TEACHING AND LEARNING PORTFOLIO

by

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Learning

Research Teaching

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Table of Contents

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Teaching Philosophy

In some ways, I see educators as facilitators of knowledge, analagous to librarians and their relationship with books. We are both there to preserve yet constantly update information, to make it readily available to anyone who seeks it. For me, part of the reason that I enjoy teaching so much is from that feeling that I have a room full of precious material, gems and pearls of the most amazing information, and I want to share them, give them away like gifts, so that my students can view the universe in a different way, with a new pair of eyes.

I feel strongly that the best way to inspire awe and excitement is with a mixture of educator enthusiasm and appealing to the self-centered nature of human beings. Much in the same way journalists always need to spin a story so that readers will be interested in what happens in another, less relatable part of the world, I see the same need in teaching science. One of the easiest anatomy terms for me to remember in high school was the arrector pili muscle. It is responsible for goose bumps, and so I thought of its name every time I felt chills. Most people want to know how science relates to them personally, and relating everyday life to science is something I do well. I create a personal relationship between student and subject, which makes the topic more interesting. This tends to be best accomplished with activities, either in or outside of class, which bring the more abstract concepts together in a meaningful way. I created a science activity in which people were able to learn about supertasters, a small percentage of the population thought to have a higher concentration of tastebuds, theorized to be the most picky eaters as children, possessing potential to be the most elite food critics. Through the activity, children (and some adults) learned what a tastebud was, about how taste and smell were linked, and the pièce de résistance, whether or not they themselves were a supertaster. Appealing to this self-interested side, through which people are most interested in what concerns them personally, works wonders for student involvement.

Ultimately, the goal is for students to realize that science not only concerns them personally, but it surrounds them constantly, even outside of the classroom. I feel it is important for students to understand that there are no boundaries for where education can take place, and that they should be learning and exploring on their own. After developing and creating a science activity about the path of blood through the cardiovascular system, I took that activity to non-traditional educational venues like the Wisconsin State Fair and a charity fun run. I then compared the learning gains to more traditional educational settings, and found that the potential for learning was equal in both places. Learning is possible anywhere, even when you surprise your audience, when they did not expect to have an “educational” day. Every day is an educational day.

Beyond the capacity to learn constantly, I believe it is crucial for students to learn to think critically. It is vital for students to develop the skills to approach a problem, to research the issues, and to use that research to form their opinions. In designing a course unit as an HHMI teaching fellow, I required students to present data from primary sources to the rest of the class, and to use their fellow students’ presentations to help them write individual opinion papers. Ultimately, students took the final assignment very seriously, and were successful in finding scientific evidence to help solidify their opinions.

There is an amazing consequence to having more knowledge, in the way that a painter with a chemistry background understands paint bonding in a way that his co-workers do not, or from that extra level of comprehension coming from a high-jumper who studies physics. **The more knowledge a person possesses can contribute to the way in which he or she views even the smallest aspects of the world.** I feel that way about how I see the world, whenever I see scientific analogies in social contexts, viewing people as atoms and social pairings as molecules, and that makes me crave more knowledge. I want my students to see my excitement, and ultimately, to walk away equally excited, and hopefully, with a new outlook on the world.

**Reflection on appealing to self-interested students
(and why self-interest can be good)**

Although most people do not like to be seen as narcissistic, and would prefer to be seen as more giving, selfless individuals, the fact remains that we tend to be more interested in information that concerns us personally. This does not make us bad people, and it also does not preclude us from having that more socially desirable altruistic side. However, our self-centered sides are easily appealed to, and so, using them to make a topic more interesting for our students is extremely effective.

I have experienced this many times over as a student, which is one of the reasons I ultimately was so drawn to the biological sciences. I enjoyed learning about immunology because I have allergies, and I drew satisfaction from knowing that IgE was my own personal immunoglobulin responsible for this excessive response. After I learned about actin and myosin in muscle, lifting weights took on a new dimension. These are topics that still stick with me many years after learning about them, partly due to a select few dynamic teachers and professors, but mostly due to the fact that I was so enthralled with learning about a personally undiscovered world inside my own body. I know that it was my personal interest more than the specific educators who taught me. I have had some truly amazing teachers who taught subjects I never found a personal interest in, and to this day, I remember nothing specific about those subjects. I cannot recall any fun facts, any information I find relevant in my life, and I believe that connection to my own life was the missing piece. Although those educators were enthusiastic about the material, they never found a way to make me see their subject's relationship to my life- a reason I should care beyond getting the grade.

This is where **learning-through-diversity** really comes into play. In reality, every subject is amenable to this strategy- I have met people who really have made me see how physics is relevant to me personally. However, it is necessary to understand what an individual may find relevant for him or herself. Every student brings a different background into the classroom, and it is the job of the instructor to realize the diversity surrounding them in their students. It is only then that we can harness these individual differences to enhance the classroom as a whole, showing students that the differences among us only make learning only make learning together more interesting for us all. Trying to appeal to a variety of learning styles or moving toward a more discussion-based or case study-based class are ways of trying to make the material accessible to every student. In implementing a hands-on "Exploration Station" at UW-Madison's Science Expeditions, I created an informal science station about the concept of supertasters (a small portion of the population theorized to have a higher density of tastebuds). The first part of the activity allowed participants to paint their tongues blue with food coloring so they could better view their own tastebuds. This caused the groups that came together to inspect each others' tongues, viewing the diverse tastebud densities of their friends and families, and comparing them against their own. They all wanted to know if they had enough tastebuds to be a supertaster, and sometimes, it seemed clear that one member of the group had many more tastebuds than anyone else. The participants knew from the background of the activity that everyone has a different number of tastebuds, and that those who had the most might turn out to be supertasters. It was incredibly interesting to watch them test their theories about who was a supertaster when they tasted the chemical that revealed the results. It was then that I knew a connection was being made between what were originally perceived as bumps on their tongues and the real-world consequence of how having more tastebuds actually allows you to taste compounds more strongly than people who had fewer. It is the job of the instructor to take words on a page and translate them into something meaningful and real. If that job is performed well, it also shows the connection between the subject and the student's own lives.

Despite the fact that everyone is at least a little self-centered, the most effective way to teach a group is to focus on the topics that are common to everyone as human beings. Although I was particularly interested in my own biology, it is the same basic biological makeup as every other human being. Those topics that drew me in could have done the same for everyone else in that class who has an arrector pili muscle (which happens to have been every other student). The same concept applies to the booth I created about supertasters- everyone has tastebuds, and they wanted to compare their tongues with their friends and families. Everyone wanted to know if they were a supertaster, and if they could correlate that with their own selective eating habits. My sister, a social worker, still calls me and asks if we can test friends of hers who are particularly choosy about their food. She continues to spread the concept of supertasters, years after my project has ended. When people discover those commonalities, it provides an opportunity for those who are most excited about the topic to share that with others, and consequently, **learning communities** can be built around the information. Sometimes, all it takes is one person in a group who seems passionate about a topic to inspire their other group members. In this way, students can build off of each other's ideas, spurred by a single student's enthusiasm.

