Testing the Effectiveness of Laboratory Activities on Students' Understanding of Biological Concepts

Uma Mahalingam

Honors Thesis Project

22 March 2018

Introduction:

Created in 1980, Howard Gardner's Theory of Multiple Intelligences has firmly rooted itself in the belief that "human cognitive competence is better described in terms of a set of abilities, talents, or mental skills, [called] *intelligences*"[1]. While individuals may illustrate each of these abilities, talents, or mental skills to an extent, no two people exhibit the same exact combination of intelligences [2]. Gardner has based each intelligence off of commonalities between all individuals, like sensitivity to sound and ability to speak a language. Linguistic, logical-mathematical, musical, spatial, bodily-kinesthetic, interpersonal, intrapersonal, and naturalist intelligences describe the different intelligences with which people learn[2]. A few years after proposing these intelligences, Gardner added two more, the existential and pedagogical intelligences. The existential intelligence is known as the intelligence of asking big questions, while the pedagogical intelligence focuses on the ways in which humans are able to relay information, such as knowledge or skills, to others [3]. Being aware of the intelligences one possesses and utilizing them as mechanisms to learn new material, can be incredibly beneficial, especially in the classroom.

Gardner's Theory of Multiple Intelligences has a very crucial role in the classroom. Students learn in a variety of ways, and teachers should teach content with innovative ways which allow opportunities for all learners to excel. For example, a teacher might have a student in his/her class who learns best by reading, exhibiting the linguistic intelligence. In the same class, another student might struggle to read, but might learn better by hearing pitches and singing along with a song, which exhibits the musical intelligence. At the same time, if a child is good at one thing, it does not mean that the child will be good at other things [2]. Therefore, by

individualizing teaching, learning, and assessing as much as possible, teachers can be better able to gage what each student is capable of and how much each student has learned [4]. By finding ways to allow each student to utilize their dominant intelligence as a mechanism to understand content, teachers can effectively ensure that all of their students are learning.

The purpose of this study was to determine whether the facilitation of laboratory activities, which involve the interpersonal, intrapersonal, naturalist, logical-mathematical, and bodily-kinesthetic intelligences, help students learn biological concepts. An experiment was conducted with juniors and seniors enrolled in an Advanced Placement (AP) Biology class in high school. The topic to be explored by students in this experiment focused on Charles Darwin's research with finches in the Galapagos Islands. The experiment consisted of three groups of students with one exposed to a lecture, another exposed to a laboratory based activity, and the last group exposed to both a lecture and laboratory based activity. The same assessment was given to all three groups to determine whether the laboratory based activities enhanced students' understanding of the material.

Materials & Methods:

The experiment was conducted over the course of two days. Nine AP Biology students, comprised of juniors and seniors, volunteered as participants. Three students were placed in each of the following groups: Group 1: Lecture, Group 2: Lab, Group 3: Lecture & Lab. Groups were determined by students' availability, leading to random assignments of students. At the end of each session, students in each group independently took an assessment. Each student was given the same assessment of six multiple choice questions and two open-ended responses worth a total of 8 points.

Figure 1: Screenshot of PowerPoint slides used to teach students in the lecture session

The PowerPoint, shown in Figure 1**,** created for those listening to the lecture about Charles Darwin and the finches he studied in the Galapagos Islands was based off the information from Chapter 22 of their AP textbook [5]. During the lecture sessions, I presented the PowerPoint slides while asking questions along the way to check for understanding. By doing so, I addressed learners who might have exhibited the linguistic intelligence by orally and visually communicating information. After going through the slides, I gave students the assessment to complete independently, addressing the intrapersonal intelligence. The naturalist intelligence was required throughout as students needed to be able to connect Darwin's work with the Galapagos finches to the big idea of Natural Selection.

