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Investigating Critical Thinking in Experiential Learning

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Action Research: Investigating Critical Thinking in Experiential Learning

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Abstract

This action research project reviews the relevant literature on experiential learning to research whether experiential learning promotes critical thinking in a middle school science classroom. Based on constructivism, research shows experiential learning, particularly problem-based learning, increases motivation, promotes professional skills, and multiple strategies used to solve problems. Even though its effects are difficult to measure on standardized tests and most of these research studies are small qualitative studies, this teaching method's benefits are significant enough to warrant its implementation. The results from this study show no conclusive evidence that experiential learning promotes critical thinking. Suggestions for expanding the action research study to gather more detailed data are given.

Introduction

Students occasionally have an opportunity to conduct experiential activities in science class. However, they do not regularly interact with ideas and use meaningful personal experiences to help them learn. Experiential learning is one method of providing meaningful experiences for students to construct knowledge. Because students already have a framework of knowledge before they walk into a classroom, it is much easier for them to retain knowledge and skills when they gain personal experience related to exploring a concept. These experiences are more likely to be remembered because rich and meaningful experiences give more opportunities for students to form connections with their previous knowledge than lectures or procedural activities would. Current research indicates experiential learning might improve students' knowledge and skills through meaningful experiences.

The way experiential activities help students learn by relating their direct practical knowledge to new concepts fascinates me. The idea of students "pinning" new knowledge into their memory by connecting in-class learning with previous experiences is amazing. After first encountering this idea in a psychology class, other classes and observations in various schools have further fostered my interest in this topic. It is believed teachers need to be able to effectively design rich experiential learning opportunities to facilitate students' processes of understanding material thoroughly. Teachers who utilize this process can take advantage of what their students' brains can do well by using teaching methods which integrate experiential encounters into students' learning experiences. It is vital to understand how students' experiences assist in constructing knowledge and articulate the teaching methods most effective in creating rich learning experiences.

In this action research project, the effectiveness of experiential learning in creating functional educational experiences to promote critical thinking is explored. Does engaging in experiential learning promote critical thinking skills? Though many studies have been conducted concerning various aspects of experiential learning, their collective conclusions are somewhat vague. The following literature review attempts to summarize the current research findings concerning the challenges and effectiveness of experiential learning in a middle school science classroom.

Literature Review

Small scale studies of between 35-150 participants have shown cognitive benefits of experiential learning, but there is very little generalized evidence to support it. These qualitative studies support the cognitive benefits of experiential learning not assessed on standardized tests. Experiential learning itself is a very broad term containing a diverse range of educational methods with some hands-on or interactive aspect to it (Kolb, 2014). These methods can be anything from experiments to creating models to working with physical aspects of a real-world problem. For this literature review's purpose, experiential learning will be defined as teaching methods where students learn about a concept through meaningful experiences with some stimulated aspect of the idea or learn a skill though practice. For example, students may learn about electrical circuits by experiencing this concept while trying to turn a lightbulb on by constructing a circuit. Several studies examined have shown cognitive benefits of experiential learning, but the exact benefits students would receive from implementing this method is difficult to determine.

The roots of experiential learning are found in constructionism, the idea knowledge is a built though experiences (Kolb, 2014). In 1971, David Kolb first introduced the idea of experiential learning with his constructivist theory of learning based on his own research and the work of other constructivists such as Jean Piaget and John Dewey (Kolb, 2014). After decades of research and advances in psychology and neurology, Kolb's theory is still valuable and relevant to educational theory and practice today. Kolb describes experiential learning as "A process whereby concepts are derived from and continuously modified by experience." (2014, The Process of Experiential Learning, para. 13). Students enter the classroom with their own ideas of how the world works and modify their preconceived notion only if they have meaningful experiences demanding the revision of their ideas (Kolb, 2014). Being naturally curious, children form their own, often misleading, explanations for the world they see (Kolb, 2014). Teachers can provide students with meaningful learning experiences to help them adjust their thinking by integrating new knowledge into their mindset. Therefore, the purpose of experiential learning is to provide students with meaningful and though-provoking experiences to help them incorporate new knowledge into their existing ideas.