Although sheer enthusiasm may be enough to build a learning community, evaluation of how those concepts are being absorbed and interpreted by others is vital. This is the reason that each project must incorporate some level of **teaching-as-research**. For the supertaster project in particular, we wanted to make sure that our participants understood what a tastebud was, and if taste and smell were linked. Once we were confident that most of our participants were proficient in the world of the tastebud, we let them and their excitement (paired with accurate information) spread to others to their hearts' (or tongues') content.

Artifact 1: Painted tastebuds

Participants painted their tongues blue for better visualization of their taste buds, and then inspected their tongues in a horizontal mirror. The painting occurred after they learned about tastebuds, and about how supertasters tended to have more tastebuds than other people. This fact caused most of the participants (who were there with friends or family) to compare their tongue against the other people at the mirror with them, and excitedly postulate about whether or not they were supertasters before they took the chemical taste test.

Artifact 2: Quantitative exit data for supertasters

These were the summative results taken from the supertaster booth, designed to determine how well the participants understood the function of tastebuds, as well as if taste and smell were related. In addition to these data, which were taken on tally sheets, there were a small portion of the participants whose summative questions were taken on video. The video was interesting on many levels (although it does not translate well to a paper portfolio), but it allowed us to follow groups the entire way through the activity, as well as to capture the nuances that graphs cannot. For example, we were able to capture the loud exclamation from a family in which multiple members ended up as supertasters, and each member found the PROP (propylthiouracil) solution disgustingly bitter. It was moments like that which proved to our other participants that we were not handing out cotton swabs dipped in water. Additionally, the video also showed us that at least one of the participants caught on video did not think taste and smell were linked because he did not pinch his nose closed entirely when attempting to identify different flavors of jelly beans (another portion of this activity). This gives us additional information about why our data may have shown its ultimate result, and what we may be able to improve upon for the future.

Question	**Correct Answer**	**Learned or Already Knew**	**Did Not Learn**	**Total People Surveyed**
What on your tongue allows you to taste food?	Tastebuds	# People/Percent 65 / **91.5%**	# People/Percent 6 / **8.4%**	Total: 71 **91.5% Learned/Already Knew** **8.4% Did Not Learn**
Are taste and smell related?	Yes	# People/Percent 45 / **72.5%**	# People/Percent 17 / **27.4%**	Total: 62 **72.5% Learned/Already Knew** **27.4% Did Not Learn**

Reflection on learning outside of the classroom

Sometimes, it is easy to think of schooling as a concept that is relegated to a specific time and place- namely, in school. Growing up, I particularly felt the need to compartmentalize school and homework inside a box that was separate from the other aspects of my life. That is not to say that I did not really enjoy going to school and learning- I was that student in elementary school who, with a hopeful tone, asked the teacher if we were going to have homework on the first day of first grade. I raised my hand interminably, to answer every question until my arm fell asleep (and then I switched hands). I loved participating in class, and as a result, many subjects in high school seemed more like a conversation between me and the teacher than a 30-student class. However, it took several more years before I realized that my education was not confined to the classroom, and to recognize the opportunities for learning in the context of the rest of the world.

My internship through the Delta program was an opportunity to design an educational activity and bring it out into the world to recruit participants who would not be expecting to encounter science education at that moment. Usually, when I talk about learning outside of the classroom, I am referring to looking at more subtle opportunities to apply classroom knowledge to the world around us. My internship project was not quite that subtle. For my internship project, I designed a game about the cardiovascular system. Participants were given red and blue “blood bags” (filled with colored corn syrup), and the anatomy of the cardiovascular system was then explained to them using a floor map that depicted the anatomy of the heart, lungs and body. They then raced through the floor map, switching off colors of “blood” as they went. Participants were also asked to participate in a card-sorting activity both before and after they raced, which gave us the opportunity to assess their knowledge both entering and leaving the activity.

This was a chance to bombard people with an educational experience in a completely unexpected setting. It was a chance not only for the participants to learn, but also for us, as the designers of the activity, to see how receptive the audience was to learning in an unusual context. So much of the ability to learn is about attitude, and for this project, we saw great attitudes from all of the participants, at every location. The concept we were investigating was whether strangers would be open to participating in an informal science activity when they were not seeking it out, as is the case when families travel to museums. We wanted to see if it was possible to reach people who might not have the time or money to visit a museum. Ultimately, we were surprised by how receptive members of the public were, especially at the Wisconsin State Fair, but also at a charity fun run, during which our activity was an optional stop on their way to someplace else. This really showed us how open everyone was to learning and made the project incredibly enjoyable to moderate. Also, the willingness and capability to learn in public was the same as when we first ran the activity in an informal science education fair (an expected educational setting), which also speaks to the possibilities of reaching out to the public instead of assuming their disinterest.

However, despite yielding a valuable result, I believe the concept of **teaching-as research** goes beyond summative data. My internship has shown me that the true essence of teaching-as-research is woven through the project development phase. Summative data is a snapshot taken after the project has been refined, and that refining process is where the real research comes into play. One can talk about what worked or did not work along the course of a project or developing a class, but what is the definition of what "worked"? There must be a basis for that decision, and to form that basis, there must be goals of what the activity intends to achieve, as well as a way to assess whether those goals are being met. The assessment of those goals, which must be consistently performed as the project is developed, is the basis for refinement and improvement, and I believe that is the true meaning of teaching-as-research.

Upon reaching the public, our activity did more than teach people about the anatomy and blood flow of the cardiovascular system- in many cases, it brought strangers (and families) together to work as a unit. I see a **learning community** as a collection of people who combine ideas in an effort to advance their understanding of a given topic, and through our activity, we were able to form learning communities *de novo*. Children were extremely excited about running around and playing with their parents, siblings, or friends. When a younger child was having difficulty with the activity, older siblings or parents would cheer them on, show them where they were making mistakes, and encourage them. I had previously envisioned learning communities to be more strictly limited to the realm of students in a classroom, but through the internship, I found that learning communities can be easily created among strangers in a public sphere, simply by creating an activity that allows members of the public to participate and advance their learning together.

