AC 2011-1636: INFORMAL ENERGY EDUCATION: FUEL CELL EXHIBIT PILOT STUDY

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Informal Energy Education: Fuel Cell Exhibit Pilot Study

Abstract

This paper addresses the growing need for renewable energy education, by looking at the design, development, and implementation of an informal energy education exhibit that was developed to be placed in regional science museums, local schools, and community centers. This study examined the hypothesis that an informal energy education exhibit would yield a significant increase in participant's knowledge of energy concepts as well as motivation for and attitudes towards renewable energy. An initial pilot study showed significant learning occurred, though only lower level learning was assessed.

Literature Review

Motivated by energy security requirements and the desire to create a sustainable and safe environment, there is a growing need to transition gradually from fossil fuels toward new and emerging energy solutions. An important component of addressing the global energy challenges of the future will involve public understanding and acceptance of new and emerging energy technologies as safe and reliable sources for transportation fuels, energy storage, and power generation [1]. Creating a highly educated workforce who will contribute to overcoming the energy challenges and increasing the public awareness of the challenges and opportunities are essential components in bringing about the transition [6]. Informal science education approaches can be applied to promote energy literacy at all levels, by providing opportunities for the public to interact with energy technologies in a community-based environment [4]. For this paper, informal means educational interactions which take place outside of the classroom. Educating youth through informal channels strengthens the formal school learning, and provides early exposure to concepts and applications that will be required knowledge in the workforce of the future [2].

The goal of the proposed research is to expand efforts in new and emerging alternative energy education needed to meet the growing global energy needs. Informal science education methods will be applied to the energy discipline to provide public exposure to the high-profile concept of hydrogen and fuel cell technology. This study examined the hypothesis that an informal energy education exhibit would yield significant increase in student's knowledge of energy concepts and motivation for and attitudes towards renewable energy. However, this pilot study looked at only performance. The target audience is focused at 4th and 5th grade students but has been designed to engage older students and adults and encourages social interaction and scaffolding among participants of different levels of understanding. However, this pilot study collected data on only college student interaction with the exhibit.

This preliminary research is the first step in a large-scale informal energy education program covering multiple energy technology areas (e.g., solar, wind, bio-energy, etc.). Our vision is to develop several permanent outdoor energy demonstration exhibits throughout Indiana, which will promote overall energy literacy through broadly disseminated energy education sites. This type of setting bears a closer resemblance to the natural world, were the opportunity for informal education is everywhere [5].

Previous research has altered the design of the exhibit; Falk's paper looked explicitly at the effect of labeling the exhibit with a concept title and found that it significantly improved the understanding of the visitors [4]. Therefore the design of the fuel cell (FC) exhibit included the title 'Our Energy Future: Hydrogen and Fuel Cells' which provides a foundation for storing and retrieving information. Inkpen showed that children tend to play in groups and that groups have a significant impact on learning compared to individual learning [3]. Thus, the exhibit concepts were separated into three areas to allow visitors to naturally group up around a concept and share their ideas within their group. The exhibit was also designed for a social constructivist viewpoint which allowed for group interaction, active involvement, purposefully manipulating objects, and inter-group discussion which were identified as important factors in learning by Falk [2].

Methods

The context for the study was a fuel cell exhibit that was developed to be displayed in small regional museums, interactive science centers, local G4-12 schools, and community centers. These sites target elementary students, but engage older students and adults, and provide exhibits that engage students in informal science education that is directly related to state academic standards. The target audience typically arrives at the museum or interactive science center in one of two ways, either as part of a school tour or with their families, both of which afford the opportunity for both guided and self guided interaction in a social constructivist framework. However, for the pilot study the exhibit was viewed by the participants, as a group, in the workshop where it was constructed. A group viewing was selected to maintain the social constructivist framework, but no guide was provided and only the self guided case was analyzed in this paper.