To provide these experiences, teachers must thoughtfully design opportunities for learning to take place. As Provenzo, Butin, and Angelini describe in their book *100 Experiential Learning Activities for Social Studies, Literature, and the Arts, Grades 5-8,* experiential learning should be designed to make meaning and shift paradigms (2008). If experiential activities are not meaningful for students, they will not adopt new knowledge. Students need to be able to relate the new information to something personally meaningful such as a past experience or related topic (Provenzo, Angelini, & Butin, 2008.) For example, expert chess players can duplicate a chess board after viewing it for 5 seconds only if the chess pieces are arranged for a specific strategy, not truly random placements (Provenzo, Angelini, & Butin, 2008). Paradigm shifting is a unique aspect of experiential learning because significant personal experience is necessary for students to drastically change their mindsets (Provenzo, Angelini, & Butin, 2008). In other words, students can radically shift their views based on new evidence from their experiences. A student might think backing up from a mirror would increase the area he can see reflected in the mirror. However, after exploring reflection in an experiential lesson, he would realize distance from a mirror has no effect on the angle of reflection, and therefore the area seen in the mirror is always the same (Harvard-Smithsonian Center for Astrophysics, 1997). Experiential learning is one of the few educational methods providing students with enough functional application to rethink their ideas. According to Provenz, Butin and Angelini, experiential learning can force students' unspoken assumptions and beliefs into the open where they can be critically examined (2008). For example, students can correct their misunderstanding of ancient scientific inquiries, such as old men sitting around and thinking about the world, through a class simulation of ancient Greek society. They can use their new experiences from role playing ancient Greek society to better understand Plato's perspective of planetary motion. Once students have a better understand their own perspective, they are more capable of evaluating other perspectives as well (Provenzo, Angelini, & Butin, 2008). With these two aspects of well-designed experiential learning, students can correct their own misconceptions though meaningful experiences.

In a research study of 12 classrooms, Kristin Powell and Marcella Wells looked at the effectiveness of two experiential learning curricula. They found experiential learning did not significantly increase students' performance on standardized tests, but it still helped students learn enough to meet content standards (Powell & Wells, 2002). The evidence from this study suggests while experiential learning is not significantly helpful for increasing standardized test scores, it is still an effective method for improving students' comprehension (Powell & Wells, 2002). Other studies suggest experiential learning encourages relevant abilities not assessed on tests such as professional communication and presentation skills. For example, the Gatton Academy of Mathematics in Kentucky relies heavily on experiential learning for their research program (Roberts, Breedlove, & Strode, 2016). Though this program, 11^{th} and 12^{th} grade students have the opportunity to learn from conducting research in STEM (science, technology, engineering, and mathematics) related fields with college faculty. Learning outcomes from the program far exceeded the stated objectives of forming research questions, thinking critically, and analyzing data to answer their questions, to include life skills such as building professional relationships, professional presentations, and professional communication (Roberts, Breedlove, & Strode, 2016).

One type of experiential learning, problem-based learning (PBL) has been shown to increase students' repertoire of resources and strategies to solve problems at the middle school level (Drake & Long, 2009). PBL involves experiences connecting classroom material through some hands-on exploration while attempting to solve a problem (Drake & Long, 2009). A study completed in a 4^{th} grade science class involved giving students some supplies to explore and attempt to solve the real-world problem of creating a lamp powered by a battery. The results showed students in the PBL group could list more ways to solve problems using more resources throughout their investigations and tended to have greater time-on-task behavior than their peers taught with traditional teaching methods (Drake & Long, 2009). Experiential learning has also been shown to increases positive attitudes towards science. Students in this study saw scientists in a more positive light after their practical application experience. The students drew pictures of scientists with fewer stereotypical aspects such as lab coats and disheveled hair and portrayed themselves as scientists more often after their experience with PBL (Drake & Long, 2009). In another study of over 300 students in informal summer camps, experiential learning engaged motivated students to learn about science (Weinberg, Basile, & Albright, 2011). PLB has also been implemented in various secondary education programs such as nursing and dentistry (Balim, Inel-Ekici, & Özcan, 2016). It is growing in popularity because it encourages critical thinking and problem-solving strategies in students (Chaves et al., 2006). These benefits of experiential learning suggest its value for implementation to enhance cognitive skills, motivation, and problem-solving strategies for students within a wide age range.