A major driving force behind the project, in terms of bringing science to the public in unexpected places, is to increase the diversity of the groups that would participate in our activity. Self-selected groups are all looking for a similar experience, which leads to a particular type of person attending that event. By bringing science to the public, instead of waiting for them to seek it out, the resulting sampling of participants from the public was a more diverse crowd than the one we observed at the informal science education fair (the expected educational setting). At the Wisconsin State Fair, we had more than one participant with a number on his back, indicating that he was about to compete in one of the farming competitions. That was a demographic we would never have reached if we had stayed in downtown Madison, WI. At the charity fun run, we were able to reach families who expecting a purely athletic experience that day. Part of the motivation behind setting up an educational activity in such unexpected settings was to reach people who come from families without the means and/or motivation to seek educational enrichment outside of a classroom. Not every family believes that an outing to a museum is worthy of their limited time or money. However, if we can reach out to them, knowing that they will still be a receptive audience, it is worth the effort. My own understanding of **learning-through-diversity** was enhanced through the internship, as it was the first time I have ever presented educational materials in such diverse settings. There was a part of me that felt that students in an academic setting would be the most enthusiastic about learning, but this internship has directly shown me, in many ways, that members of the public are just as excited to learn as students, if not more. This shows that although it can be difficult to entice all members of the public to visit your activity in a classic educational setting, it can be incredibly successful to meet the public halfway and to physically bring education out into the world.

Artifact 3: Using an Informal Cardiovascular System Activity to Study the Effectiveness of Science Education in Unexpected Places

(appears as accepted for publication in the Journal of Research in Science Teaching)

Abstract

Venues for informal science education are usually those sought out by people who are specifically looking for an educational experience. Whether planning a trip to a museum or choosing a television program, these individuals are actively seeking an informal educational experience; they are a self-selected group. This paper investigates whether members of the public will respond to an informal science activity that is placed in a location where learning about science would be unexpected. This project developed and used an activity about the cardiovascular system in which participants were able to walk the path of blood flow through the heart, body, and lungs. This activity was tested in two types of settings: where science was either expected or unexpected. A non-traditional assessment method was used to evaluate the effectiveness of the activity in the unexpected versus the expected settings. Ultimately, the activity was found to be equally effective in both settings, providing evidence for success in bringing informal science education to the general population in non-traditional venues.

Key words: assessment, cardiovascular system, embodied learning, informal science education, public science education

Introduction

Venues for informal science education are usually those sought out by people who are specifically looking for an educational experience. Whether planning a trip to a museum or choosing a television program, these individuals are actively seeking an informal educational experience; they are a self-selected group. This paper investigates whether members of the public will respond to an informal science activity that is placed in a location where learning about science would be unexpected. If the activity is not the main focus of the trip, but rather an additional option, surprisingly presented during a person's day, will it be greeted with a positive response? Will individuals learn anything? If the response is positive, then there is an opportunity to reach a new demographic, one which may not normally actively seek out informal science education experiences.

Research has proven informal science education to be an effective method for helping individuals to learn about science and develop a positive attitude toward science. As evidence of this research trend, several journals have devoted entire issues to the topic (International Journal of Science Education 2007, Science Activities 2006, The Science Teacher 2006, Science Education 2004, Journal of Research in Science Teaching 2003). In addition, learning through physical movement, sometimes called creative drama, drama in education, or embodied learning, effectively engages students, increases student retention of content learned, and offers instructors a real-time opportunity for evaluation of student learning (Bort 2007, Bullion-Mears et al. 2007, Gassert & Wenger 2001, Hommerding 2007, Kase-Polisini & Spector 1992, Palmer 1999/2000, Whitaker 1993). However, despite this growing field of research dedicated to learning in informal environments, the majority of the literature focuses on institutions of learning such as museums, aquaria, planetariums, and zoos. There is a paucity of articles that discuss informal learning in contexts outside these establishments, and no literature was found that discusses science learning in places where science is unexpected.

To determine the answer to this principal question of the efficacy of science education in unexpected locations, an informal science activity was created. The theme of the activity was the cardiovascular system, which is an extremely important topic to engage the public in, as cardiovascular disease is the most prevalent cause of death in the United States, with an estimated 80,700,000 deaths in 2005 (American Heart Association's Cardiovascular disease statistics). The activity was led in several locations, which included an informal science outreach event where participants would clearly be expecting to encounter an activity such as the one used for this work (described in more detail in Methods), as well as at non-traditional locations: the Wisconsin State Fair and a charity running event, neither of which is generally considered a destination for science education. The results obtained from this project represent the feasibility of bringing science education/outreach activities to the unsuspecting and non-science-self-selected public and quantify the success of the learning experience.

Methods

The activity

The activity implemented in this work consisted of multiple parts: the floor map (shown sideways, on the floor, in Figure 1a), the "blood bags" filled with colored corn syrup (seen being passed between children in Figure 1b), and red and blue buckets to hold the blood bags (seen in the top of Figure 1b). The concept of the activity was that a participant would pick up a red blood bag and begin in the left atrium on the floor mat. They would be asked where they were in the "heart" and then be told to jump to the left ventricle, where they would again be asked to provide their current location in the "heart". They would then walk to the "body", where they would be instructed to drop off the red blood bag (in the red bucket) in exchange for a blue blood bag (from the blue bucket). They would then walk to the right side of the "heart", jump again from atrium to ventricle, both times being asked to verbalize their location in the "heart", walk to the "lungs", exchange their blue blood bag for a red blood bag, and return to their original location in the left atrium. If they were playing the game with one or more other participant(s), the other participant(s) would also walk the entire pathway, so that both or all participants would have the same opportunity for learning. The participants were then told that they would get to play a game, where they would compete against the clock to perform as many complete cycles around the circulatory system in 30 seconds as possible. During the game, the participants and the game mediator would chant "atrium" and "ventricle" when the person racing was in those locations, respectively. The participant or team would then be informed the number of cycles they completed in 30 seconds.

The assessment

In an effort to avoid presenting the overall activity as a formal education experience that could be intimidating for the participants, written evaluation was relinquished and replaced with card sorting, a unique form of assessment often utilized by museums (Muir & Wells 1983) which was presented as a game to the participants both before and after the floor mat activity. This first set of cards consisted of four cards, and each card had one word printed on it. One of the words was "atrium" and another was "ventricle". The other two words were chosen randomly from the following choices: arm, ankle, violet, vein, such that there were always two words beginning with the letter "a" and two with the letter "v". The cards were shown and read aloud to the participants, and they were then asked if they could choose the two words that were the names of the chambers of the heart. If the participant was unable to choose the names of both chambers correctly for the first question during the pre-activity interview, the rest of the questions were skipped, and the participant proceeded directly to the activity. If they answered Question 1 correctly by choosing both the words "atrium" and "ventricle", they were given all three questions during the pre-activity interview (see Table 1).

The second set of cards can be seen below in Figure 2. The heart drawings on these cards were designed to be the same as the heart drawn on the floor map for the activity. The participant was then asked to choose the heart picture that was labeled correctly.

The words were color-coded (with “atrium” colored orange, and “ventricle” colored yellow) and read aloud in order to increase accessibility for non- or challenged readers. Regardless of the participant’s card choice from Question 2, the correct heart picture (Figure 2a) was used for Question 3. For Question 3, a piece of laminated, red construction paper, cut in the shape of a drop of blood, was placed on the left atrium of the heart picture. The participant was then asked to move the drop of blood to its next location in the heart. The answer was considered correct only if the drop was moved to the left ventricle.