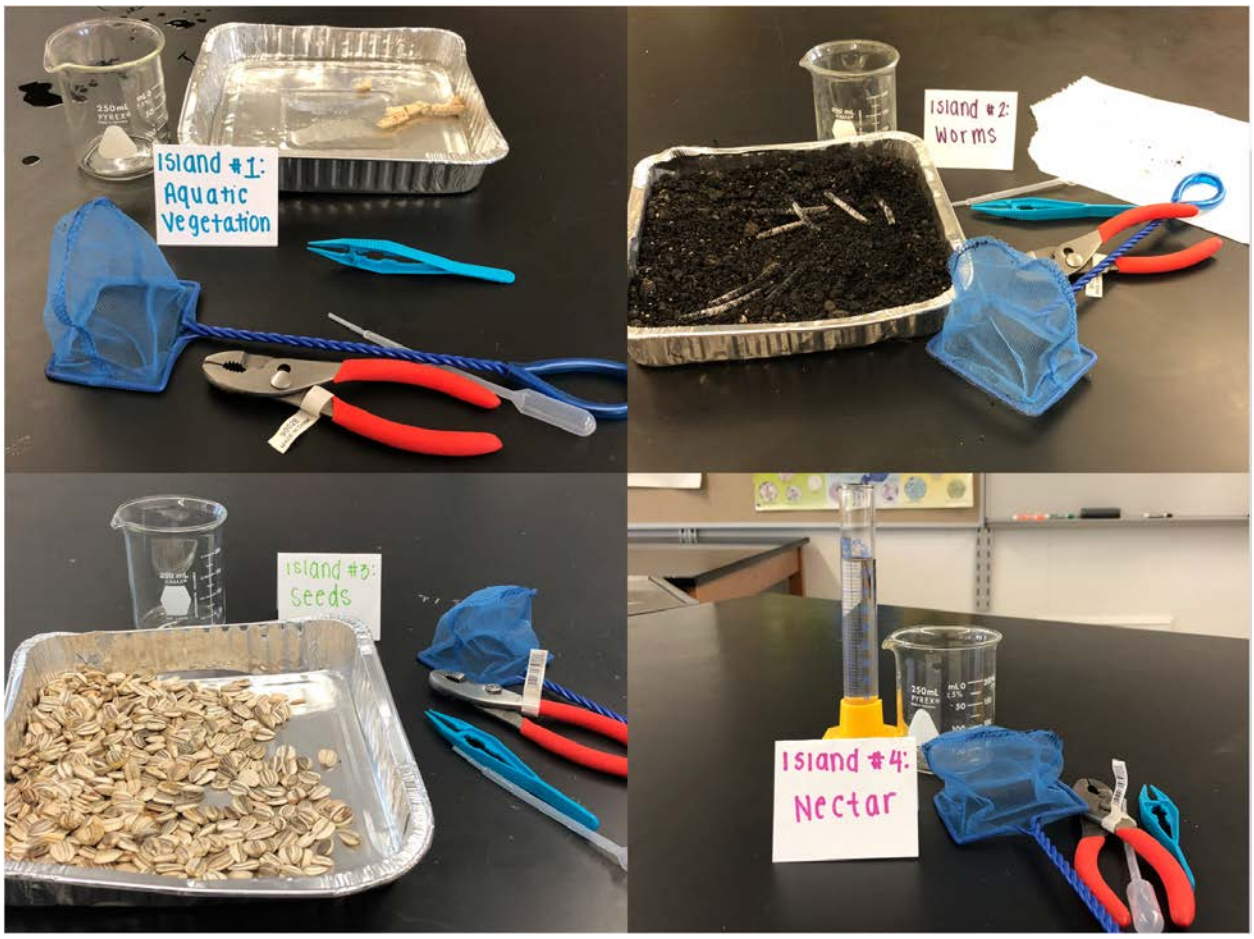

Figure 2: "Investigating Bird Beak Adaptations Lab Activity" Set-Up

The lab activity utilized for those participating in the lab sessions was from a kit called, "Investigating Bird Beak Adaptations Lab Activity", shown in Figure 2 [6]. The kit provided the procedure along with all of the supplies needed for the activity. Each lab table represented an "island" in the Galapagos, and students had to go from one island to the next to determine which beak would be best at obtaining the food source. By working as a group and traveling together, learners exhibited the interpersonal intelligence. The food source for "Island #1" was aquatic vegetation, represented by pieces of cork floating in water. The food source for "Island #2" was worms, represented by cut pipe-cleaners buried in moist soil. The food source for "Island #3" was seeds, represented with sunflower seeds that would need to be crushed. The food source for

"Island #4" was nectar, represented by water (nectar) in a graduated cylinder (plant). At each "island", students had to use each "beak", represented by the dip net, the pliers, the pipette, and the tweezers, to obtain the food source. Students had fifteen seconds at each island to try each "beak" using only one hand, totaling one minute at each "island". Afterwards, students had to determine which "beak" was best at obtaining the food source on that particular "island" by counting the pieces of food, addressing the logical-mathematical intelligence. When facilitating the activity, I allowed students to read the background information independently, addressing the intrapersonal intelligence. I then asked some basic questions to check for understanding. Afterwards, I moved with students from one "island" to the next, timing them as they used "beak" after "beak". After completing the lab activity, students completed the assessment independently, addressing the intrapersonal intelligence. The whole lab activity itself addressed the naturalist intelligence as students had to determine which "beak" would work best for the food source on each "island". In addition, since the activity had a tactile component, it appealed to bodily-kinesthetic learners.