Though many case studies demonstrate the worth of experiential learning, it is difficult to justify its application. Despite the abundance of qualitative studies showing the value of experiential learning in science, few studies are large enough to generalize its effects, leaving doubt to whether experiential learning is beneficial to a majority of students. This lack in current research begs the question whether allocating the time needed for students to engage in experiential learning is an effective use of instructional time. S. Scogin, C.J. Kruger, R.E. Jekkals, and C. Steinfeldt (2017) addressed this question when they researched the challenges of implementing experiential learning in our present "standardized testing culture" in education. Their findings revealed the noncognitive benefits of experiential learning indeed outweigh the challenges of implementing it (Scogin, Kruger, Jekkals, & Steinfeldt, 2017). Students gain experience communicating with their peers and persist in problem solving as they work through success and failure in their investigations (Scogin, Kruger, Jekkals, & Steinfeldt, 2017). These benefits are valuable, but the lack of large scale evidence leaves doubt to the exact benefits, cognitive or noncognitive, most students will receive from using experiential learning in science class.

Based on the data from the studies reviewed above, experiential learning could help students polish noncognitive skills and help them use their experiences to remember new information. From sculpting perspectives, to increasing professional skills, to enlarging a toolbox of problem solving strategies, experiential learning can help students explore and learn about the world around them in engaging and meaningful ways.

Methodology

Both qualitative and quantitative data was collected during this investigation on the benefits of experiential learning related to critical thinking in a science classroom. This study was completed over the course of two week in a suburban 8th grade science classroom. Students from three 8th grade classes participated in the study. The students in each class were treated the same and taught the same content. Students' application of critical thinking was assessed before and after an experiential learning lab. Quantitative data was collected from the pre-assessment and post-assessment. Qualitative data was collected from an online learning style survey and general survey on the different teaching methods used over one week's time. Students also took a learning style survey directly after the experiential learning lab. Students' thoughts on the experiential learning lab were collected from the survey. Students' application of critical thinking skills was pre-assessed with a short essay prompt. This prompt asked students to identify relevant information, make a claim based on the information, and support their claim with evidence. The pre-assessment was unrelated to the content to be taught to ensure all students were assessed uniformly. The pre-assessment prompt simply asked students if it would be better for humans to have eyes on the sides instead of the front of their faces. The prompt gave several pieces of information (how humans walk, sleep, talk) for students to consider and asked them to support their claim with evidence. The pre-assessment was given a week before students participated in the experiential learning activity.

In the experiential learning lab, students simulate the process of island arc formation over a hot spot using shaving cream and a piece of plastic mesh, see Figure 1.

Figure 1.

