

THE EFFECTS OF USING SOCIAL CONSTRUCTIVISM IN THE HIGH SCHOOL
SCIENCE CLASSROOM

by

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July 2011

DEDICATION, ACKNOWLEDGMENTS

I would like to dedicate this to all the people who encouraged and helped me in this program. To the MSSE staff who were tireless in their ability to re-read and edit and help me format this document; Jewel, who I could call at anytime, Laurie who can reference even the most obtuse source of information properly, and Suzanna for reading this with insight. Also, I want to thank my fellow MSSE students who also encouraged me, made me laugh and had real interest in what I was doing. I also wish to thank my friends, neighbors and colleagues who had suggestions, watched me teach and made dinner during the last two years. Most importantly I want to thank my students that I was so fortunate to get to know during the 2010-2011 school year. Taking my project seriously, turning in IRB permission forms, giving up lunch periods for interviews, and taking non graded surveys with due diligence and making the most of every assignment given.

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ABSTRACT

Some students show a disinterest in science yet a great interest in making social connections with their classmates. This project looks at using social constructivism in the high school biology class and its effects on student attitudes, understanding of biological concepts, and long-term retention. This project used three units of study done with the same class. One was done in a traditional biology classroom manner with hands-on labs and teacher lectures. The other two units contained lessons designed to build social relationships with classmates as part of the learning of the unit. Each unit lasted two weeks. Students were assessed before, after, and again two weeks later for each unit. The unit topics were genetics, biotechnology, and evolution. Students took short-answer quizzes, answered essay questions, and filled out survey questionnaires for each unit. Some students did in-depth interviews with the teacher about both the content and the methods of learning. Assessments from each unit were compared with some mixed results. Students did build relationships with their classmates and enjoyed the changes in teaching style. Long-term retention of biological concepts also occurred. The use of the same assessment for the study helped the students show improvement and may not reflect actual improvement. Teacher and student attitude did show improvement.

INTRODUCTION AND BACKGROUND

With a recent change in the school's bell schedule, our science department could offer many more electives and students would be allowed to take more than the basic core classes. When surveying students about what sort of science electives the science department could offer in the coming year, I was met with statements like "Why would anyone choose science?" also "Science and Elective, that is a dichotomy, right?" Even good students have more important things to do than science. When I give assignments that somehow change social status or increase friendships, I can get remarkable dedication from the students as well as results. Teenagers are learning to build personal relationships outside of family. As I reflected on my teaching situation, I realized that if I could somehow take advantage of that natural learning, I might help to increase their science knowledge. In this day of social networking and using Facebook as a study tool, students are learning how to have positive social interactions. These social needs often outweigh the need for academic achievement. Having and maintaining friendships can outweigh the importance of getting schoolwork done. As I reflected on this dilemma, it occurred to me that if lessons were designed to create positive social bonds, then students might look forward to improving their academic achievements. That translates into better understanding of concepts.

My project focus question is what are the effects of using activities that utilize social constructivism with building personal relationship strategies on students' understanding of high school biological concepts? Studying this question leads to the following sub-questions: what are the effects of using activities that utilize social constructivism with building personal relationship strategies on the student's long-term memory of biological

concepts; what are the effects of using social constructivism with building personal relationships on my teaching strategies; and what are the effects of using social constructivism with building personal relationship strategies on students' attitude and motivation?

Social constructivism occurs when learners construct their understanding of a concept collaboratively while developing positive and respectful relationships with each other. From personal observations of students as well as from more formal assessments, I find that friendship is one of the most important things in their lives and science is often one of the least important things. I have spent much effort in my curriculum design trying to make science education relevant and to move it up the scale of importance, but have never thought about approaching it from the top down and using friendship formation as a means to teach science. For me, this is a new and intriguing idea that I believe has great merit for my teaching strategies. This could be a major piece in my solving the puzzle of becoming a great teacher.