The locations

The expected location was a University-sponsored science outreach event. The event was advertised as an educational experience, thereby creating the expectation of science activities and allowing for a self-selected population of people who were interested in science education events.

There were two unexpected locations, from which the data were combined: a local charity running event, and the Wisconsin State Fair. The project was at the Wisconsin State Fair as part of a larger University of Wisconsin day at the fair, but this project was separated from the main University of Wisconsin booths, which consisted of musical performances, skills tests for sports fans, and hands-on science demonstrations. The main booths were deeper in the central mall (represented by the # symbols in Figure 3) than the position of this project, which was positioned at a far corner of the central mall. This positioning was deliberate, so that participants could approach the project or be approached before they reached any deeper areas of the central mall, which may have contained other science demonstrations.

Statistics

All statistical analyses were performed using ANOVA with Tukey’s post-test.

Results

Figure 4 shows the comparison between the percentage of correct responses in the pre-activity survey, compared to the post-activity survey, in either a location in which the participants were expecting to encounter an educational experience (Figure 4a), or in locations where an informal science activity would be unexpected and was not the primary reason for being in that location. As can be seen in Figure 4a, the baseline data show that when conducted in an expected learning environment, which was an advertised, organized science outreach event, there was a significant improvement in the percentage of correct responses for all three questions (Question 1 asked for the names of the chambers of the heart, Question 2 asked for their correct orientation, and Question 3 asked for the order that blood would flow through the chambers). This trend was repeated for the unexpected locations, which were the Wisconsin State Fair and a local charity run. Those results can be seen in Figure 4b.

To further analyze the differences between the results from expected versus unexpected locations, the pre-activity survey results were compared to the post-activity survey results between locations. Figure 5a shows that, coming into the activity, a higher percentage of participants at the unexpected locations knew the correct responses to all three survey questions, but that despite this trend, there was no statistical difference. This trend was also true for the comparison between the post-activity surveys (Figure 5b), in which a slightly higher percentage of participants knew the correct responses when leaving the unexpected locations versus the expected location, but again the difference was not statistically significant.

Discussion

The efficacy of this activity in unexpected locations is heartening because it shows that informal science education is effective even when members of the public are not expecting it. This implies that traveling educational exhibits and activities can be just as effective as when participants seek them out and/or when they are in their traditional locales. This could open up an entirely new demographic of people who can be effectively sought out, but who might not necessarily be able or willing to intentionally pursue informal educational experiences for themselves or their family.

There are some examples of attempts to bring science to the public, rather than waiting for a specific demographic to seek it out. Examples of this include the World Science Street Fair in New York City (The City University of New York's Science and the Arts), an exhibit about nanotechnology by MEMS-Point that traveled to seven different shopping malls in Switzerland in 2008 (Nano ganz gross); and science pubs and cafes taking place around the world in bars and coffee shops, including nanotechnology research images as coffee shop art (Sights Unseen). However, some such events might not be considered completely unexpected, even if they are in unusual locations. For example, science pubs and cafes are often advertised and regularly held so that people would learn to expect them. However, it is also entirely possible that the science pubs impact numerous individuals who *were* surprised by the event. Nevertheless, the results contained in this paper used clear assessment techniques to demonstrate the potential efficacy of public science education in unexpected locales and at unexpected events and, consequently, support more widespread and frequent use of this approach.

It was surprising that more people in unexpected locations would come in knowing the correct answers to the survey questions, if only because it is expected that a random selection of the public would include a wider cross section of the population than the standard educational and socioeconomic backgrounds that are often seen with, for example, the self-selected population of museum-goers. It has been reported that, of college graduates, less that 40% had attended a science/technology museum in the past year. For those with some college, approximately 22%; high-school graduates, 18%; and those who did not graduate from high school, less than 10% (National Science Board 2008). However, the number of correct responses given by volunteers participating in this particular project would be expected to vary with age. Older children and young adults would be more likely to know the answers before participating because they may have learned about the heart in a biology module in a formal classroom setting. This would be in contrast to younger children, who would not have taken biology courses yet, or older adults, who are often further removed from the information they learned years ago in school settings. Although it is difficult to make accurate comparisons about the initial (pre-activity) performance of the self-selected population versus the general public without much more demographic data, the main point in this work is that despite the identity of the population that is participating in the activity, both seem to be equally capable of leaving with similarly high levels of success in understanding the material presented.

The importance of this activity, other than to demonstrate the efficacy of science education activities placed in unexpected places, is to increase public science literacy. Due to the prevalence of cardiovascular disease in the United States, the cardiovascular system was considered to be a vital topic to address through this activity. The primary learning goals of this activity were for participants to walk away with an understanding of their own basic heart anatomy and physiology, and a basic understanding of cardiovascular flow. The activity can also be further developed to help participants learn about specific failures of the cardiovascular system, such as valve disease and myocardial infarctions (heart attacks), which was done in some instances after the activity was completed and a parent wanted their child to have an explanation of their own heart defect. This could raise awareness of various manifestations of cardiovascular disease and their consequences in a more exciting setting for children than traditional passive learning techniques.

Learning through physical movement effectively engages students, increases retention of information, and involves a physical learning activity that instructors can use to assess student learning. This is all in addition to the fact that the activity described herein requires a certain amount of physical activity, certainly enough for the participants to be able to feel their own hearts beating, which they could listen to with stethoscopes. The primary learning goals in conjunction with physical activity all help to tie in to the overarching theme of good cardiovascular health.

Conclusion

With only a small portion of the American population choosing to attend science and technology museums and poor science literacy among adults in the United States (National Science Board 2008), more creative and innovative strategies may need to be adopted to share science education with public audiences. This work presents evidence that there is a strong possibility for success in bringing movement-based learning opportunities to general populations in a casual, public atmosphere. Regardless of what level of knowledge a member of the general public possesses, it is possible to design informal science activities that are accessible to the large majority of the population. These activities may serve not only to enhance general science literacy, but also to create a sense of community among groups of people as they participate. Although these activities may take an extra level of orchestration with the targeted public venue, it seems worth reaching a population that may have lost interest in learning about science in an attempt to re-energize participation in science learning.

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Figure 1. a. The activity floor map, shown sideways, was a drawing of the cardiovascular system on a 12' x 12' canvas. Red and blue buckets were placed at either end of the floor map for the red and blue "blood bags" to be contained during the activity. b. Three participants (and the game moderator) are shown on the floor map, passing a bag of red "blood" from the left atrium to the left ventricle (Photo credit: Jeff Miller/University of Wisconsin-Madison).

Figure 2. The drawings that were on the cards used for the card sorting assessment. a. The correctly labeled heart diagram. b and c. The two incorrectly labeled heart diagrams.

Figure 3. The layout of the Central Mall at the Wisconsin State Fair in Milwaukee. The * denotes the location of the cardiovascular activity discussed in this work, while # shows the location of the other University of Wisconsin booths.