A convenience sample of mechanical engineering technology students were selected for the study. The sample consisted of ten students. The demographics show ninety percent were male, ten percent were female, sixty percent were undergraduate, forty percent were graduate, eighty percent were Caucasian, ten percent were African, and ten percent were Hispanic. The students were selected based on their proximity to the applied energy lab, most had completed an introductory 'Heat & Power' course and most were in a graduate 'Facilities Engineering' course, both of which cover some content on renewable energy. The students were separated into two groups using a stratified random method such that an equal number of undergraduate and graduate students were assigned to each group. Finally, the groups were stratified into a Control group and an Experiment group by forcing the one individual with prior fuel cell knowledge, and the rest of his randomly assigned group, into the control group.

The participants assigned to the control group were given a pre-test to determine prior knowledge of renewable energy topics, specifically fuel cell technology, operation, and concepts. The pre-test consisted of five questions and they were allowed five minutes to complete the test, although no one utilized the full time allowed. Next, the control group watched a video for ten minutes. The video discussed the importance of renewable energy topics in the context of joining a club that deals with certain aspects of those topics, but gave no factual information about the topics or fuel cells. Finally a post-test was provided which also contained five questions, two of which were repeated from the pre-test. The participants were again given five minutes to complete the test and again did not avail themselves of the full time allotment.

The participants assigned to the experiment group were given a pre-test to determine prior knowledge of renewable energy topics; the pre-test was the same as that used for the control group. As with the control group the experiment group were allowed five minutes to complete the test, although no one utilized the full time allowed. Next, the experiment group was taken to a fuel cell exhibit and given access to visual information, textual information, and manipulable objects related to renewable energy, power, and fuel cell technology and concepts as shown in Figure 1, Figure 2, and Figure 3. Figure 1 shows the factual information provided to the experiment group. The information was divided into four zones which, from left to right, give examples and illustrations about energy, electrolysis, fuel cell operation, and fuel cell applications. The interactive PowerPoint™ in the center of the exhibit provided more in-depth coverage of electrolysis, fuel cell types, construction, and applications.

Figure 1: Fuel Cell Information

Figure 2 illustrates a close-up view of the electrolysis manipulable; due to concerns about hydrogen generation inside public spaces, it only simulates the actual process. The simulation started when participants pressed the blue button, which filled the tank with water. Then when the green button was pressed the ‘sun’ light turned on which ‘created’ an electric current that ran down the wires to the electrodes in the water and produced ‘hydrogen and oxygen’ bubbles which were trapped in the smaller storage tanks. The participants could see the information related to the manipulable in the information cloud above while interacting with the manipulable object.