I teach at Roosevelt High School in the city of Honolulu, and have been in-serviced in the Rigor, Relevance, and Relationship framework. This is a curriculum that provides rigorous academic coursework, relevant learning opportunities, and meaningful relationships with instructors to help students achieve high standards. The school promotes this model of instruction. We are encouraged and rewarded for submitting lessons that follow the framework. I also have approximately 160 students that would no doubt benefit from a personal relationship, but with this number of students to teach, it is more about quality curriculum that differentiates for a wide variety of students and learning styles than it is about individualized curriculum design. The school itself has 1500 students that come from three distinct neighborhoods: 25% live in nearby Hawaiian Home Lands and many

of those students are living below the poverty level, 30% come from well-educated families living in an upper middle class neighborhood, and the remainder come from an area with high-population density (high-rise apartments) made up of many immigrants from Asia, the Pacific speaking many different languages. Building relationships with students becomes nearly impossible unless I can use a curriculum that fosters and builds positive relationships between peers. For this project, I used separate but similar consecutive units, and looked at the number of students that gain enduring understanding. The first unit had my usual curriculum and the second and third units incorporated curriculum specifically designed to include the necessary mechanisms of social constructivism. I chose an Advanced Biology class for this project precisely because there are so many details, the overarching concepts are complex, and I tend to teach this course with traditional lectures and labs common to many science classrooms.

I hope that this study helps others with large numbers of students to think about providing strategies and activities to prevent social isolation and promote positive personal relationships in their classrooms to help students understand concepts. To help design and implement this project as well as dissect the data and learn from, I had a team of helpers. First, and foremost my project advisor Jewel Reuter has been instrumental with this initial project design since before I had even heard of the term social constructivism and just wanted to 'build friendships'. Jewel has been my mentor. My MSU reader is Suzanna Soileau, who was willing to take the time from teaching science to read and listen to what I had to say. I also work at a wonderful school full of supportive colleagues. Dawn Kuna and Jackson Vo are two science teachers who were willing to watch me teach, help me collect data, and tactfully make insightful recommendations. My wonderful and pa-

tient husband, Chuck, who gives me great support by reading the same paragraph over and over, compliments me on a new comma, corrects basic grammar, and reminds me of upcoming due dates.

Although my goal of using social constructivism strategies was to have students make friends, be enthusiastic about coming to class, and enjoy the material, I hoped to reach the more tangible and directly related goal of increased understanding of scientific concepts. The large overarching concepts that sweep through all of the biological sciences, while fundamental, often times become neglected as students get buried in the myriad of important details and emphasized specific examples. I would like to improve student appreciation for conceptual understanding in a detail-rich field of study. Students should be able to create an intellectual framework with which to approach future studies in biological science as well as issues they may face as members of society.

CONCEPTUAL FRAMEWORK

With nothing more than an idea about using social interactions as a means to teach concepts, I began to research and study what others had done and how to translate that into teaching biological concepts. In order to both study social constructivism and develop an enduring understanding of a concept, there needs to be understanding of both parameters of the project. Social constructivism is a process where a learner collaboratively constructs a new understanding while building positive and respectful relationships. What makes a positive and respectful relationship and what does enduring understanding mean? These two questions need to be addressed.

As I learn about social constructivism and use of it, I find that there are five basic parts to the collaboration that seem common to many successful studies. Not all studies specifically contained all five, but most have some variation of them. There is more to collaborative learning than simply letting the students work in groups. True collaboration in the sense of creating a new construct of shared knowledge seems to have these five aspects.

First, in order to make connections students have to spend time with each other where they are allowed to talk with one another, either in a group of two to five students (Schroeder & Blanton, 2004), or even speaking as part of a class discussion (Stears, 2009). This phase is a chance for students to realize and share how much they know and don't know about a subject. In order to remain in long-term memory, new information needs to be stored attached to prior knowledge or fit into an existing file. (Kinniburgh, 2010). This can also help students realize that they need to learn more about the topic, that they don't have all the answers, the discussion topic should be challenging enough to create some interest in new information, and give them a chance to create a framework for information. (Kinniburgh, 2010).

Second, students should be able to share information in a very nonthreatening way, in order for social bonds to be formed, they should share some aspect, but what they are sharing should be benign information where there is no threat of repercussions from classmates (Crall, Day, Frost, & Tselikis, 1994). That way, students don't feel too exposed, yet those listening feel like they are getting to know the speaker.

