of laboratory applications. This may include the lack of effective and sufficient teaching materials [17], lack of attention to safety in laboratory conditions [18], crowded classrooms [19], insufficient background about the topic [20], and using justification activities in the laboratory instruction [21]. Owing to identified gaps, this study was conducted primarily to introduce computer simulated laboratory (CSL) and compare the latter hands-on laboratory (HLE) in Physics 11 (electricity and magnetism).

The CSL application have the potential to likely increase the chance to conduct experiment virtually comparable to hands-on laboratory environment [22]. The CSL application can lessen the costs associated with classroom, buying laboratory apparatuses, and laboratory spaces. Further CSL may allow students to (i) systematically explore hypothetical situations; (ii) interact with a simplified version of a process; (iii) practice tasks and solve problems in a realistic environment [23]. However, the extent of its functionality over HLE was not tested in the field of Physics.

The main objective of this study was to incorporate CSL in conducting the Physics 11 (electricity and magnetism) laboratory experiments in the University of Science and Technology of Southern Philippines (USTP) formerly Mindanao University of Science and Technology (MUST) and compare with the HLE application. This was done by comparing students' responses by gender and college.

2.Materials and Methods

2.1 Research Design

This study focused on which of the two laboratory models was preferable to use during Physics 11 laboratory experiments in USTP formerly MUST. A categorical questionnaire regarding the study was administered to students enrolled in Physics11, academic year 2016-2017. Two parameters were set for this study: (1) gender of the respondent and (2) college/department to where the respondents were enrolled.

2.2 Conceptual Framework

Computers can supplement large lectures by acquiring data and display those data in real-time [24]. Despite the advantage of computer assisted learning, its application locally in Physics 11 experiments was not evaluated. The study was conducted in USTP-Department of Physics. The respondents were students enrolled in Physics 11 of the 1st semester academic year 2016-2017. The respondents came from the former three colleges, of USTP namely, College of Arts and Sciences (CAS), College of Engineering and Architecture (CEA) and College of Information Technology (CIIT). The College of Policy Studies and Education Management was not included owing to lack of respondents. Two laboratory models were introduced in this study the CSL and the HLE. Figure 1 presents the variables in this study.

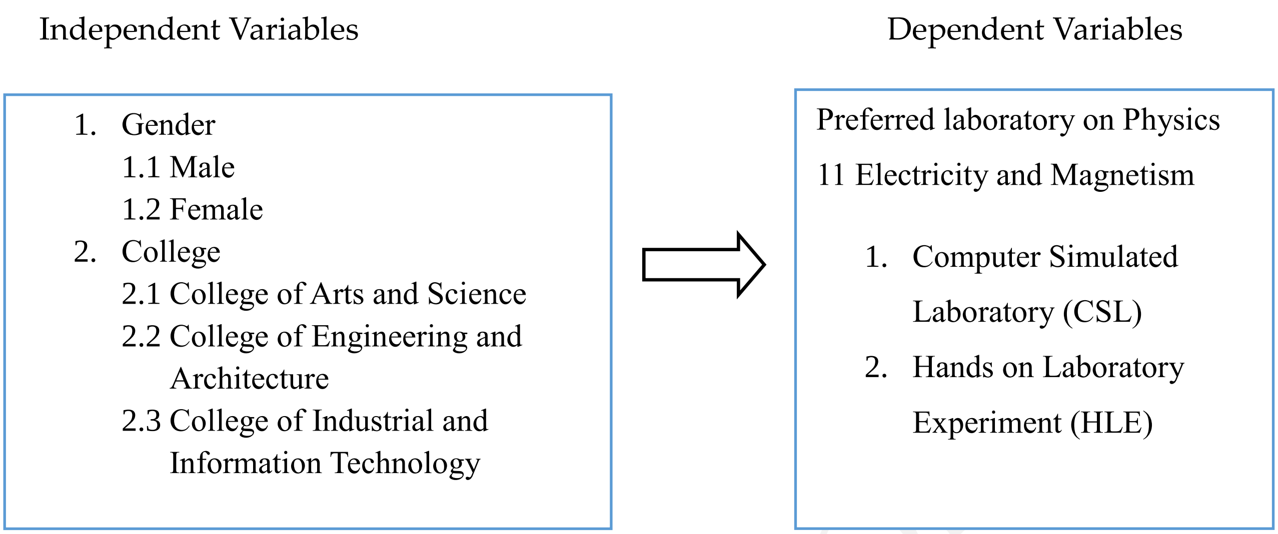

Figure 1. Schematic Diagram of the Conceptual Framework

2.3 Hypotheses

This research was conducted in USTP campus during the first semester of S.Y. 2016-2017. The following null hypotheses were formulated and tested at p=0.05:

