ETEC 543 Action Research Final Project, fall 2017

***The performance effects of guided experiential learning for students in the planning and wiring of electrical circuits***

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Abstract

The action researchers of this study cited a problem in traditional community college lectures on electricity and electronics as related to the construction of circuits where wiring methods were not effectively taught. They proposed a solution to this deficiency, called the Leighton-Graham Method (LGM) of guided, hands-on, experiential learning that was tested in this mixed-methods quasiexperimental study. Two separate courses of beginning electricity students participated. A control group of 11 students and a treatment group of 19 students were pre, and post-tested using a hands-on wiring performance test to ensure the groups were roughly equal in beginning wiring skill levels. Scores were assigned based on a performance rubric. An exit survey was administered to each group after the post-tests, to gather qualitative information to help clarify the quantitative post-test results. Even though the researches admitted that the participant groups were small, they stated that their LGM appeared to be what enabled the treatment group to achieve 100% success on the hands-on wiring post-test, as compared to only 45% in the control group, and in 34% less time than the control. While both groups contained roughly the same number of participants with a history of work experience that included wiring, only those participants in the control group could wire their circuits properly during the post-test. While the researchers felt that their LGM had made a significant difference in the performance between the two groups, they also stated that more research needed to be conducted.

Introduction

Community colleges work closely with local industries that hire their graduates. "Career and Technical Education (CTE) has traditionally been viewed as the cornerstone of workforce preparation" (Asunda, 2012). Our topic is: ***The performance effects of guided experiential learning for students in the planning and wiring of electrical circuits.*** Therefore, the goal is to make these CTE college electrician students more marketable by learning this new information about wiring electrical circuits, in new ways. Recently, twenty of the largest employers in America jointly requested that electrician students be taught how to wire electrical circuits more effectively, because this skill is becoming a serious deficiency in industry. This area of study has not been taught through traditional methods in community colleges, but only in university engineering schools. So, industrial technicians may never receive this training. Therefore, we explored how to translate the Leighton-Graham Method (LGM) of circuit planning and wiring, from electronics over to the electrical trades, to accomplish this goal, set by industry leaders.

To test our ideas, we envisioned having two beginning electrical courses sampled, to see if the LGM might be an effective training modality. The challenges that were encountered were not having enough of the identical devices for each student to work individually, with the same hardware. So, substitution of functionally equivalent parts was required. Most lab projects are done in teams at our college, when in normal lab situations, so that fewer supplies are required. Another problem was having enough repeat students in classes for teaching and testing on consecutive nights, using the same students. This limitation would reduce the number of qualified participants to maintain continuity in the training and testing. A goal was set to see if the treatment group, receiving the hands-on LGM training in guided, hands-on, experiential lecture/demonstrations would benefit more than the control group who only received the traditional training.

This action research report, will illustrate our findings from the quantitative and qualitative data collected. At the outset of this study, it was hoped that it would demonstrate that the alternate LGM training for the treatment group would enhance their overall performance and understanding of the new methods to be learned, as compared to just the traditional lecture the control group would receive.

This report will also show what we discovered through literature review, the methodology we employed, statistical findings from our research of our two groups, as well as the materials we created and implemented for the treatment group, all of which can be found in the appendix section of this report.

Literature Review

The literature review for the project covered many aspects of our scope of interest. According to Burgher (2015) “Results indicate that 72% of students receiving the hands-on (Desktop Learning Modules) DLM treatment thought it helped more than lecture; of those receiving lecture,…”(p. 44). This came from the Burgher article, “Implementation of a Modular Hands-on Learning Pedagogy: Student Attitudes in a Fluid Mechanics and Heat Transfer Course”. At the IEEE conference in India, Pranab et al (2014) gave a paper on “A novel wiring planning technique for optimum pin utilization in Digital Microfluidic Biochips”. Illustrating the universal wire routing and planning can be transferred to full-scale electrical circuits, such as we are proposing to optimize, using the LGM for the planning and wiring of electrical circuits. This further adds to the scaffold of supportive information mentioned in the previous Burgher article about the effectiveness of hands-on training experiences. In reading Hyun’s et al article “Students' Satisfaction on Their Learning Process in Active Learning and Traditional Classrooms” helped to substantiate our premise that our students do better with hands-on activities rather than straight lecture classes. The results of their study show that ALEs increase student satisfaction directly, and served to boost student learning actions productivity and retention positively. So, the guided learning experiences of the LGM of planning and wiring electrical circuits both satisfies our CTE hands-on learners, and engages it them in their own natural learning styles, which makes the experience even more meaningful and memorable for them. “Teaching for Engagement: Part 3: Designing for Active Learning” by Hunter (2015) outlined the theory behind his rationale on the classroom Active Learning Environment (ALE) an subsequent research, using case-based methods of teaching and problem learning, as he termed it. He went on to describe means of facilitating contemporary technologies in traditional classrooms to support ALE. Active Learning Environments for CTE students means to me that hands-on activities will be included to both establish and maintain full engagement with these hands-on learners, but also so true that learning may begin through tactile feedback from the objects being manipulated, as though the devices are revealing their secrets to the learners via an immersive communications link, akin to telepathy for these learners—that is, experiential learning. Furthermore, the memory retention of first-hand experiences, such as these are more lasting and personally internalized by hands-on learners. Cattaneo (2017) addressed the difficulty in dealing with a transition from traditional transmission-based lectures to Active Learning Environments (ALEs) in his paper “Telling Active Learning Pedagogies Apart: From Theory to Practice”. He believes that inquiry and discovery are strong tools for learning that are rooted in student projects, where hands-on, discovery learning, and experiential learning modalities naturally occur. He classified five ALE pedagogies that are based on six constructivist ideas, related to PBL. This article reflects our findings, where Project Based Learning (PBL, not to be confused with problem-based learning) as a benefit to our treatment group, as compared with only the traditional lectures transmitting information to our control group. Asunda (2012) focuses on STEM Literacy as the CTE cornerstone of our modern economy, and the skills needed to keep it growing, which is right on target for our research project.  We researched more articles that can be found in the Appendix-A.