Third, students need to be listened to, the information being shared should be relevant to the task at hand, there should be a reason for others to listen, pay attention and remem-

ber what is being said (Vacha, Archibald, Brescian, Martin, & Fitzpatrick, 2009; Crall et al., 1994).

Fourth, students have to feel that they will be able to accomplish the task set in front of them, if any student feels like they are not qualified for the task, there is a chance that they will back away from the assignment rather than embarrass themselves in front of others. Everyone should have something that they can bring to the table (Palmer, 2005). There needs to be a common goal, everyone should be aiming in the same direction with a clear goal in sight. It should seem possible, yet it should have many subparts, be intriguing, and captivating with many possible results (Schroeder & Blanton, 2004).

Lastly, there is intervisitation, where students spend time in each ~~others~~ other's space. This does not have to be physical space, it can be just seeing it from others point of view through telling a story or some personal information (Schroeder & Blanton, 1995; Treagust & Duit, 2008).

There is a place in this for leadership, or a guide to make sure that it remains constructive collaboration this can be done by the teacher or a member of the group. This is critical as students can shut down if they feel isolated, unfairly treated, fearful, or unsupported in any way. (Kransnow, 1993; Vacha et al., 2009; Malone & Barabino, 2009).

While this research has empowered me with a good understanding of the theory, coming up with well-designed lessons that meet these requirements is still a challenge. I hope with time and experience I will be able to quickly come up with lessons at the normal rate required for day to day teaching, that my teaching strategies will begin to foster the building of personal relationships between students, and that in turn will improve the attitude and motivation of my students. Students who make personal relationships in a class, gain

a sense of belonging and have a better attitude for learning (Thousand, Villa, & Nevin, 2002). For now, it takes careful design to make sure that lessons will meet all of the requirements that I feel are essential for this to work. The research others have done makes me feel strongly that if my lessons do correlate with previous social constructivist work, then students will have biological concepts and scientific thinking ingrained into their own conceptual framework for their future reference. I did not find perfect lessons dealing with exactly my content area to test out for myself, but I did find many science teachers using a variety of lessons that I could glean from and make adaptations to. These are most valuable in helping my lessons improve at hitting the mark. It is more time consuming, but the resulting lessons do end up being customized to my class.

METHODOLOGY

For this project, I used separate but similar consecutive units and looked at the number of students that gained enduring understanding. The first unit has my usual curriculum, and the second and third units incorporated curriculum specifically designed to include the necessary mechanisms of social constructivism. I also looked at my role during class time to see if I was needed to help with the dynamics or whether it flowed on its own. I kept track of each ‘call out’ as I wandered around during group time to determine if I was being called in as mediator, problem solver, enforcer, or just to show off to? Were the comments, “Mrs. Williams, is this right?” or “Mrs. Williams, look how we did this.” I used these field notes to track and categorize my role in a quantifiable way.

Project Treatment

I worked with three consecutive units over a timeline of seven weeks with one additional postunit assessment occurring two full weeks after the project ended (Appendix A). On all three units, the students took a preunit assessment to see what they knew about the subject already. There was group work in all three units, but in the nontreatment unit I did not implement group activities that were socially constructive. I had lab groups that worked together on assignments that were submitted to me as individual labs. Students had reading assignments and class discussions about the material and had a short answer and essay question test at the end of the unit. The treatment units that followed used the same lab groups, but the assignments met the five criteria of a socially constructive lesson. Students had time to communicate about the project and plan the outcome. The group members had a clear objective with clear roles for each member. Students had a chance to share problems and concerns in a positive manner. The students did these assignments and submitted their work. I then tested students on these units, using both short answer and essay questions. I compared scores for each part of the test, looking particularly at the broad overarching conceptual questions. At the end of each test, there was a quick survey that students filled out about their lab group's effort and how well they thought they mastered the material.