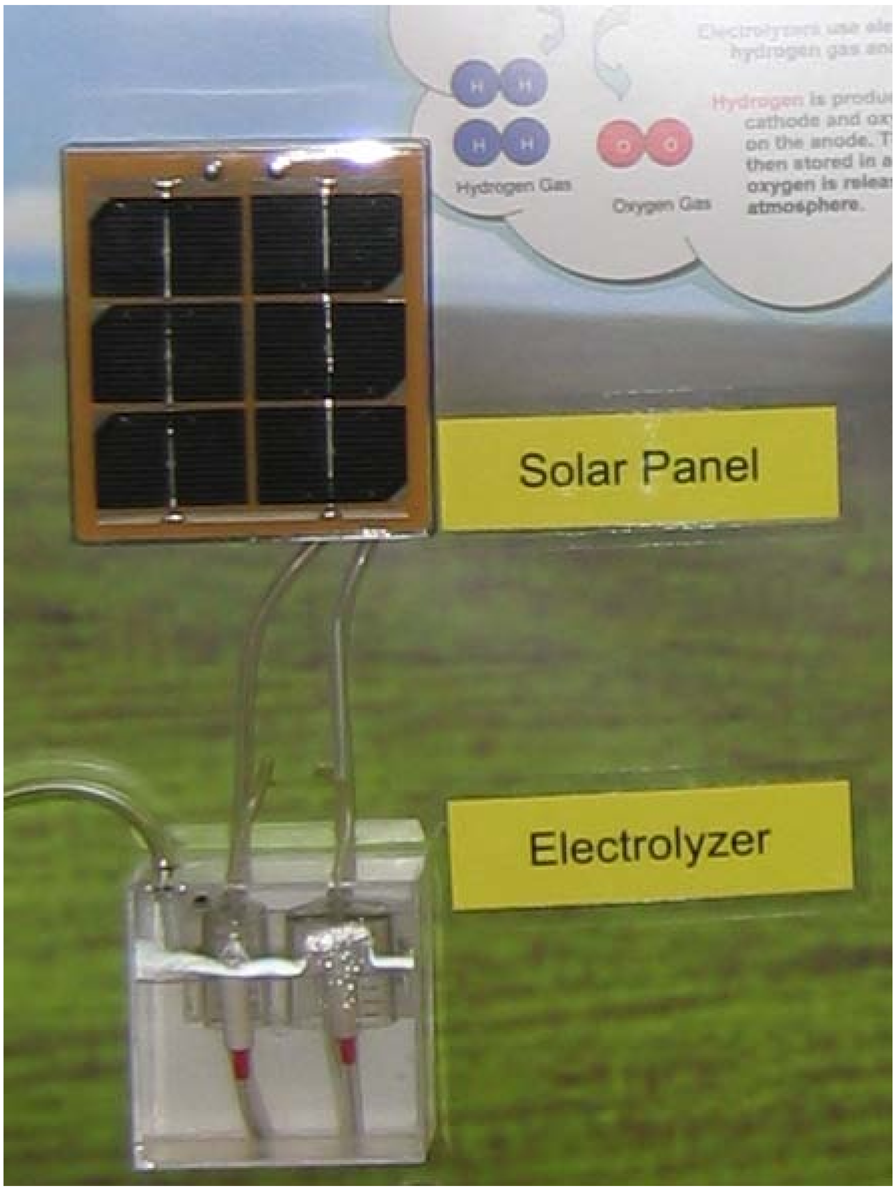

Figure 2: Manipulable Object: Electrolysis

Figure 3 illustrates a close-up view of the fuel cell components manipulable, in which each element of a PEM type fuel cell was labeled. When the proper element was placed in the correct order a green light illuminated and when all elements were in place and the green button was pressed the wheel on the Hummer® would start spinning and the lights in the house would illuminate.