Figure 4. Results of the pre-activity and post-activity surveys (* $p<.0001$). a. Results of the surveys from the expected location, showing a significant increase in correct responses after the activity was completed (N=25). b. Survey results from the unexpected locations, also showing a significant increase in correct survey responses after completion of the activity (N=58).

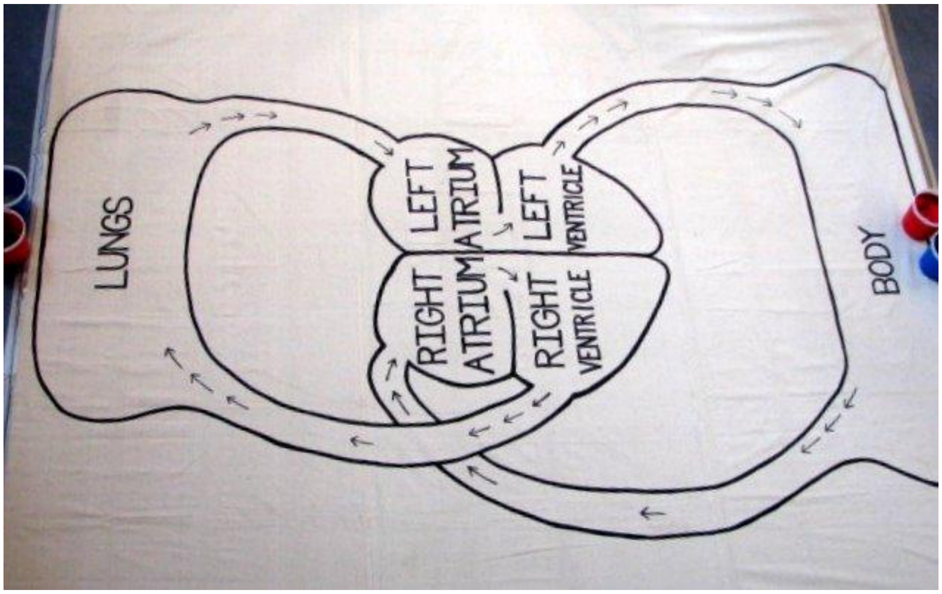
Figure 5. Comparing results from the pre-activity surveys from expected and unexpected locations, and the post-activity surveys from expected and unexpected locations. a. There were no significant differences in comparing the pre-activity surveys from the expected vs. unexpected locations (N=83 for all pre-activity surveys). b. There were also no significant differences between the post-activity surveys from the expected vs. unexpected locations (N=85 for all post-activity surveys).

Question 1	Which two cards do you think have the names of the chambers of the heart?
Question 2	Which heart do you think has the chamber names in the right places, if “ventricle” is yellow and “atrium” is orange?
Question 3	If blood starts here (in the atrium), where would it travel next?

Table 1: The questions (as related to the cards) as they were posed to the participants during both the pre-activity and post-activity interview.

Figures

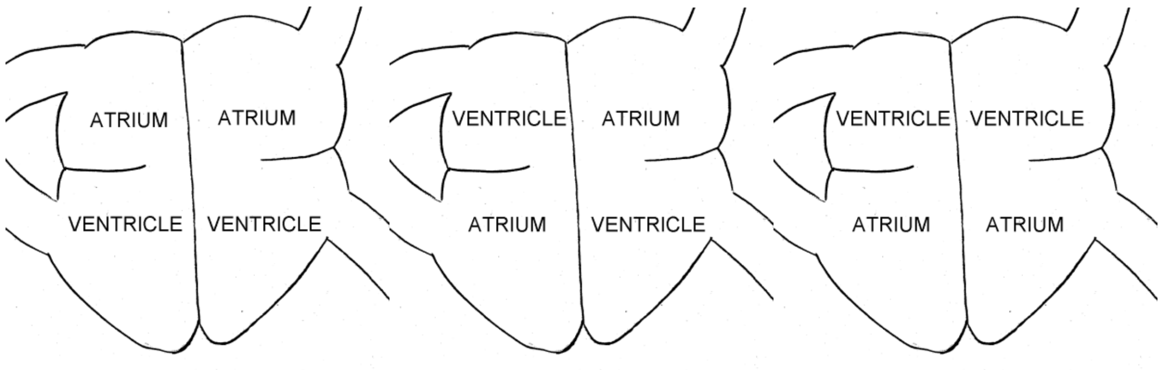
Figure 1



a.

b.

Figure 2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a. b. c.