The nontreatment unit took place over two and a half weeks and covered seven class periods. It began with a preassessment, which consisted of seven short answer questions (Appendix B), followed by a reading assignment from their textbook (Campbell & Reece, 2009). The following class was on genetics and the overarching concept of trait heritability. The lesson was a PowerPoint lecture on the unit. I went over the historical aspects, introducing Gregory Mendel and the plants and traits that he used for his studies as well

as what makes a good organism for genetics study. I also passed out the lab (AP Lab 7: The Mendelian Genetics of Corn) that the students did during the next class and went over briefly what the point of the lab was. The students read the lab for homework and came to class ready to do the lab. During the next class, students worked in their lab groups. Each student made counts of traits from F1 and F2 generations of corn. They had genetics problems to solve as part of the lab. They worked in groups and could share their findings with each other. During the next class, students worked on the genetics problems from the textbook, and they worked in lab group teams and put their answers on the board. Students got practice on working out problems of genetic probabilities. For homework, the students read a fruit fly lab that focuses on sex-linked traits and uses chi square analysis to determine the statistical significance of data. The lab is from the College Board curricula for Biology (Bronston & Ingram, 2009). The next class students worked in their lab groups and looked at live flies, examined the life cycle, and learned how to distinguish sex and eye color. I gave them mock data to use for their F1 and F2 generations. Students worked on labs and chi square analysis in their groups. I went over the problems and looked at chi square outcomes toward the end of the period. On the last day of the nontreatment unit, students had a postunit assessment that was the same as the preunit assessment. The assessment was followed by the postunit survey (Appendix C).

The first treatment unit was on DNA and uses of biotechnology which took two weeks and seven class periods. The unit began with a preunit assessment which gave me pre-treatment unit data (Appendix D). I also passed back the graded lab reports and the short answer assessment. We graded the essay question from the last unit in class. The second

lesson was a PowerPoint lecture on biotechnology, an overview of what is possible and what could be possible. Students took notes and asked questions. The third lesson was a socially constructive lesson where students chose their roles for the upcoming labs (Appendix E). Students looked at their own aptitudes, were they the most organized one? The most accurate one? The most coordinated one? The one who could best see the big picture and direct? Each group member learned one of the key skills involved in the following two labs. Each member was responsible for one aspect of the labs. The labs were about bacterial transformation and restriction enzyme PCR. The labs were taken from those recommended and published by the College Board A.P. Biology Labs 6 and 7 (Bronston & Ingram, 2009). The labs were complicated and require more time and skill than what we have allotted so each group member needed to rely on his or her partners to complete the assignment. With this treatment group, to insure social constructivism took place, each group member was assigned more specific duties to bring to the group; this insured that each member played an important role (Appendix F). The task of looking at group member's aptitudes gave students a chance to communicate and talk to each other in a positive manner. The first group activity then became choosing the roles, which forced opening up to each other, listening, and sharing personality information with each other. Each group member was selected for a specific role by doing socially constructive activities. A colleague came in to do a first observation and she helped with the training of group members for their individual tasks. The next two classes were laboratory classes, one doing bacterial transformation and the other doing DNA electrophoresis. The students worked collaboratively in their groups, each member having their own separate roles. They compiled their experiments and shared what they had contributed. Each

lab group member had their own area of responsibility and separate tasks that they were in charge of. We shared class data and debriefed on the labs at the end of the second day. The next class meeting was a posttreatment unit assessment as well as a follow up assessment for the nontreatment unit. The students also took the same postunit survey that they took for the nontreatment unit. At the end of the first treatment unit, I handed back the assessments and we graded the essay question as a class.

To start the second treatment unit, the class took a preunit assessment. We finished the class with a discussion of the Darwinian view (Appendix G). In the next class period[,] students did a cooperative learning activity on population genetics (Appendix H). As a group they came up with enough data to answer questions and work out Hardy-Weinberg equations. Each student had different data to contribute to explain the activity as a whole. The following class activity was a game on adaptive radiation. Two group members were in charge of abiotic factors and the other two group members were in charge of biotic factors that they chose and sent to the neighboring group. Each group selected an organism out of the jar and picked what traits might be selected for given the factors that were sent over to them from the neighboring group (Appendix I). There were several rounds as groups sent and received second third and fourth sets of biotic and abiotic factors. There were no winners or losers in the activity; it was more about making the point that evolution is not goal oriented. In the end, each group sent up a representative to draw their adapted organism while another group member explained the changes that the organism had gone through.