This activity gave students personal experience with the Earth Science concept of island arc formations. Simulating this extremely slow process helped students see how the islands formed and moved over time. In groups of 3-4 students, the students simulated the formation of an island arc over a hot spot by spraying shaving cream up through the plastic mesh and moving the mesh away from the shaving cream can. They placed the can's opening against the bottom of the mesh pointing upwards to simulate magma from a particularly hot spot in the mantle, called a hot spot. As the students sprayed the shaving cream up though the mesh, it simulated the rising magma melting through the crust and forming islands on Earth's surface. As the students moved the plastic mesh away from the still spraying can, they simulated the movement of tectonic plates which carries islands away from their point of origin to create an island arc. During the experiential learning lab, all the students were involved in the simulation. One student held and sprayed the shaving cream can, another student wrote down the group's observations, and one to two students held and moved the plastic mesh. After the lab, student reflected on their observations and wrote descriptions of how the simulation represented the formation process of island arcs from hot spots. They then took the online learning style survey. The learning style survey consisted of 20 questions. It gave each student an analysis of their preferred learning style. Each score gave a percent score of the three main learning styles: tactile, visual, and auditory. For example, one student received a score of 30% tactile, 35% visual, and 35% auditory.

The day after the experiential lab, students completed a post-assessment testing their content knowledge and critical thinking skills. The student's content knowledge was assessed by asking them to match the ages of 4 different islands in the Hawaiian island arch (they were created by a hot spot.) Students had to analyze the picture of the island arc to find the direction of the islands' movement to determine the relative ages of the islands. Students' critical thinking skills were also assessed on the post-assessment. Students were asked to make and support a claim about which island would be best for farming based on the ages of the islands. Students' thoughts on experiential learning as a teaching method were also collected with a survey over the different methods used during the current week of instruction.

These methods of data collection were used to collect data from three 8^{th} grade science classes. Because two of the science classes were very similar with about the same number of gifted students and students on Individualized Education Plans (IEPs) in both classes, one of these classes acted as the control for the study. The class acting as the control, referred to as the control, experienced the lesson on island arcs formed from hot spots through a primarily visual and auditory teaching method. These students watched 5 minutes of the first episode of the series *Galapagos,* where the ages of the islands in the Galapagos island arc are discussed. This video was followed with a whole class discussion on how the physical characteristics of each island changed as the islands move away from the hot spot where each was created. The class similar to the control group comprised the first sample, Sample A. The third class did not have any students on IEPs and about half the students were gifted, which made it a significantly different group of students from the students in Sample A. Because of these differences, the students in this class were placed into a separate sample, called Sample B. The students in Samples A and B were taught the same material with experiential learning as the primary teaching method with a focus on critical thinking with the simulation lab described above.