1. There is no significant difference between computer simulated laboratory and hands-on laboratory on each colleges: CAS, CEA, and CIIT
2. There is no significant difference between computer simulated laboratory and hands-on laboratory according to gender.

2.4 Respondents

A total of 390 students were enrolled in Physics 11 in the first semester of academic year 2016-2017. A total of 194 students were selected as respondents following the Slovin's formula. The samples were composed of students from three colleges: College of Engineering and Architecture (CEA), College of Arts of Sciences (CAS), and College of Industrial and Information Technology (CIIT).

Table 1. Demographics of the students

College	Course	Gender	Age	No. Of Respondents
CAS	BS Applied Mathematics	Male	17-18	12
		Female	17-20	12
	BS Applied Physical	Male	17-18	6
	Sciences	Female	17-18	10
		Male	18	1
	BS Chemistry	Female	17-18	10
	BS Environmental	Male	17-19	12
	Science and Technology	Female	17-18	12
CEA	BS Mechanical Engineer	Male	17-19	27
		Female	17-19	26
CIIT	BS Information	Male	17-20	28
	Technology	Female	17-18	29

2.5 Survey questionnaire and conduct of survey

The survey questionnaires had two parts. (1) requiring the students to select which laboratory tool they prefer (CSL and HLE), and (2) five questions to assess the preferred laboratory tool. The questions had five choices: 1. Totally agree, 2.Agree, 3.Totally disagree, 4.Disagree, and 5.Do not know.

2.7 Data Analyses

Survey questionnaires were given to 194 respondents to acquire sufficient data in this study. Responses from the collected data were statistically interpreted using the Two-Way ANOVA. Tables and graphs were used to illustrate the results of the study.

3. Results and Discussion

3.1Overall students' perception on computer simulated laboratory (CSL) and hands-on laboratory experiment (HLE)

Respondents from CAS preferred the HLE compared to CSL (refer Table 1). By doing the hands-on laboratory experiment, students can develop critical observation, interpretation, assessment and practical problem which support the learning of theory. Further, respondents from CEA preferred CSL (refer Table 2-4). The CSL application had the potential of giving a chance to carry out the experiment virtually [22]. Likewise, student respondents from CIIT preferred the CSL than HLE (refer Table 4). Respondents chose this application owing to convenience of accessing technology, without requiring all the teaching materials or the apparatuses [17].

Table 2. CAS student's response on HLE and CSL survey questionnaire

Questions/Statements	HLE					CSL				
	TA	A	TD	D	DK	TA	A	TD	D	DK
Obtain accurate data	10	29	4	1	0	11	25	1	1	2
Easy to use/access	15	27	1	2	0	5	19	1	0	2
Using this is time consuming	15	22	5	2	1	18	12	9	13	2
Easily understand concept	15	26	2	1	0	14	22	2	0	2
Acquire sufficient knowledge in physics	21	21	2	0	0	14	20	1	0	4

HLE: Hands-on Laboratory experiment; CSL: Computer Simulated Laboratory; TA: Totally Agree; A: Agree; TD: Totally Disagree; D: Disagree; DK: Don't Know

Table 3. CEA student's response on HLE and CSL survey questionnaire

Questions/Statements	HLE					CSL				
	TA	A	TD	D	DK	TA	A	TD	D	DK
Obtain accurate data	7	10	4	4	4	12	8	0	0	8
Easy to use/access	7	13	1	4	0	14	1	1	0	1
Using this is time consuming	10	8	5	7	0	13	6	9	5	4
Easily understand concept	8	2	2	2	1	12	8	11	0	5
Acquire sufficient knowledge in physics	10	13	2	2	2	0	11	13	0	0