The next class was a PowerPoint lecture on reproductive barriers followed by a short game on speciation. The groups lined up and each member took a turn running to the

board. I picked a species out of the species jar and a type of isolation out of the reproductive barriers jar (Appendix J). Students quickly discussed and sent up their member who wrote on the board a possible example of the two and earned points for their group. While the group could discuss, each member had to take their turn at running up and scoring points.

History of life on Earth was the next subject covered in the unit. There was a timeline/table in their text that I wanted students to become familiar with. I allowed lab groups to pick one member to become an expert on each separate era: the Cenozoic, Mesozoic, Paleozoic, or Proterozoic and Archaean Eras. As a group they were encouraged to come up with ways to help each member learn his or her respective Era. The following day, we played a game where group members earned points for their group by answering questions about their respective eras (Appendix K). No notes were allowed, but group members were allowed to use hand signals to help out their group members. The last assignment for the Evolution unit was specifically about Hawaii. Each group selected one endemic plant, one endemic insect, one endemic bird, and one other endemic animal from a list of Hawaii's endemic species (Appendix L). The selection process was done by each group one at a time so there was a chance for discussion about any animals they might already know something about. Once each group had chosen their four organisms they were allowed to start researching and putting together a group presentation, each member doing one of the four species they had chosen. They had the rest of the class period to research their individual species. The next class they had a chance to assemble and prepare a PowerPoint presentation with all four species together, each student bringing their own research to the presentation. They were to have a ten-minute lecture

to present to the class the following day with each student explaining their own chosen species.

During the following class period, there was a postunit assessment and a follow up assessment from treatment Unit 1. Attached to that was a Postunit Survey and Questionnaire. At that time I began postunit interviews with students which were ongoing during lunch periods for the next few weeks (Appendix M). Two weeks after finishing the second treatment unit, gave a follow up assessment from the second treatment unit.

Data Collection Instruments

The advanced biology class was made up of 25 students: 19 seniors, five juniors, and one sophomore. All of the students were planning to attend college after high school. There was a broad range of scholastic ability and grades in the class. There was also a broad social background with many different cultures represented. There were immigrant populations (approximately 20%) that represented several countries as well as native populations (approximately 15%) that represented several local cultures.

The class has so much required content that the students were always pressed to cover large amounts of material in short periods of time. I rarely took the time to have one-on-one discussions with students. The students in the class ran the full gamut of academia, but most were seniors (79%) and have finished high school. There were 50% on the honor roll, 20% were members of the Health Academy and were planning careers in the health industry, and 20% were enrolled in some sort of athletics. The class covered a wide cross section of the student body. For the interviews I chose students who I thought would be willing to talk openly and share their ideas. I chose three high achievers, three

middle achievers and three low achievers. I also used the pre and postassessment results, my field notes and reflective journal. Collecting several types of data allowed for triangulation by gaining specific information from more than one type of data. Table 1 shows my data triangulation matrix.

The personal interviews were a big part of my research in terms of how students' personal relationships have developed. I visited with them one-on-one, asking questions about how they got along with their lab partners. The 10-question surveys were administered to all students after each unit along with short answer assessments. The field notes that I took were done during group time. As I got called over to a particular group, I noted the nature of what students were requesting from me and categorized those requests to the best of my ability.

Once the data were collected, I looked at those items that compared conceptual understanding of the material between nontreatment and treatment units. I took the scores from the lab reports, presentations, and games and looked for improvement. I also disseminated the assessment questions to the students. Some from each unit were conceptual or analytical questions, and I compared those scores across each unit looking to see if there was any improvement. I also looked at the essay question scores. These questions asked students to apply their knowledge in a new way, and the scores on their essays reflected conceptual understanding of a topic. I also looked at the survey questions to see if indeed social constructivism actually took place. Did students feel they helped and were helped by their lab partners? Did they make deeper bonds and have an improved attitude about the class? I also used my journals as well as test and lab report scores to ascertain whether certain lesson designs and teaching strategies improved my teaching and how to

incorporate any successes into future lessons.