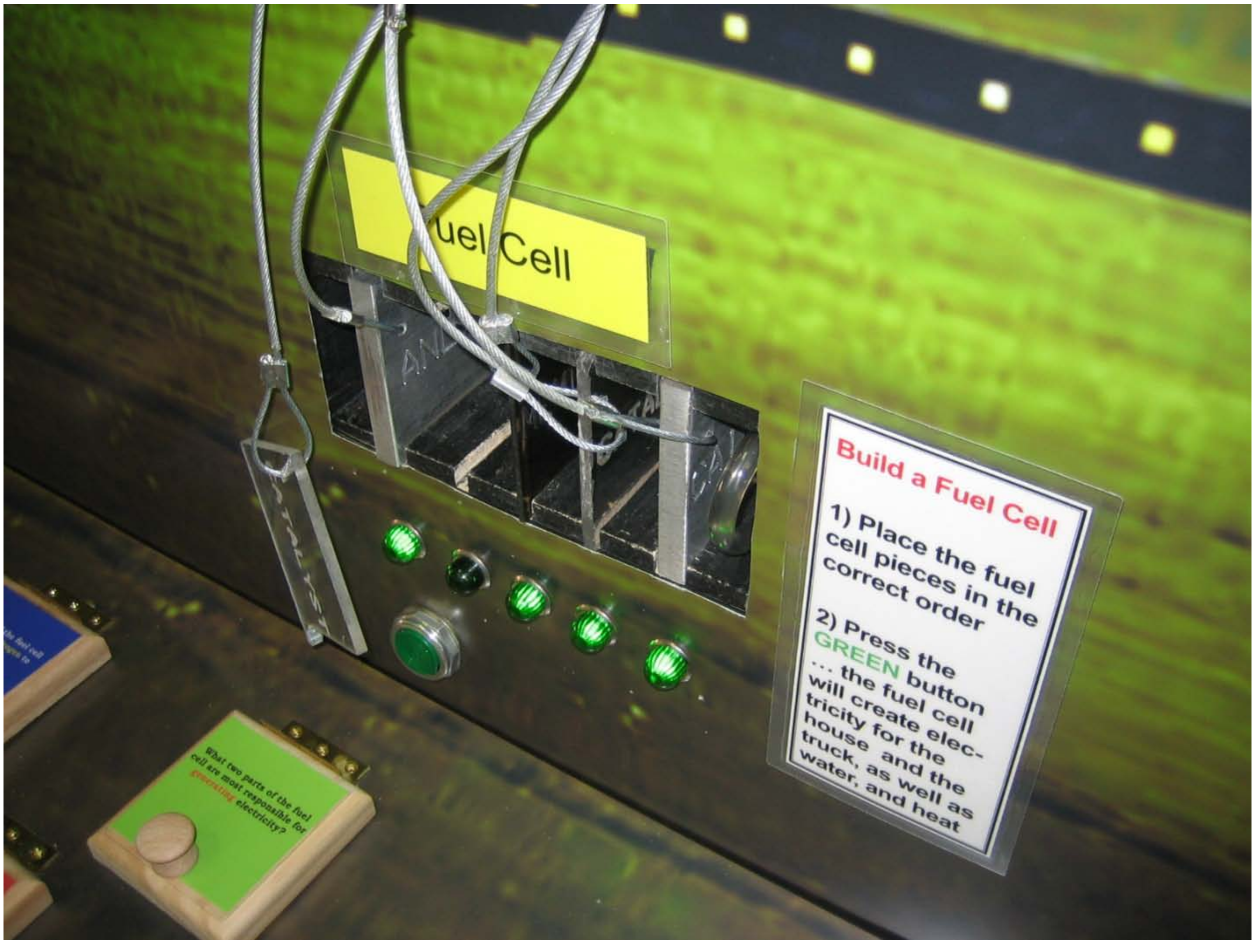

Figure 3: Manipulable Object: Fuel Cell Components

The experiment group were allowed ten minutes to interact with the exhibit, during which they were observed reading the information clouds on the exhibit, looking at the graphics on the exhibit, manipulating the fuel cell and other components, and discussing the exhibit among their group. Finally a post-test was provided which was again the same as that provided to the control group. The participants were again given five minutes to complete the test; the experiment group post-test took noticeably more time to complete than did their pre-test or the pre and post test of the control group. A thirty second warning was given and one participant utilized the full time allotment.

Results

The Control group pre-test results are based on five questions for which either a one was given for a correct response or a zero was given for an incorrect response. The pre-test assessed the prior knowledge of the participants on factual information about fuel cells using a short answer format that yielded a mean of 2.4, a standard deviation of 1.1402, and a standard error of 0.51.

The Control group post-test results are based on five questions for which either a one was given for a correct response or a zero was given for an incorrect response. Additionally, two questions were repeated from the pre-test. The post-test assessed whether any change in knowledge occurred without a treatment and was used as a baseline for comparison with the experiment group. The post-test for the Control group yielded a mean of 1.8, a standard deviation of 1.1304, and a standard error of 0.58.

The Experiment group pre-test results are based on the same pre-test given to the Control group. The Experiment group pre-test yielded a mean of 2.4, a standard deviation of 0.55, and a standard error of 0.25. The Experiment group post-test results are also based on the same post-test given to the Control group, which included two questions that were repeated from the pre-test. The post-test for the Experiment group yielded a mean of 4.4, a standard deviation of 0.55, and a standard error of 0.25.