HLE: Hands-on Laboratory experiment; CSL: Computer Simulated Laboratory; TA: Totally Agree; A: Agree; TD: Totally Disagree; D: Disagree; DK: Don't Know

Table 4. CIIT student's response on HLE and CSL survey questionnaire

Questions/Statements	HLE					CSL				
	TA	A	TD	D	DK	TA	A	TD	D	DK
Obtain accurate data	8	7	2	2	0	13	13	3	1	9
Easy to use/access	5	9	2	2	1	12	17	3	11	5
Using this is time consuming	8	3	3	1	17	9	7	3	7	12
Easily understand concept	7	8	3	1	0	11	17	1	3	8
Acquire sufficient knowledge in physics	8	8	3	0	0	12	15	3	1	8

HLE: Hands-on Laboratory experiment; CSL: Computer Simulated Laboratory; TA: Totally Agree; A: Agree; TD: Totally Disagree; D: Disagree; DK: Don't Know

Overall, CSL was the preferred laboratory method by student respondents in all surveyed colleges despite being unavailable (see Figure 2). About 54 % of the students preferred the CSL whereas 46% students preferred HLE (Figure 3). The students from CAS and CEA had relatively comparable response towards laboratory preference (either

CSL or HLE). Distinctively, students from CIIT preferred the CSL than HLE. Studies in the past similarly showed a comparable effectiveness between virtual laboratory and the traditional hands-on physics laboratory [25], suggesting homogeneity of students' response.

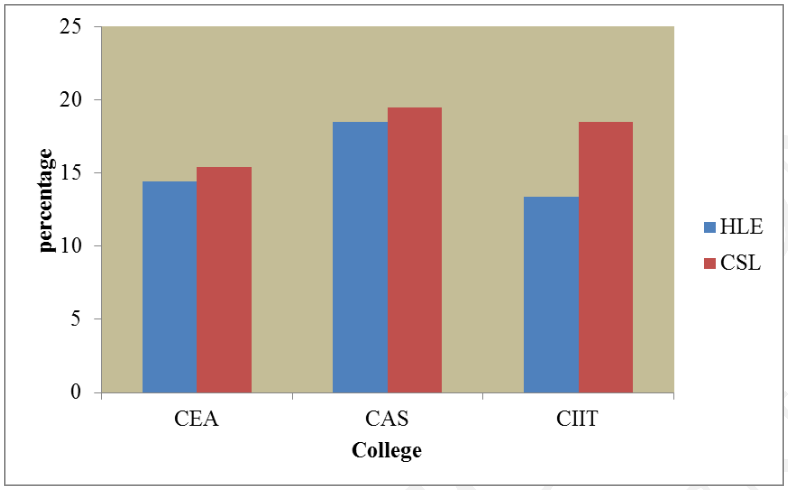

Figure 2. Percentage of each colleges preferred laboratory experiment tool

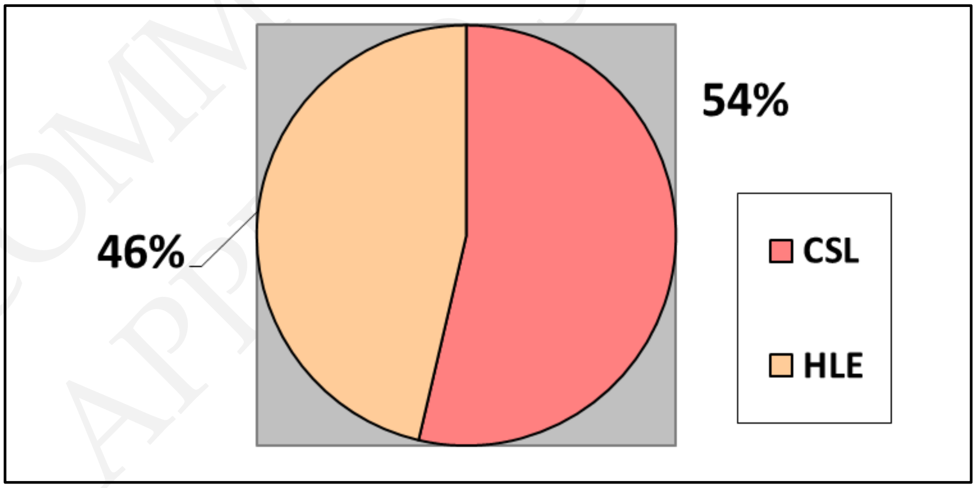

Figure 3. Over all calculated percentage between HLE and CSL preferred by the student's from CAS, CEA and CIIT.