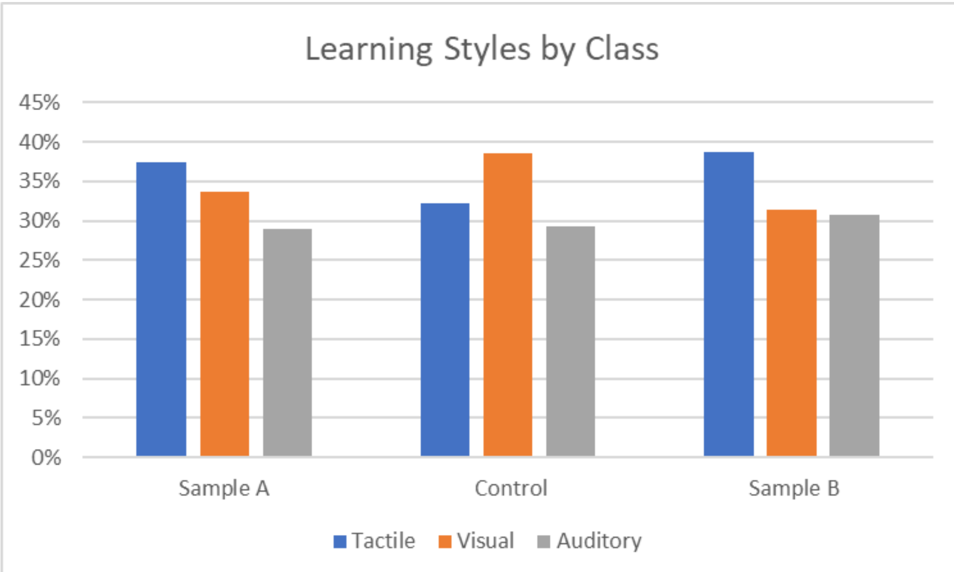
Data and Analysis

The pre-assessment and post-assessments from both Samples A and B was analyzed for application of critical thinking skills. The changes in critical thinking in these two experimental groups were compared to the change in the control to determine if students in the experiential groups achieved any significant gains over the control group. The gifted students in Sample B and students on IEPs in Sample A were also compare to the gifted students and students on IEPs in the control to determine if the experiential learning affected these students differently from the whole samples. Because the subject of this study, critical thinking, is impossible to assess with purely quantitative measures, a rubric for assessing critical thinking skills was create before conducting this action research to limit the subjective of the results as much as possible. The below grading criteria was created before any data was collect and was used to score the pre-assessments and post-assessments as objectively as possible. As Figure 1. shows, the essence of the critical thinking assessments was the ability to identify relevant information and support a conclusion with this information. A student scores a 2 if he identifies information relevant to the topic, and a 3 if he uses this information to support his conclusion or claim.

Score	Criteria
3	Conclusion based on relevant information. Evidence relevant to topic is supplied. Evidence clearly connects to and supports conclusion.
2	A conclusion is given. Evidence relevant is supplied. Connection between relevant evidence and conclusion is missing or vague.