Methodology

Action Research Questions

***Will guided experiential learning practices in the planning and wiring of electrical circuits impact student hands-on performance skills? If so, what will the impacts be?***

Data Collection

We collected both Quantitative (quasiexperimental), and Qualitative (voluntary answers to survey forms), to triangulate the data for better understanding of the results. We used the pretest / posttest method of comparative assessment. Community College CTE students in each of two beginning electrical classes were tested and compared. Prior to any instruction, both groups took a hands-on performance based pretest to assess their entry-level abilities, in the previous class, for 3-hours duration. One classroom of students served as the control group with 11 participants that did not receive the treatment, but received the traditional training in electricity and circuits, for 3-hours duration. The 19 participants of the treatment group classroom received the alternate training through the use of the LGM guided experiential learning instruction for planning and wiring of electrical circuits for the same 3-hour duration. True-random selection of participants in each group will not be possible. We used opportunity-selection of participants, resulting from chance-enrollments in each class. At the end of training, both groups of students were evaluated based on the same hands-on performance test that measured the accuracy and effectiveness of their skills. For our quantitative results, there were two measures of hands-on performance (1) the length of time each student took to plan and wire the circuitry correctly; (2) the number of wiring errors each student exhibited, prior to getting the assigned circuit wired to properly function. Successful demonstrations to the instructor/evaluator were used as evidence of proper functionality. Failures were recorded as error incidents for each anonymous student I.D.; and, each student then needed to repair the errors, iteratively, until successful operation was achieved and recorded. The hands-on performance posttest at the end of all instruction was used to calculate the change in the learners’ performance skill levels. After this posttest was administered and collected, a Qualitative exit survey questionnaire was given to students, so that their feedback could be later analyzed to help the researchers better understand the Quantitative data (and revisions made, as needed, based upon later reflection). This survey was comprised of a total of 15 open-ended questions, with four Likert-type questions—19 in all. See Appendix-B (primary and supplemental online survey questionnaire links); see Appendix -C for instruments used to gather data, record responses; see Appendix -D for analysis of the results; see Appendix-E for general handouts; see Appendix -F for the LGM materials the treatment group received throughout the study; and see Appendix -G keys to wire-listings and planning.

Data Analysis

As part of a holistic process to assure validity and reliability of test data, both pretest and posttest data was collected and judged to be relatively equal between the two groups, so that the performance results of the hands-on posttest could be generalized to represent a much larger population of students. If the initial study questions had been translated into hypotheses, then chi-squared statistical methods could have been effectively used to compare the results through the corresponding p-value, to demonstrate significance in outcomes between the two groups. But, because questions were used instead, answers were sought to satisfy them using educated judgment, guided by the resulting statistical values of the two groups. Mean values and low-population standard deviation values were calculated for each data set. Then, like values from each group were compared from the quantitative data gathered of the final hands-on performance test scores. To triangulate (the text calls it polyangulation) the results of the qualitative survey questions and answers were categorized into similar groups. Then, the responses were tallied as a frequency of occurrence, in percentages of total similar responses, having been further categorized as positive, neutral, or negative in nature. This is where the participants’ previous wiring experience numbers, and other added information emerged to clarify aspects of the meaning of the quantitative data.