Figure 3

Figure 4

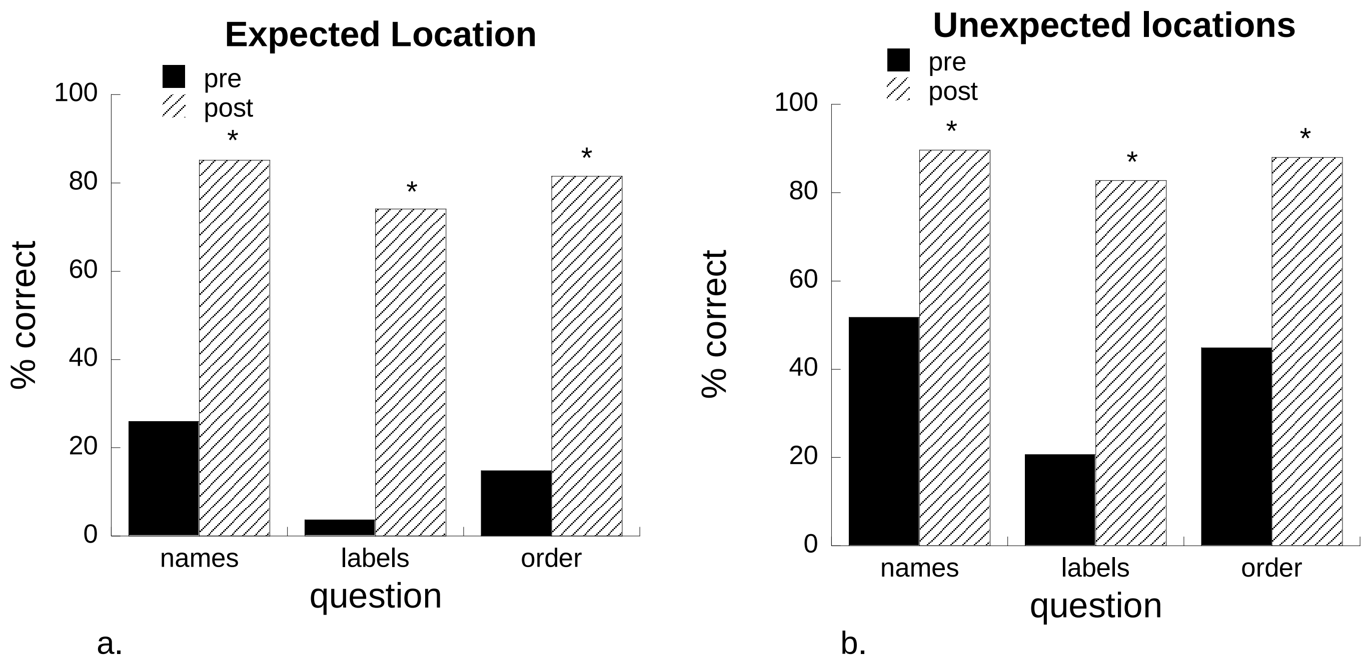
Expected Location
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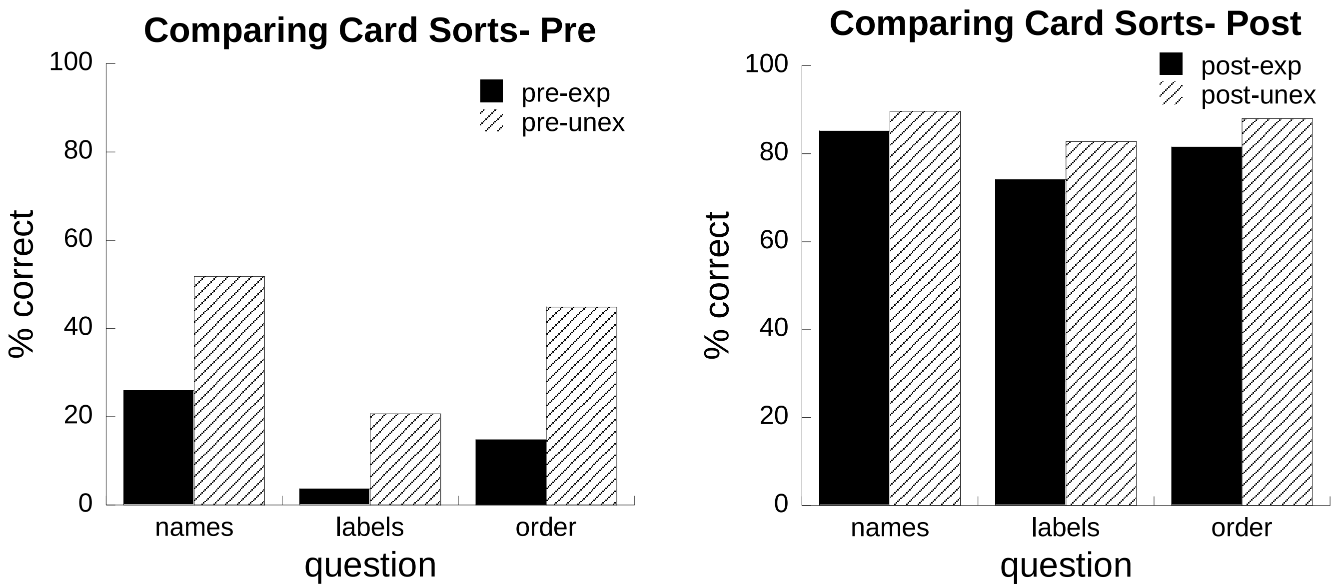
Figure 5


Comparing Card Sorts- Pre
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order
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a. b.

Reflection on coaxing students to think critically

It may seem obvious that critical thinking is important. Even the phrase "critical thinking" seems clichéd and dull, not at all representative of the vitality of the skill. And critical thinking *is* a skill, one that requires practice and conditioning, building up from the most basic understanding of material to the most complex interpretation and evaluation. Bloom's taxonomy was developed in the 1950's by Benjamin Bloom, an educational psychologist, and was designed to define the levels of thinking important in education beyond just the basic recall of information. Escalating through and among Bloom's levels of intellectual behavior takes time and energy on the part of the student. However, working in tandem with the effort it takes on the part of the student is the effort that the educator must also exert in order to develop appropriate class activities and their evaluative tools.

Personally, as a student, I have experienced a variety of educators over the years, a few who truly made a great effort to make their students apply the knowledge from their classes and others who never went beyond rote memorization on multiple-choice tests. Because of my past experience, and the fact that I remember such a small portion of the vast heap of facts I have memorized over the years, I have made a genuine effort to push my students to go beyond only facts. I developed a self-contained, four-class unit for part of a course as a HHMI/WPST teaching fellow. The overarching goal of my learning objectives for the unit (see Artifact 4 for the complete description) was to give the students the tools to develop critical thinking skills about a controversial issue prominently featured in the media. The topic of my unit was the potential link between vaccines and Autism. The reason I chose that topic was because the media had taken minimal scientific evidence and displayed those few results over and over, ignoring the opposing studies. I really wanted students to understand how to read the primary evidence, those studies and articles that had been published on the topic, and to use their personal examination of the evidence to form or define their opinions.

To foster the students' analysis and understanding of primary evidence, 13 different scientific studies or newspaper articles were assigned to pairs of students. Each student pair then presented a summary of their assigned piece of evidence (study or article) to the rest of the class. The students were instructed to present the main ideas behind their study or article, along with the strengths and weaknesses and a judgment on its overall importance. Upon sharing their determinations with the rest of the class, a **learning community** was reinforced. Students first worked in micro-communities (as pairs) to analyze their evidence, but then they came back and shared their evidence with the larger community (the class). I explained that the students were presenting a representation of the evidence to their fellow classmates, which represented how scientists present their findings to the rest of the scientific community. This was intended to drive home the point that in the scientific field, we must trust that our fellow scientists are representing themselves with integrity, because we are all part of the same community, and can only move forward in our own research when we can trust the foundation upon which we are building.

I was also able to use a portion of the class to foster **learning-through-diversity**, during which I was able to show portions from movies like *Rain Man* with Dustin Hoffman as well as clips from documentaries that showed what life was like for a person with Autism. Not only were the multimedia portions of this class a compelling example of the diversity regarding Autistic individuals we were discussing in class, but this was also a way to appeal to different learning styles of the students in the class. Playing these clips was a way to appeal to both visual and auditory learners, and was in general a way to provide information beyond simple text. Many students remarked, both after that specific class as well after the unit had ended, what a memorable part of the course those videos were. I felt that it was incredibly important for the words on the page from the DSM-IV (a diagnostic tool in medicine) to become tangible for the students, and for the class to learn more about the challenges that Autistic people face, potentially developing empathy for them.