As mentioned previously, two questions were repeated on the post-test from the pre-test. The first question stated 'What does a fuel cell produce?' and the second stated 'What are the four main parts of a fuel cell?' No participants in the Experiment group correctly answered either question in the pre-test. During the treatment, information was provided in the form of text and visual graphics to develop that knowledge and a manipulable object was provided to inform about the fuel cell components. As shown in Figure 4 and Figure 5, after the treatment each participant in the Experiment group correctly answered the first question but only two of five correctly answered the second question despite the manipulable object.

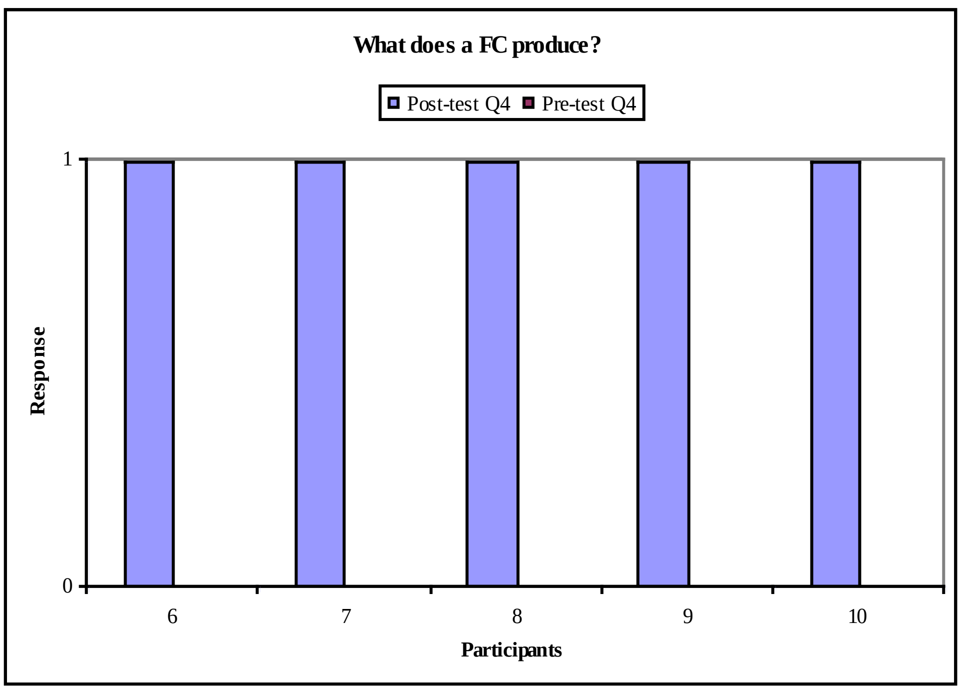

Figure 4: First Repeat Question

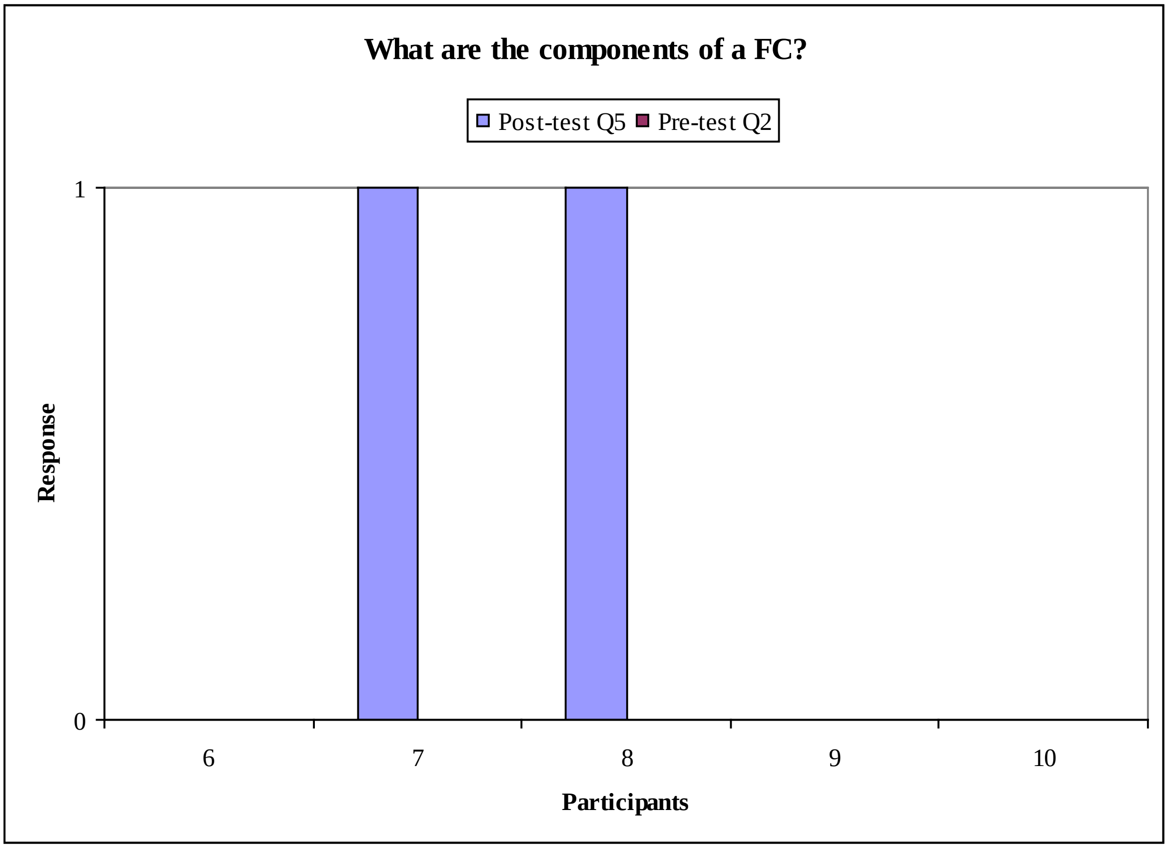

Figure 5: Second Repeat Question

Conclusions

The results for the Control group showed no significant difference between the pre-test and the post-test, with alpha = 0.05 and t = 0.77, although the mean decreased from pre-test to post-test. This indicates that with no treatment, no change in knowledge occurred even though the concept of renewable energy was discussed in the video played during the interlude.

The results also reveal no difference in mean and no significant difference between the pre-test taken by the Control group and the pre-test taken by the Experiment group. This reveals that both groups had the same level of prior knowledge about renewable energy and specifically fuel cell technology and concepts prior to the treatment. Figure 6 illustrates the pre and post test results by individual.