Results

While both groups contained roughly the same number of participants (control=5; treatment=6) with a history of work experience that included wiring, only those participants in the control group could wire their circuits properly during the hands-on performance posttest. In the wiring performance posttest, quantitative analysis showed that only five out of 11, or 45% of control group participants successfully got their circuits wired to function properly within the allotted time of three hours. Of the successful five in the control group, the average time required for success was 139 minutes. Average point-scores, according to the grading rubric in Appendix-D, were as follows: the average control group score was 39%, with a standard deviation of 22%; while the average treatment group score was 89.5% with a standard deviation of 6.7%.

Qualitative data from open-ended and Likert-scale question responses on the exit surveys were grouped together into coded categories. These categories were characterized as: enjoyment; adequacy of instruction; improvement of training; hands-on learning; post-test self-performance assessment; and previous wiring experience. From those surveys, the control group indicated that 10 of their 11 (91%) members were hands-on learners, as compared to 19 out of 20 (95%) in the treatment group. The other responses to each of the qualitative categories were subsequently judged to be: positive, neutral, or negative. Referring to the Qualitative Summary of both Groups by Category from the Questionnaire links in Appendix -B, the scores indicated that about 66% of the control group and 73% of the treatment group enjoyed the experience of the hands-on performance testing. 73% of the control group assessed their own performance as being negative on the post-test, as compared to only 10% of the treatment group being negative about their post-test performance. When asked how participants felt about how well prepared they were to do the wiring of the post-test, only 49% of the control group felt good, as compared to 72% of the treatment group. Open-ended comments about how the instructional experience could be improved were around 60% neutral for both groups, with about 20% positive, and 20% critical of the training they received.

Summary and Conclusions

Even though the participant groups were small, the Leighton-Graham Method appeared to make the difference in enabling the treatment group to achieve 100% success on the hands-on wiring post-test, as compared to only 45% in the control group, and in 34% less time than the control group. Based upon the performance data gathered in this Action Research project, the answer to our initial question, “Will guided experiential learning practices in the planning and wiring of electrical circuits impact student hands-on performance skills?” seems to be Yes. While the Leighton-Graham Method of guided hands-on planning and wiring of electrical circuits seems to have made a substantial improvement in the skills of participants in the treatment group, there are probably many ways in which this treatment can be improved. While further study is encouraged, it is safe to say that the actual results of this research astounded us, when compared to our expectations. We believed that our method would be generally effective, but we never imagined that the success rate would be 100% for treatment group participants, where 68% of them had no previous work experience related to the wiring of electrical circuits. This surprised us because nearly half of the control group members had previous work experience related to wiring, yet less than half of them were successful in wiring their circuits properly without receiving the treatment, given three-hours to complete the task.

The second question we asked was, “If so, what will the impacts be?” It is safe to say that the impacts were that improvements were seen in both: (1) student performance; and (2) student satisfaction through use of the guided hands-on, experiential learning provided through use of the Leighton-Graham Method of planning and wiring electrical circuits for the treatment group, as compared to the control group.

Future Actions and Directions

The sample population of our study was very small. So, conclusions based upon these low numbers could be faulty, based upon the logical fallacy of hasty generalizations. Because the best statistical data comes from large sample sizes, this research needs to be repeated and hopefully correlated to demonstrate even greater relevance and reliability. While the analysis of our data suggests somewhat strongly that teaching students how to plan and wire electrical circuits by the Leighton-Graham Method is an effective process, further research needs to be conducted. Both our Action Research and our teaching methods will be evolving over time. Our desire is to optimize the ways we can accomplish the over-arching goal--preparing teachers to train technicians and future engineers how to more effectively plan and wire electrical circuits, to better serve the needs of industry.

Reflections

We wish to continue to improve and enhance our Leighton-Graham Method of teaching and increase and expand the areas our method can cover, to incorporate more CTE topics. We see that what we have started, can branch out into other areas such as robotics, engineering, fluid power systems, manufacturing and maintenance where there is a high demand for highly trained personnel in our modern workforce. Along the way, we plan to iteratively re-enter the Action Research process, as we strive for continuous improvement, based upon evidence we gather from future studies.

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**Appendix Table of Content**

APPENDIX-A Literature Review - 13 Annotated Bibliographies

APPENDIX-B Links to Google forms for questionnaires

APPENDIX-C Data Collection forms

Assessment Instrument Time Score Sheet Blank

APPENDIX-D Results

Quantitative

Qualitative

Responses

APPENDIX-E General handouts

Schematic

Datasheet for control circuit

Scoring Rubric

APPENDIX-F LGM materials

Wire List Blank form

Transition Matrix Blank form

APPENDIX-G completed LGM examples

Schematic w/color and lettering

Wire List Blank form

Transition Matrix Blank form

**[These appendices are all located in the attached zipped folder, with the CSUSB 543 submission.]**