Ultimately, after all the facts are absorbed and the students have thought about the material presented in class, and (hopefully) put time and thought into their final papers, we still need to know if the goal has been accomplished, because that is the crux of what **teaching-as-research** is about. Because of the importance that I attach to this concept of critical thinking, I was most interested in evaluating several aspects of the critical thinking process. In an effort to evaluate what the students were most concerned with in writing their final papers, the students were asked to select their top priorities (they were allowed to select more than one option) from four options: (1) finding evidence to support their already formed opinion, (2) looking through evidence in an effort to form their opinions, (3), the least effort for the highest grade, and (4) Other. This survey was intended to discover why the students chose the evidence they included in their final paper, and how that related to their opinions, really trying to understand how (or if) they formed their opinions carefully or if they were simply trying to earn the easy grade. Overall, I was incredibly pleased with the students' responses, and they really made me feel like, at the very least, most students were open-minded to new information and had put true effort into finding what they felt supported their opinion the best. Additionally, to truly assess how open-minded the students were to the new information presented in class, another survey question asked the students if any part of their opinion on the unit topic had changed as a result of the class. Less than 20% of the responses indicated that there had been no change in opinion, reinforcing the students' willingness to learn new information and incorporate that into their personal consciousness. This was exactly what I had hoped for in my first teaching experience, and although I can of course find areas for improvement for next time, I assessed that I achieved a great end result.

Artifact 4: Learning goals and intended outcomes for Microbiology 375

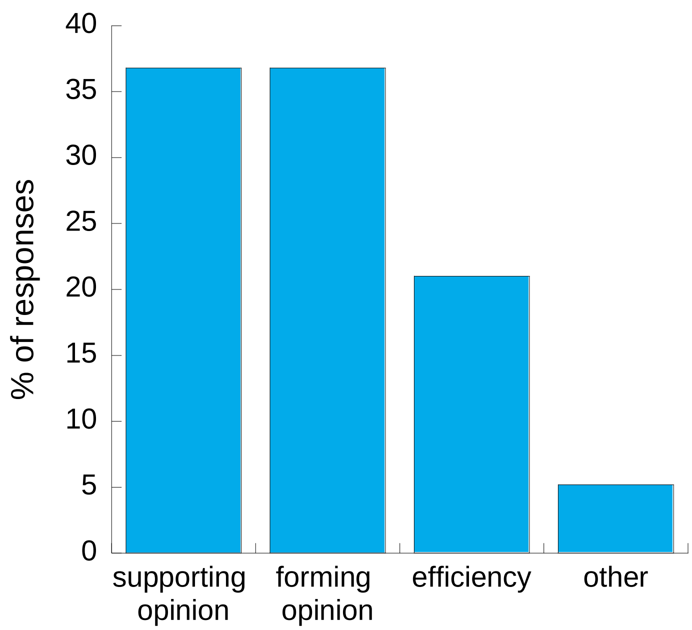
Learning goal	Intended outcome
Students will know the components contained in various types of vaccines.	Students will be able to participate in an interactive demonstration in class, during which they will analyze the patient outcome of combining various vaccine components ((un)attenuated bacteria/virus, killed bacteria/virus, preservative, etc.) and then injecting them as a vaccine.
Students will have a basic understanding of how the immune system works.	Students will be able to match up themselves as “antibodies” to various “antigens”, demonstrating an understanding of the lock and key relationship, as well as how the body generally does not attack antigens that it recognizes as “self,” as well as how B cells expand clonally after recognizing an antigen.
Students will understand how science progresses and the process through which scientific discoveries are made.	Students will be able to take a partially-developed scientific question and posit what the next step might be in the process.
Students will be able to identify the characteristics of an Autistic person.	Students will be able to read/analyze a case study, and determine if the person featured in the case study is Autistic or not by analyzing what features (from medical literature) of the case study point to Autism.
Students will be able to view a variety of evidence and decide what their belief is about the link between vaccination and Autism.	Students will view presentations by other students that summarize a variety of current evidence during the last class. They will answer a final exam question about whether or not they believe there is an Autism/vaccination link, and will need to cite the evidence presented in the last class.

Artifact 5: Students did form/support opinions with evidence rather than prioritizing the highest grade for the least effort

Students were asked in a post-class survey what they were most concerned with in writing their final papers (more than 1 answer was allowed):

A: Finding evidence to support their already-formed opinions.
B: Looking through evidence in an effort to form their opinions.
C: Least effort for the highest grade.
D: Other.

With 62.5% of the class responding, the data show that of all the collected responses, over 70% of those responses indicated that the students were either looking for evidence to support the opinions they had already formed or were looking for evidence in an effort to form their opinions. Less than 25% of the responses indicated that the students were most concerned with the efficiency of writing their papers. Considering the fact that students were able to select more than 1 response, every student could have been equally concerned with supporting their opinion as with pure efficiency. The fact that so few of the students selected efficiency as their priority indicates that the students were truly more concerned with critical thinking than with obtaining an easy A in the class. Since this is clearly a surprising outcome, in the future, I would consider asking students to rank the order of importance rather than simply choosing the answer(s) that were prioritized the highest. This would be in an effort to see where efficiency is ranked, and if that ranking is reasonable or if the students are ranking efficiency lower because they perceive a negative connotation with it. This possibility should have been eliminated through the anonymity of the survey, but a negative connotation associated with efficiency may have been subconsciously ingrained.

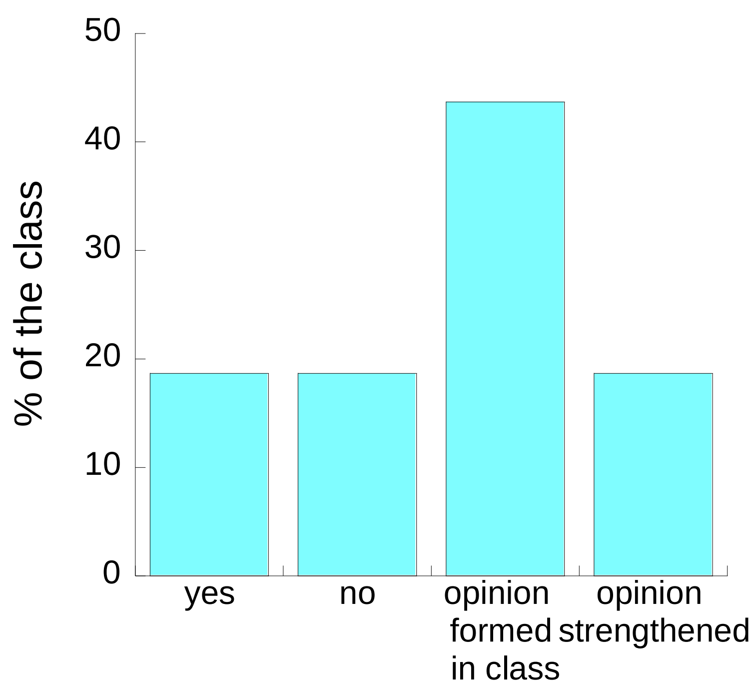


Artifact 6: Student opinions were generally formed or changed in class

Students were asked on a post-class survey if any part of their opinion on the unit topic had changed after they took the class. Their responses were grouped into the following categories:

1. Yes
2. No
3. My opinion was completely formed in class
4. I already had an opinion, but it was strengthened due to the class