1	A conclusion is given. No relevant evidence is supplied to support conclusion.

Figure 1.

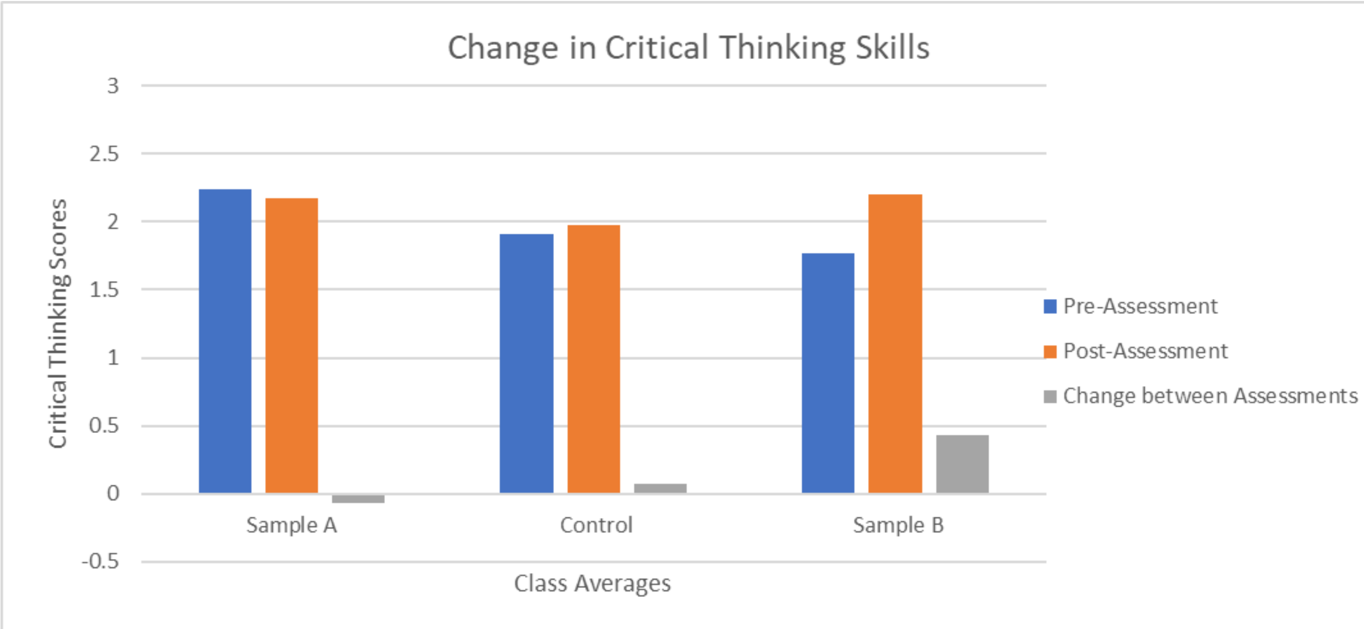
Due to student absences on the days when the pre, post, or experiential learning lab took place, only 61 students participated in the study. Sample A contains 23 students, including 4 gifted students and 4 students on IEPs. Sample B contains 17 students, 9 of which are gifted students. The control contains 21 students, including 6 gifted students and 3 students on IEPs. As seen on Graph 1, the average learning styles of each group of students is slightly different. Sample A's students had an average tactile learning score of 37%, average visual score of 24%, and average auditory score of 39%. As a group, these students tend to prefer tactile learning followed by visual and auditory. Altogether, the students in Sample B prefer tactile learning above visual or auditory with an average tactile score of 39%, visual score of 31%, and auditory score of 30%. The Control group tended to prefer visual learning with an average visual score of 39% as opposed to their average tactile score of 32% and auditory score of 29%. Because the teaching method used for the control was a video clip and discussion, the instruction for the control was unknowingly tailored for that particular group of students. As Sample B also shows a strong preference for tactile learning, the experiential learning lab was also advantageous for this group of students. While Sample A also shows tactile as the highest average preferred learning style, the instruction was not as advantageous for this group of students because they also had a high visual learning style preference.