Table 1
Data Collection Instrument Triangulation Matrix

Project Questions	Data Source		
	1	2	3
Understanding of concepts	Lab reports with treatment and nontreatment units	Short specific pre and postunit assessments (with each unit)	Essay questions done postunit (treatment and nontreatment units)
Students' long-term memory of biological concepts?	Postunit compared to delayed unit assessments given 14 days after post-assessment (unannounced)	Postunit Surveys & Interviews	Pre and Postunit interviews
Students' attitudes and motivation	Pre and Postunit Self-Assessments after each unit	Pre and Postunit Interviews	Postunit Surveys
Students' ability to apply concepts	Lab reports Postunit assessments Essay scores scored with rubric (treatment and nontreatment units)	Essay questions given postunit Short specific pre and postunit assessments (treatment and nontreatment units)	Surveys & Interviews with application questions (pre and postunit)
What are the effects of using social constructivism with building personal relationships on my teaching strategies?	Teacher reflection journal with prompts (through nontreatment and treatment units)	Teacher notes and student quotes (through nontreatment and treatment units) Interviews	Teacher Field notes

DATA AND ANALYSIS

In order to study the overall understanding of biological concepts, I compared the average scores from labs and the postunit assessment as well as the essay questions answered for each unit. The results are summarized in Figure 1.

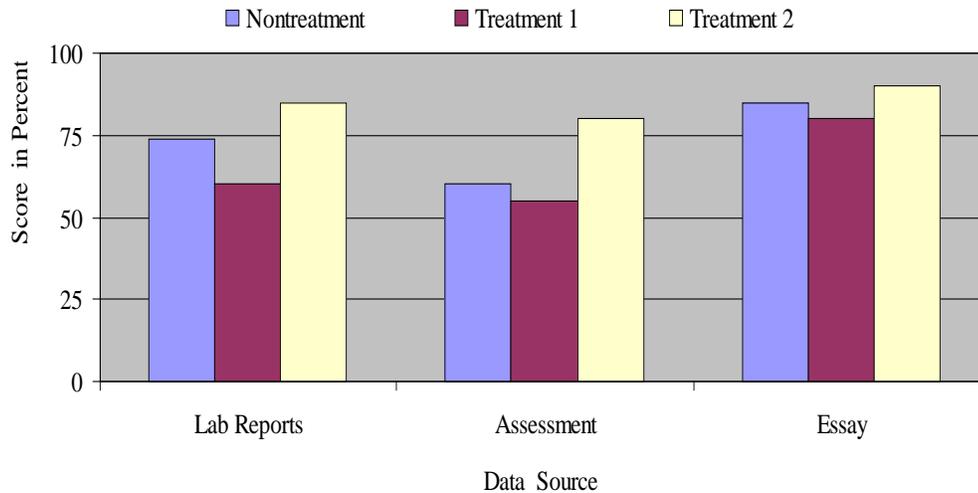


Figure 1. Average student percentages measuring understanding of biological concepts, ($N=25$).

Students improved in treatment unit 2 over the nontreatment unit in terms of understanding. During the first treatment unit students did not do as well. Treatment unit 1 was on biotechnology, a subject totally new to the students, and they had no previous experience in the field in any previous life science classes. The units on genetics and evolution were not such brand new subjects for the students. This case was easier to see when I compared the preassessment scores to the postassessment scores. The results are summarized in Table 2.

In Treatment 1, only about half of the students could answer chemical questions about DNA in the preassessment. The students did show a tremendous gain in understanding

Table 2
Average Assessment Percentage Change in Three Units Covered (N=25)

Unit and Subject	Nontreatment Genetics	Treatment 1 Biotechnology	Treatment 2 Evolution
Preunit Assessment	30	5	30
Postunit Assessment	60	55	70
Percent change	100	1000	133

over the course of all the units, but more so during the two treatments. During treatment 1, students had almost no previous framework and the scaffolding that took place was tremendous.