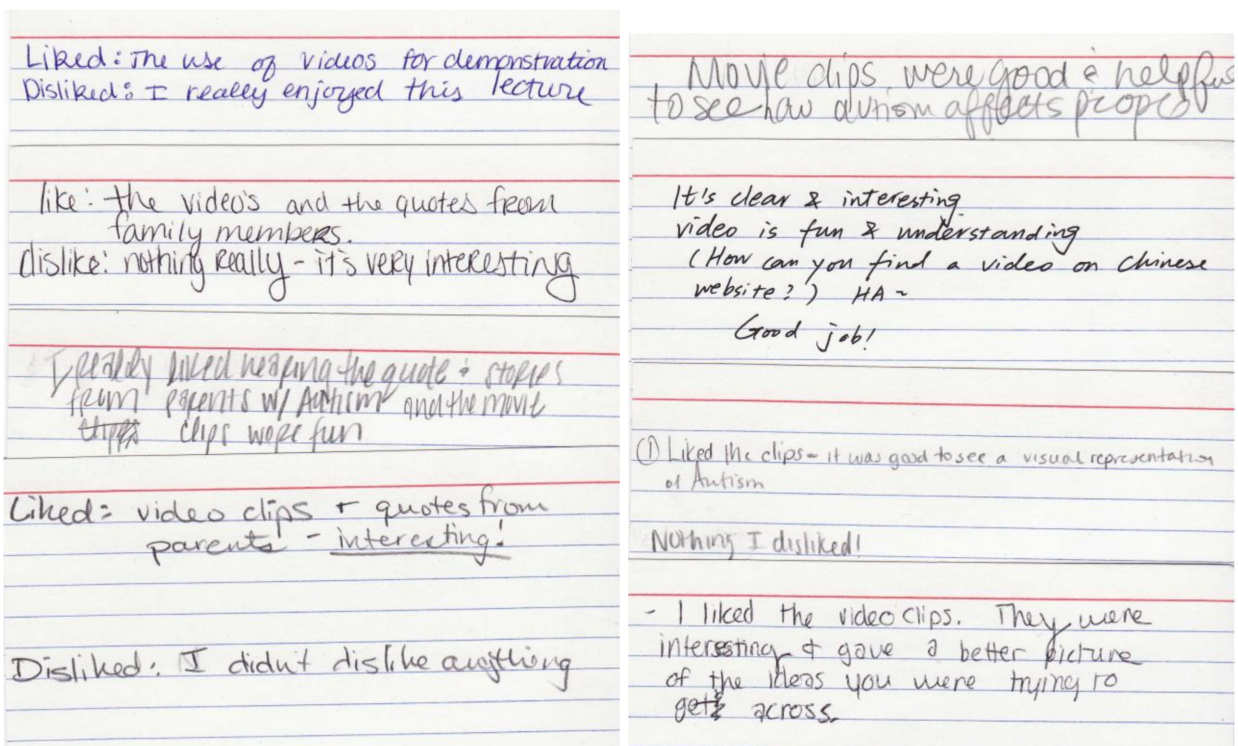
With 66.7% of the class responding, a surprisingly high percentage of the students (>40%) indicated that they had not formed an opinion prior to the class. This was surprising because the possible connection between vaccines and Autism has been highly publicized since the 1990's, and so these students had clearly not investigated the topic on their own. However, this also indicates the importance of the role of an instructor who is able to present the topic in an unbiased way, as well as encourage the students to sift through evidence to form an opinion based on primary literature, rather than simply facts that are fed to them in the class. Overall, less than 20% of the students indicated that their opinion had not changed at all, which showed that students were open-minded about the topic, and took something meaningful away from the unit.



Artifact 7: Student comments on seeing video portrayals of Autistic individuals

In the class I taught on Autism, which was part of a larger unit about the publicized potential link between vaccination and Autism, we discussed many aspects of Autism. We covered the diagnosable symptoms of Autism from the DSM-IV, and I also brought in quotes from parents of Autistic children relating their real-life experiences. Additionally, I showed video clips of Autistic individuals, both fictional, as in *Rain Man* with Dustin Hoffman, as well as documentary clips, and clips of Autism appearing topically in prime time television programming. I believed that by showing the students what life would be like living with Autism, through providing videos and quotes to accompany the facts covered in class, that students would be more interested than just from the facts alone, and they would gain a better understanding of what it meant to be Autistic.

At the end of each class, I asked students to fill out index cards with something they liked from that day's class, as well as something they disliked. The comment cards seen below really captured how well the class responded to the videos and quotes, and demonstrate how meaningful it was to connect with the students on a more personal level.


Liked: The use of videos for demonstration
Disliked: I really enjoyed this lecture

like: the video's and the quotes from family members.
dislike: nothing really - it's very interesting

I really liked hearing the quote + stories from parents w/ Autism and the movie clips were fun

Liked: video clips + quotes from parents - interesting!

Disliked: I didn't dislike anything

Movie clips were good & helpful to see how autism affects people

It's clear & interesting
video is fun & understanding
(How can you find a video on Chinese website?) HA~
Good job!

(I) Liked the clips - it was good to see a visual representation of Autism

Nothing I disliked!

- I liked the video clips. They were interesting & gave a better picture of the ideas you were trying to get across.

Reflection on Expeditions in Learning

Expeditions in Learning was the formation of a learning community composed of graduate students and post-docs, led by two members of the Delta program, during which we all journeyed into the educational world individually, and then came together to discuss our experiences. The first assignment we had in Expeditions in Learning was to write one page about how people learn. I remember this assignment distinctly, not for what I wrote, but because I remember hearing what others had written and being surprised. I had never given much thought to the fact that everyone has a unique learning style, although it had been something I had always known on some level, but hearing how different the responses were from the group was almost shocking. It set a wonderful tone for the rest of the experience, in which we all ventured out on individual expeditions, learning in our own way, but then reconvening with the group and comparing our experiences. It showed how learning communities are ideally composed of heterogeneous thinkers, able to communicate their own perspectives and learn from what others have brought to the table.

Even in our communication styles, differences were apparent. Everyone was timed in their initial presentation of their most recent expedition, and while there were always some, including me, who could easily use all of their time plus more, there were also others who barely spoke, and preferred to end their time early. We all learned what strengths and weaknesses we individually contributed to the group dynamics, and spent the semester trying to harness our strengths while keeping our weaknesses in check.

This was an extensive introduction into the world of those who thought differently from me in the classroom, and it allowed me to gain a window into a variety of thinking and learning styles. Hearing from those students who had the same physical experience as me, but who came away with a completely different perspective never ceased to amaze me. Today, when I am in the classroom, I try to incorporate my insight into different learning styles throughout a lecture when I am introducing a new concept. I know that no matter what I do, each student will come away with a uniquely personal experience of that lecture, and I try to use multiple techniques to make each topic engaging. With my insight into the variation among my students’ viewpoints, I have a better picture of some of the many possible ways they may see both the classroom and the world.