Graph 1.

The pre-assessments and post assessments showed changes of various sizes in students' critical thinking skills, see Graph 2. The Control group's average score increased slightly, while Sample A's average score decreased slightly, and Sample B's scores increased dramatically. The control group's average score changed from 1.90 to 1.93 with an increase of 0.07 or 3.8% in their average score. Sample A's average score moved from 2.24 to 2.17 with a decrease of 0.07 or -5.5% in their average score. Sample B's average score for the critical thinking assessments moved from a 1.77 to a 2.2 with an increase of 0.43 or 24.5% in their average score. Based in these results, it appears experiential learning has very little effect on critical thinking. Even though Sample A's average score decreased while the Control's average score increase, both of these changes are very small. Because the changes seen in Sample A and the Control are so slight, it is possible that these changes are just due to chance not the teaching method used. The large increase in Sample B's score shows a large increase in the average critical thinking among the students in Sample B. This increase may have been emphasized by the high preference for tactile learning among students in Sample B and possible confounding factors.

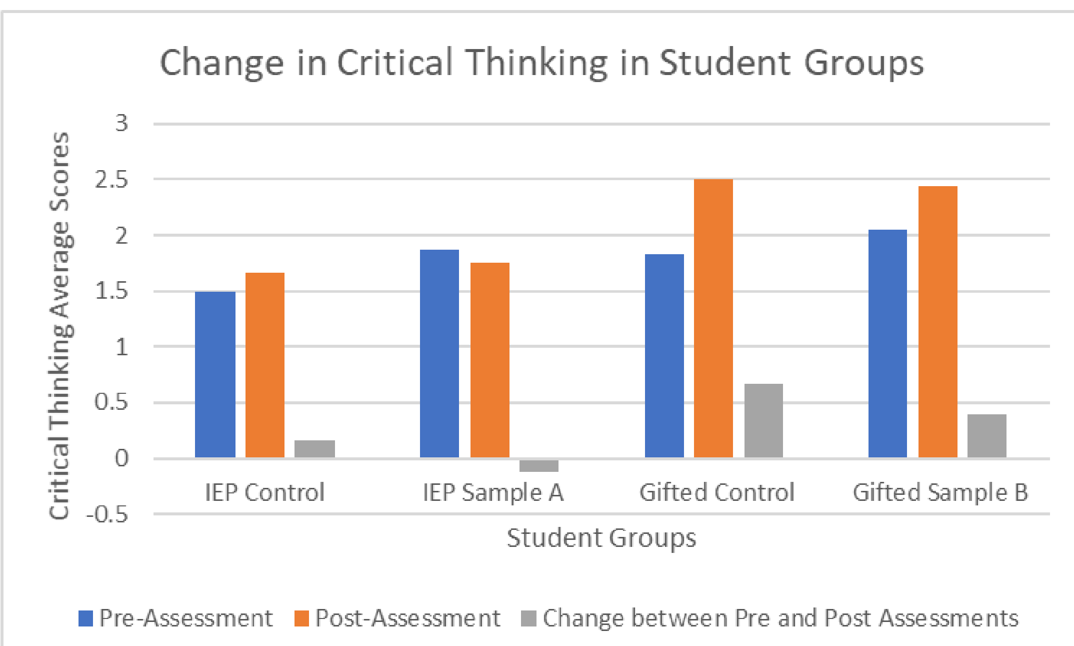
To determine if there was confounding factors involved in Sample B's results, I took a closer look at the Sample B's pre-assessment data. The data showed that Sample B did not score as high as the two other classes on the pre-assessment. This low average score on the pre-assessment caused a larger change between the two assessments. It is difficult to determine if the students in Sample B did in fact improve their critical thinking skill enough to increase their scores by an average of 24.5% or if some unknown factor caused them to not do as well on the pre-assessment and thus artificially increase the effect of the teaching method. It is possible factors uncontrolled for (such as the temperature in the classroom or unforeseen interruptions) caused the students in Sample B to perform at a lower level the day they took the pre-assessment. Taking a closer look at students in Sample B's work, I noticed that many of the students only loosely connected information to topic. For example, Bobby mentioned the purpose of eyebrows is "to show expression," but did not connect how having eyes on the side of human faces might affect eyebrows. To clarify the cause for this dramatic increase in the critical thinking scores of Sample B, I would redo the study with other experiential learning activities. Redoing the study with other experiential activities would decrease the effect single data collections have on the complete data set. Days when one class just cannot concentrate would not matter as much because they are just one of several evaluations of students' skills. Reducing the effect a single day's collection has on the whole data set would help the data more accurately show the change in the students' critical thinking ability over time because it gives a better idea of the students' changing ability over time.



Graph 2.

The impact the experiential learning lab had on gifted students and students on IEPs was analyzed by comparing gifted students and students on IEPs to similar students in the Control. The 4 students on IEPs in Sample A were compared to the 3 students on IEPs in the Control. The 9 gifted students in Sample B were compared to the 6 gifted students in the Control. As seen in Graph 3 below, the average score of students on IEPs in Sample A decreased by 0.125 while the average score of students on IEPs in the control increased by 0.167. This trend of a slight increase in the Control group and slight decrease in Sample A follows the trends seen in the average scores for these groups. Since the trend seen is the same trend in the whole class's data, it appears the experiential learning effected students on IEPs very similarly to how it's affect on the whole classes.

The gifted students in Sample B showed an increase in their average score for critical thinking of 0.389; while the Control showed an increase of 0.667 in its average score. The gifted students who participated in the experiential learning increased their scores by about 17% less than the gifted students in the Control did. This trend is opposite the trend shown in the class averages. The lower scores of the gifted students in the Sample B supports the conclusion the experiential learning activity did not improve students' critical thinking skills. This result could be partially due to the small sample size of gifted students. Because only 15 gifted students were analyzed, individual differences between students may have had more effect on the results. For example, Sarah (Control group) is a very curious young adolescent with a strong visual learning style (70% visual). Because the teaching method the Control experienced was very visual, it helped Sarah learn the material on a very deep level. If several gifted students in the Control had strong visual learning style, it would bias the Control towards visual students. While the reasons are unclear, it appears that the experiential learning lab did not improve the critical thinking skills of either the gifted students or the students on IEPs.