To study student understanding over the long term, I compared the postunit assessments with the delayed unit assessment. The results of my findings are summarized in Figure 2.

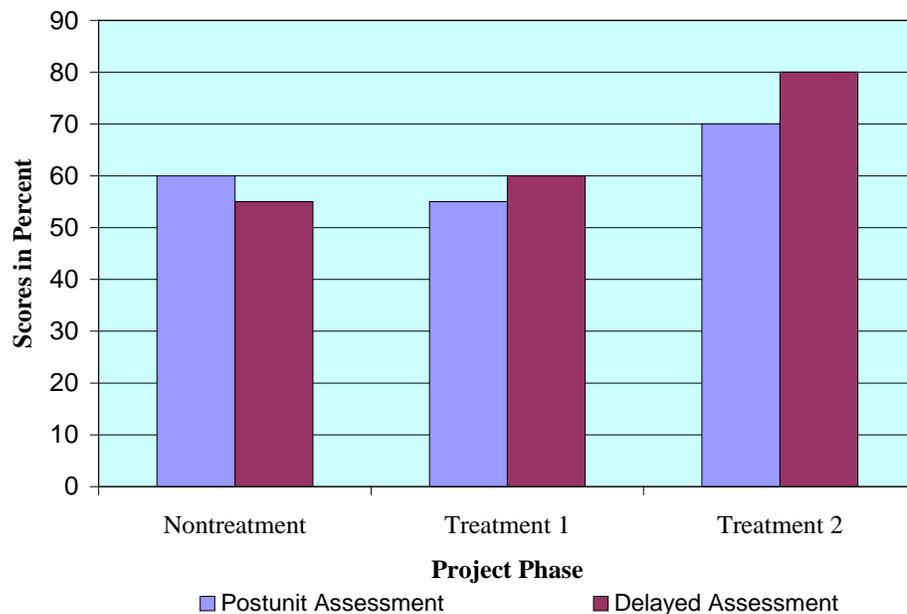


Figure 2. Average student percentages showing long-term memory of concepts for post and delayed assessment ($N = 25$).

Students in the nontreatment unit gradually decreased their understanding of concepts, while their understanding seemed to improve over time during the treatment units. I believe that this is because of a simple learning curve. Students knew that I was doing a study because they had given me permission to do so. They also had a good enough understanding of science that once they got the first delayed and unannounced assessment with the exact same questions they were prepared for the next two. I even heard students discussing it amongst themselves and noted it in my journal on more than one occasion. I really don't feel that these data, although in support of my beliefs, are of much value. The content interview questions were unpredictable and given orally. I believe these data are of more value. When looking at the content interview questions[,] there was a 10% loss in the nontreatment unit, no loss for the first treatment unit, and a 15% loss for the second treatment unit. I attribute this in part to small sample size, and I feel the results are not very conclusive.

In order to get a feel for students' attitudes and motivation, I simply asked them. The 10-question surveys were given at the end of each unit. The questions were not scored for a grade, but asked subjective questions such as how much they worked with others during the unit and what they thought of the activities they had done relating to the units. The first five questions used a Likert scale with answers of never, sometimes, often, and always. The results are summarized and averaged in Figure 3.

Students increased their group participation and were more part of the group during the treatment units. According to their survey responses, there was more cooperative learning in the treatment activities and students were aware of the difference.