3.2 Preference of students based on gender

Table 5 presents summary of results for statistical test. ANOVA showed p>0.05 indicating no significant difference between gender with regards to laboratory tool preference. Likewise, it can be extrapolated that gender had no significant effect on the students' preference on laboratory tools (e.g. CSL and HLE). Previous studies revealed disproportionate gender gaps having male students outperforming female students in physics [26] [27]. Present findings however were considerable disagreeing with previous studies possibly as a consequence of perception analysis.

Table 5. ANOVA results on the performance of students tested at *p*=0.05

Source of Variation	P-value	F-critical	Decision
Gender	0.811038	5.317655	Accepted
Perception	0.904711	5.317655	Accepted
Gender x Perception	0.904711	5.317655	Accepted

3.3 Preference of students by college

Results in Table 6 showed no significant difference among students responses by college (p>0.05). This indicates that regardless of the college the students may belong, they had the same preference on utilizing physics laboratory tools. This was evidenced by the preference on CSL than HLE (section 3.1). Study in the past similarly indicates no significant difference on the conceptual understanding between simulated vs. hands-on activity [28]. This further suggests that regardless of the variables considered, both CSL and HLE may not differ.

Table 6. Summary of ANOVA results by college

College	Source of Variation	P-value	F-critical	Decision
CAS	College	0.379456	4.084746	Accepted
	Perception	0.104511	2.605975	Accepted
	College x Perception	0.103409	2.605975	Accepted
CEA	College	0.208676	4.084746	Accepted
	Perception	0.204741	2.605975	Accepted
	College x Perception	0.256369	2.605975	Accepted
CIIT	College	0.208676	4.084746	Accepted
	Perception	0.204741	2.605975	Accepted
	College x Perception	0.256369	2.605975	Accepted

.

4. Conclusion

Overall, no apparent differences appeared with respect to the questions on the conceptual understanding learning objectives; thus, it may be that computer simulated laboratory offer an equivalent laboratory experience to hands on laboratory experiment. More studies with larger sample sizes and perhaps tests measuring mastery of material as opposed to subjective self-reported experiences would be useful in establishing the effectiveness of computer simulated laboratory with respect to conceptual understanding. Although the three colleges preferred CSL as the laboratory model, the extent of CSL functionality was not tested in the field of Physics and is not yet available locally. This research was done to introduce the CSL method in the field of Physics, since the contribution of this method is both beneficial to the students and instructors. Overall, regardless of the student's factors evaluated there was no significant difference between CSL and HLE among the three former colleges of USTP (CAS, CEA and CIIT) and between genders.

References

[1] Sarı, M. (2011). The importance of laboratory courses in science and technology teaching in primary education and the ideas of simple tools and instruments to evaluate teacher candidates on science experiments. 2nd International Conference on New Trends in Education and Their Implications. Antalya.

[2] Bredderman, T. (1985). Laboratory programs for elementary school science: A meta analysis of effects of learning. *Science Education, 69*(4), 577-591

[3] Freedman, M. P. (1997). Relationships among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching, 34*(4), 343-357.

[4] Glasson, G. E. (1989). The effects of hands-on teacher demonstration laboratory methods on science achievement in relation to reasoning ability and prior knowledge. *Journal of Research in Science Teaching, 26*(2), 121-131.

[5] Shymansky, J. A. (1989). What research says about ESS, SCIS, and SAPA. *Science and Children, 26*(7), 33-35.

[6] Staver, J. R., & Small, L. (1990). Toward a clearer representation of the crisis in science education. *Journal of Research in Science Teaching, 27*(1), 79-89. [7] Stohr-Hunt, P. M. (1996). An analysis of frequency of hands-on experience and science achievement. *Journal of Research in Science Teaching, 33*(1), 101-109.