Students in Group 3: Lecture & Lab listened to the same lecture first. They then participated in the same lab activity and then completed the assessment. Students in Group 3: Lecture & Lab had an advantage as the implementation of different instructional strategies, such as lecturing and doing a lab activity, addressed the majority of the intelligences. As a result, they should have obtained the highest scores on the assessment because linguistic, interpersonal, intrapersonal, naturalist, logical-mathematical, and bodily-kinesthetic learners all had opportunities to learn using their dominant intelligence.

Data:

Table 1: Assessment scores of Students A, B, C after participating in just lecture session

Group 1: Lecture	**Student A** *(senior)*	**Student B** *(junior)*	**Student C** *(senior)*
Assessment Score	7.5	8	7

Average Score: 7.5

Table 2: Assessment scores of Students D, E, F after participating in just lab session

Group 2: Lab	**Student D** *(senior)*	**Student E** *(senior)*	**Student F** *(senior)*
Assessment Score	7.25	7.25	7.75

Average Score: 7.417

Table 3: Assessment scores of Students G, H, I after participating in both lecture & lab sessions

Group 3: Lecture & Lab	**Student G** *(junior)*	**Student H** *(junior)*	**Student I** *(junior)*
Assessment Score	7.25	7.5	7

Average Score: 7.25

Table 4: Calculation of Statistical Significance through T-Tests

	P- Value
Group 1: Lecture vs. Group 2: Lab	0.817787
Group 2: Lab vs. Group 3: Lecture & Lab	0.492572
Group 1: Lecture vs. Group 2: Lecture & Lab	0.496055

Results:

Table 1 records the scores of Students A, B, and C who participated in the lecture session only, averaging 7.5 points. Table 2 records the scores of Students D, E, and F who participated in the lab session only, averaging 7.417 points. Table 3 records the scores of Students G, H, and I who participated in both the lecture and laboratory sessions, averaging 7.25 points between

these three students. Table 4 shows the p-values calculated through three t-tests. The p-values suggest that none of the values, since they are not less than 0.05, are statistically significant.

Discussion:

According to Howard Gardner's Theory of Multiple Intelligences, Group 3: Lecture & Lab, including Students G, H, and I, should have obtained the highest scores as both lecture and lab sessions would have appealed to learners exhibiting various intelligences. However, there were many factors that could have influenced the data collection of this experiment. Due to the recent snow days and delayed openings as a result of winter weather, I fell behind with my original plan of conducting the experiment earlier. Consequently, I wrote a letter to my cooperating teacher's AP Biology students to give them an overview of the experiment and ask for participation. After reading the letter, out of seventeen students, twelve expressed interest. However, out of the twelve, only nine shared availability with others. As a result, I had to divide those nine students into groups of three based on their availability, rather than their academic ability.

To begin with, I was faced with a pool of AP students, all of whom are on the same, accelerated academic path. Grouping them randomly based on their availability, rather than basing it off of their academic performance in my cooperating teacher's AP course or off of their dominant intelligence(s), was a factor that probably led to some groups performing better than others. To improve this experiment, I would give students an assessment for them to determine what type of intelligence is their most dominant, like those that I have taken in my teacher education courses at Ramapo. From there, I would group students, either in homogeneous or heterogeneous groups, based on their intelligences. This way, there would be more of a

correlation between the instructional strategy used, the learners' dominant intelligences, and their assessment scores.

Grouping students based on their availability led to an unequal distribution of juniors and seniors in each group, as well. Two students in Group 1: Lecture, Students A and C, were seniors while Student B was a junior. Students D, E, and F in Group 2: Lab were all seniors, while Students G, H, and I in Group 3: Lecture & Lab were all juniors. Perhaps the juniors who participated were not as prepared academically as the seniors, who have had an additional year of schooling, explaining why Group 3: Lecture & Lab had the lowest scores. To improve this experiment, I would try to work with just juniors or seniors so that I could collect data from participants at even more similar academic levels.