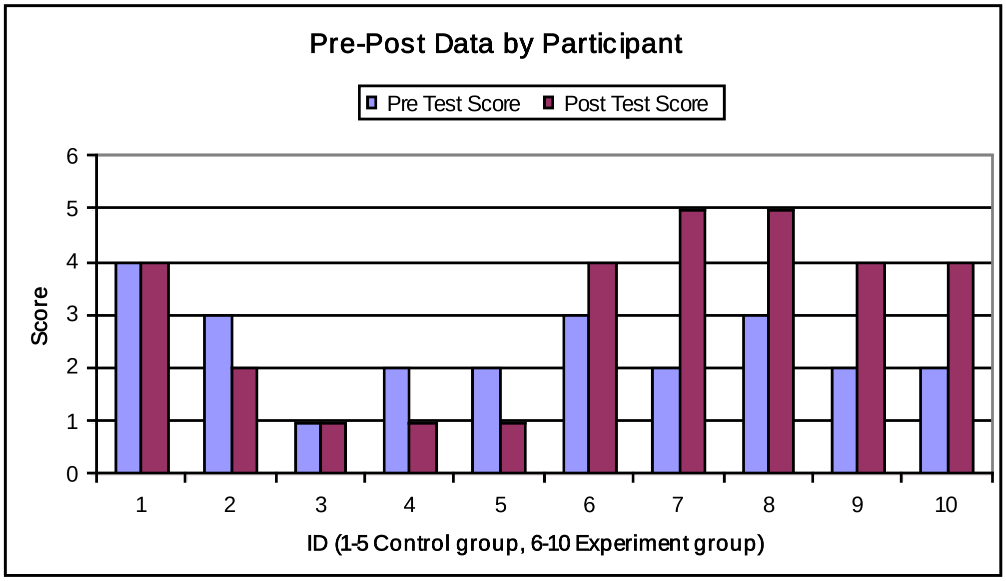

Figure 6: Test Data

Figure 6 also shows that the post-test results for the Control group tended to decline and that those for the Experiment group increased. In fact, there was a significant difference between the Experiment group's pre-test and post-test, with alpha = 0.05 and t = -5.77. There was also a significant difference between the Control post-test and the Experiment post-test, with alpha = 0.05 and t = -4.11; see Figure 7.

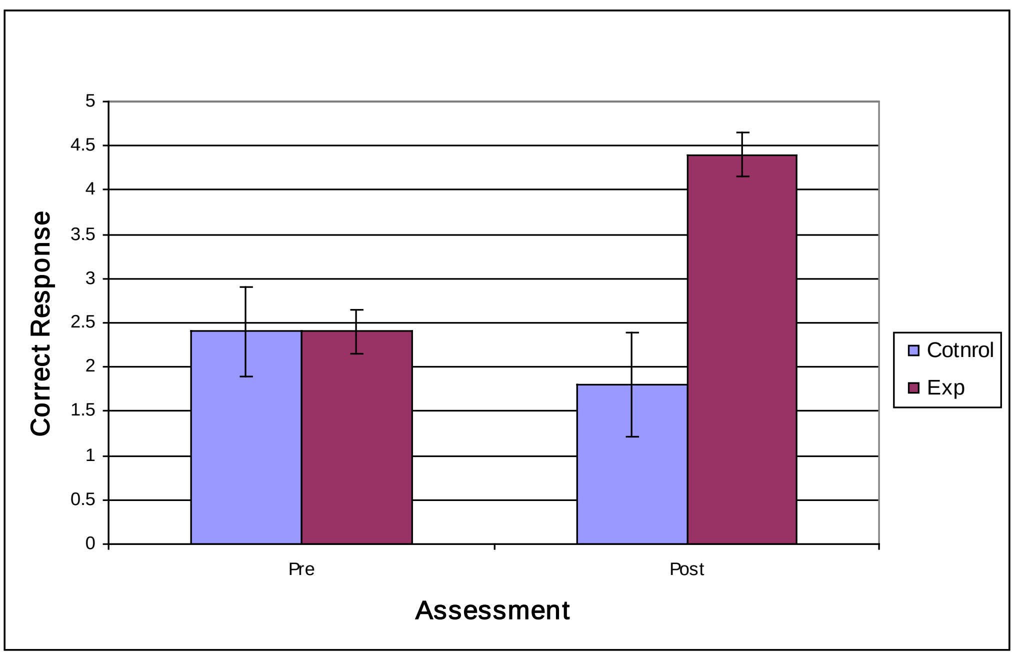

Figure 7: Pre-Post Comparison

This indicates that the treatment was successful in increasing the knowledge level of the Experiment group using and informal energy exhibit. This validates the hypothesis which stated that “an informal energy education exhibit would yield significant increase in student’s knowledge of energy concepts”. This paper further reinforces the case for museum exhibits, through which several other papers have shown a positive impact on discipline-specific content knowledge due to informal field trips [6]. Further study is warranted to make the statement definitive, given that the number of participants was small.

Additionally, the original hypothesis made statements about motivation and attitude which were not tested in this study and which would require a longitudinal study. Further study is also warranted because this study assessed only lower level factual knowledge and not the deeper energy concepts that are of more lasting importance.

Finally, it is puzzling that the fuel cell components manipulable object did not enhance the learning of the majority of the Experiment group. Further study may reveal why the components were not recalled on the post-test; whether it relates to the strangeness of the words, the requirement to recall four components, or the design of the object.

Acknowledgements

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