Graph 3.

While it is unclear whether the experiential learning lab influenced students' critical thinking skills, the students had a very positive attitude towards the lab. A general survey after the experiential learning lad asked students to share their thoughts on the teaching methods used for that week's instruction. Students' responses showed that they enjoyed the experiential learning lab and would like to do similar activities. Of the 61 students who took the survey, 54% (33 students) said they wanted to do more labs. Thirty-one percent (19 students) said the experiential learning lab was the most enjoyable part of that week's instruction. These results show students really enjoyed the experiential learning lab and would like to do more of these activities in the future. Overall, their response to the experiential learning lab was positive with several direct comments mentioning the lab. One student commented, "The shaving cream activity made the hot spot lesson more understandable."

Conclusion and Implications

In conclusion, this action research has produced puzzling results. One sample showed a slight decrease in critical thinking skills, while the other showed a large increase. This large increase could not be caused by the large number of gifted students in that sample (Sample B) because the gifted students in the control increased their scores more than the gifted students in the sample. When comparing gifted students and students on IEPs in the samples to similar students in the control, the sample students on IEPs showed a slight decrease in their critical thinking skills while the students on IEPs in the control showed a slight increase. Because the results did not show a consistent trend, it is very hard to draw well supported conclusions from this action research. I was not able to conclusively answer the state research question, "Does experiential learning increase critical think skills?" The slight changes in Sample A and the control suggest experiential learning does not promote critical thinking; however, the large increase in Sample B suggests it does. I believe more information is needed before the research question can be fully answered.

To completely answer the research question, I believe more data is needed. In order to understand if there is a connection between experiential learning and critical thinking, the study needs to be expanded. Part of the inconsistency in the study's results was due to the limited information gathered in the study. For example, only one question on the pre-assessment and post-assessments asked students to think critically. If there were more questions related to critical thinking, more subtle differences in students' abilities would have been seen in the results. Another possible reason for the inconsistent data is critical thinking is very difficult to evaluate. In my attempted to evaluate students' work as objectively as possible with predetermined grading criteria, I perhaps simplified the grading scale too much. By giving each students' work a score of 1, 2, or 3, small differences in the quality of each explanation were lost. Creating a more detailed grading criterion on a larger point scale, maybe 0-5, would show the quality of each students' response more clearly and allow more subtle differences in students' responses to be seen in the data.

Expanding the study to includes multiple experiential learning activities would also clarify the possible connection between experiential learning and critical thinking. Participating in a single experiential learning activity might not be enough exposure to this teaching method to make a significant difference in critical thinking skills. Testing students before and after multiple experiential learning experiences would better display the teaching method's effect on students 'abilities. Multiple exposures to experiential learning with different topics will also make the research less topic specific. One difficulty with the topic, hot spots, was the confusion from students' misconception about the size of each island made it difficult for them to identify the relevant information to support their claims.

By designing an action research project and analyzing its results, I have learned how to practically investigate a topic within a classroom and identify steps to address weaknesses in my methodology. Through designing this research study, I learned how to design a practical procedure appropriate for my student teaching placement while also addressing my research question. I considered the number of students in each class section, the different times of day the students received instruction, and the time needed for students to perform the experiential learning activity to design a realistic procedure for gathering data. Through analyzing the data from this research project, I identified ways to lessen the weaknesses in the research study. If I did this study again, I would create a more specific grading scale and use more critical thinking questions to show more subtle differences in students' thinking. I would also use multiple experiential learning activities to limit the effect single data collections had on the study's results. These changes should help the data give a better picture of students' abilities improve its accuracy.

While the collective research on experiential learning shows it to be an effective strategy, the research study did not strongly support any conclusion on how experiential learning affects critically thinking. The conflicting trends in the data show a need to expand the study to collect more specific information on the students' critical thinking abilities. While the research study did not decisively answer the research question, it taught me how to design an action research project.

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