Another factor that could have skewed the data is the fact that I had a smaller sample size of only nine participants for my experiment. Although there was an even split with three students in each group, having more participants would have generated more data. To improve this experiment, I would try to have a total of 60 students with 20 in each group. With more data, it is likely that a clearer correlation could be determined between the instructional strategy, the learners' dominant intelligences, and their assessment scores

While facilitating the experiment, I learned very quickly that the nine students who participated already had a fair amount of prior knowledge about Charles Darwin and his research with the Galapagos finches. Because they already knew a lot about the topic, it gave them an advantage when taking the assessment, which was fairly basic to begin with. To improve this experiment, I would try to cover a topic that students do not have much prior knowledge about. This way, the assessment would be a clearer indicator of how much students have truly learned

and retained, rather than how much they have remembered from previous lessons, classes, activities, etc.

Upon further research, Gardner's Theory of Multiple Intelligences suggests straying away from standard assessments to measure student learning as many students' dominant intelligences are not well captured on a typical, written quiz [2]. An educational implication he has proposed, called individuation, refers to the need for educators to "teach individuals in ways that they can learn and we should assess them in a way that allows them to show what they have understood and to apply their knowledge and skills in unfamiliar contexts" [3]. As a result, perhaps an assessment was not the best way to measure student learning. Each assessment included six multiple choice questions and two open-ended questions. I found that students, for the most part, lost the majority of points when it came to writing complete responses for the open-ended questions. Students' responses were often incomplete as they were not written clearly enough to demonstrate their understanding of the topic. Other ways to measure student learning would be by evaluating completed lab reports, long term projects, oral presentations, etc. To improve this experiment, I could vary my assessment approach, like assigning students to orally share what they have learned, as a way to assess how much they have truly learned.

In addition, the assessment I administered was worth a total of eight points. Using such a small point value made it challenging to analyze the average assessment scores of each group. Students would have had to really perform poorly on the assessment to see a noticeable decrease in the average assessment score value. In addition to varying my assessment approach, to improve this experiment, I would make sure that students had opportunities to obtain more points. This way, there would be noticeable differences between the scores they would receive, which could then be analyzed along with the instructional strategy used.

Although there were many factors that influenced the data collected from this experiment, I learned a great deal about the importance of implementing various instructional strategies when teaching students. Although Students G, H, and I had the lowest average assessment score out of the three groups, I believe they probably learned the most information. Participating in both the lecture and the lab sessions likely provided these students with more opportunities to utilize their strongest abilities, talents, or mental skills, thus their intelligences, to truly learn the main ideas behind the lesson [3]. Having Students G, H, and I participate in both sessions addressed Gardner's idea of pluralization, or the need for teachers to present material in a variety of ways, catering to each student's dominant intelligence [3]. By listening to the lecture about Darwin and his finches and then participating in a lab activity that simulated how each "island" would require a different "beak", Students G, H, and I probably had a deeper understanding of how the finches beaks were adapted to the food source they had on their island

If I had the opportunity to redo this experiment, I would be sure to eliminate the factors that influenced the data I collected. With an improved experiment, I would hope to see a stronger correlation between the idea that lab activities help reinforce content that students have learned through more traditional, teaching methods like lecturing. The data would likely show that as a teacher, addressing different learners and their strengths, thus acknowledging a variety of the intelligences from Howard Gardner's Theory of Multiple Intelligences, is crucial to students' ability to learn and retain content.

References & Resources:

1. Gardner, Howard. *Multiple Intelligences: New Horizons in Theory and Practice*. Basic Books, 2006, books.google.com/books?id=8K54fg6YU4EC&printsec=frontcover#v=onepage&q&f=false.
2. TEDxTalks. "Beyond Wit and Grit: Rethinking the Keys to Success | Howard Gardner | TEDxBeaconStreet." *YouTube*, YouTube, 10 Dec. 2015, www.youtube.com/watch?v=IfzrN2yMBaQ.
3. Gardner, Howard. "Multiple Intelligences After Twenty Years." 21 Apr. 2003, pp. 1–14., www.kvccdocs.com/FYE125/lesson-resources/Gardiner-MI-Article.pdf.
4. "Howard Gardner Discusses Multiple Intelligences - Blackboard BbWorld 2016 HD."*YouTube*, YouTube, 19 July 2016, www.youtube.com/watch?v=8N2pnYne0ZA.
5. Campbell, Neil A., and Jane B. Reece. *Biology*. 7th ed., Pearson, Benjamin Cummings, 2005.
6. "Investigating Bird Beak Adaptations Lab Activity." *WARD'S Investigating Bird Beak Adaptations Lab Activity | Ward's Science*, www.wardsci.com/store/product/8878029/investigating-bird-beak-adaptations-lab-activity.