[8] Turpin, T. J. (2000). A study of the effects of an integrated, activity-based science curriculum on student achievement, science process skills, and science attitudes. *Dissertation Abstracts International,* 61(11), 4329A (UMI No. AAT 9993727).

[9] Coştu, B., Ünal, S., & Ayaş A. (2007). A hands-on activity to promote conceptual change about mixtures and chemical compunds. *Journal of Baltic Science Education, 6*(1), 35-46.

[10] Bilgin, İ. (2006). The effects of hands-on activities incorporating a cooperative learning approach on eight grade students' science process skills and attitudes towards science. *Journal of Baltic Science Education, 1*(9), 27-37

[11] Bredderman, T. (1983). Effects of activity-based elementary science on students' outcomes: A qualitative synthesis. *Review of Educational Research, 53*(4), 499-518.

[12]Bristow, B. R. (2000). The effects of hands-on instruction on 6th grade students' understanding of electricity and magnetism. *Dissertation Abstracts International, 39*(01), 30A (UMI No. AAT 1400301).

[13] Jaus, H. H. (1977). Activity-oriented science: Is it really that good? *Science and Children,14*(7), 26-27.

[14] Schibeci, R. A., & Riley, J. P., Jr. (1986). Influence of students' background and perceptions on science attitude and achievement. *Journal of Research in Science Teaching, 23*(3), 177-187.

[15] Haury, D. L. & Rillero, P. (1994). *Perspectives of hands-on science teaching*. Retrieved January 2, 2003 from http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/eric/eric-toc.htm

[16] Lebuffe, J. R. (1994). *Hands-on science in the elementary school*. East Lansing, MI: National Center for Research on Teacher Learning (ERIC Document Reproduction Service No. ED 375003).

[17] Lawson, A. E. (2000). Managing the inquiry classroom: problems & solutions. The American Biology Teacher, 62 (9), 641-648.

[18] Deters, K. M. (2005). Student opinions regarding inquiry-based chemistry experiments. Hong Kong: Government Logistics Department.

[19] Cheung, H.Y. (2008). Teacher efficacy: A comparative study of Hong Kong and Shanghai primary in-service teachers. The Australian Educational Researcher, 35 (1), 103-123.

[20] Hofstein, A., & Lunetta, N. V. (1982). The role of the laboratory in science teaching: Neglected aspect of research. Review of Educational Research, 52 (2), 201-217.

[21] Domin, D.S. (1999). A review of laboratory instruction styles. Journal of Chemical Education, 76(4), 543-547.

[22] Finkelstein, N. D., Adams, W. K., Keller, C. J., Kohl, P. B., Perkins, K. K., Podolefsky, N. S., Kyle, W. C., Bonnstetter, R. J., & Gadsten, T. (1988). An implementation study: an analysis of elementary students' and teachers' attitudes toward science in process-approach vs. traditional science classes. *Journal of Research in Science Teaching, 25*(2), 103-120.

[23] Akpan, J. P. (2001). Issues associated with inserting computer simulations into biology instruction: a review of the literature. Electronic Journal of Science Education.

[24] Sokoloff, R.K. (1997) Thornton. Using interactive lecture demonstrations to create an active learning environment. The Phys. Teach., 35:340.

[25] Darrah, M., Humbert, R., Finstein, J., Simon, M., & Hopkins, J. (2014). Are virtual labs as effective as hands-on labs for undergraduate physics? A comparative study at two major universities. *Journal of Science Education and Technology*, *23*(6), 803-814.

[26] Bates, S., Donnelly, R., MacPhee, C., Sands, D., Birch, M., & Walet, N. R. (2013). Gender differences in conceptual understanding of Newtonian mechanics: a UK cross-institution comparison. *European Journal of Physics*, *34*(2), 421.

[27] Madsen, A., McKagan, S. B., & Sayre, E. C. (2013). Gender gap on concept inventories in physics: What is consistent, what is inconsistent, and what factors influence the gap?. *Physical Review Special Topics-Physics Education Research*, *9*(2), 020121.

[28] Renken, M. D., & Nunez, N. (2013). Computer simulations and clear observations do not guarantee conceptual understanding. *Learning and Instruction*, *23*, 10-23.