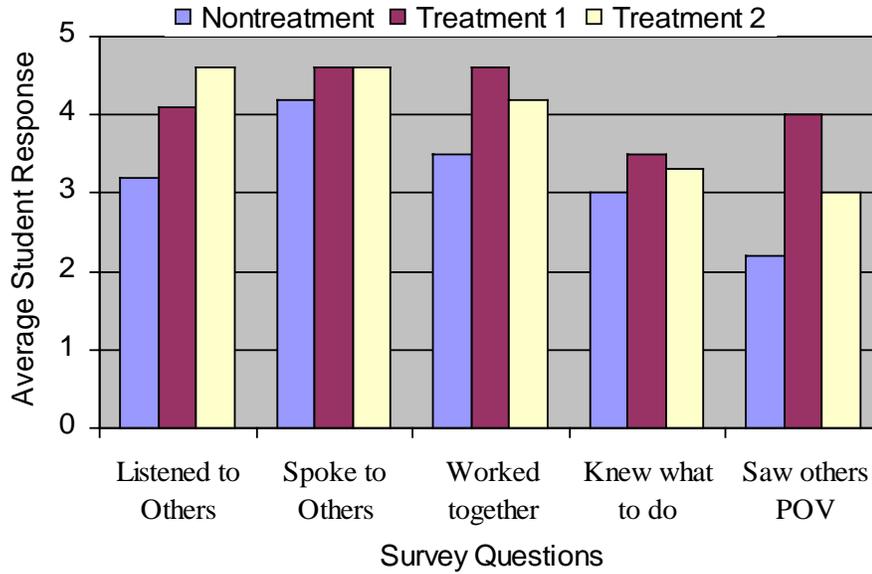


Figure 3. Average student responses to survey questions about social constructivist learning, ($N=25$). *Note.* Likert scale 5= Always and 1= Never. (POV= point of view)

The other survey questions were short answers and along with the interview questions gave a good idea of how students felt about the activities they did. The students felt that they knew more about each other during the treatment units. There were 76% who said they knew each other better after the treatment units compared to 56% on the nontreatment unit. Students were evenly split on which unit they learned the most. Thirty-two percent said the nontreatment unit, 36% said the first treatment, and 32% said the second treatment unit. These numbers correspond with the units that students scored the highest on. All of the students interviewed enjoyed the treatment units more than the nontreatment unit. One student said, “The group activity where we picked who would do what was the best, but we ended up doing it differently anyway.” The same student thought that most of the learning had been on his own when he tried to answer the lab questions at home. The attitude about learning the material was more positive. All of the interviewed students enjoyed games and took their roles to heart. Students enjoyed the second treat-

ment unit the best. This might be because the interviews occurred after this unit and the other units were a distant memory. The low-achieving students that were interviewed had not read the book or done any of the activities that were to be done on their own. All three of them did participate in the group activities and felt that they were active in their roles for in all of the units. One student said “I did all the stuff that I was supposed to do for the group, but didn’t do the other stuff. I didn’t really understand the lab until later, I just did the what everyone told me to do.” The student said she only had a general idea of biotechnology lab, and only understood the lab after going over the essay in class.

The interviews and survey questions really reflected each other. Both showed the students having a better attitude towards the treatment units. One of the questions was, “Do you think that your lab partners know you better after this unit? Please explain.” Interestingly, over 80% said they knew their partners better after the treatment units, but only 60% thought that their lab partners knew them better. It is still above the nontreatment unit with 50% and 35% respectively. It is still an interesting difference. Perhaps they felt that way because they did not have to give out intimate information about themselves but felt they had learned something about their lab partners.

To look at students’ ability to apply concepts, I looked at the essay questions, the assessments, and with the application questions of the personal interviews. With the essays and assessments, students had trouble with treatment unit 1 but when orally interviewed they could easily come up with applications of biotechnology. This might be because the language of the written questions is very technical and when doing the oral interviews, I would rephrase questions until the students understood what I was asking. Also, during an oral question, students did not leave any questions blank, all nine made attempts at

every question. Treatment unit 2 showed a small improvement across the board. The results here are also not very conclusive. The improvements were less than 10% for each treatment unit.

The last item I wanted to look at was the effects it has on my teaching strategies. Here there was no doubt there was extra work, but it was all front-end loaded; once the lessons were designed, then the implementation was very easy and the atmosphere of the classroom seemed greatly improved. From my journal entries over the course of the project I observed that my attitude toward the class as a whole was more positive. During the project treatment units, I noted in my journal that class was more fun and enjoyable for nearly every lesson. After the third day during treatment unit 1, when students spent the day choosing roles, I noted the following: "Today there was almost constant laughter, and the wondrous part is that it was content related. I hope the students will be able to do the lab tomorrow." The following day I noted: "I heard students refer to each other by their role titles no less than 23 times during the lab today. Students were less stressed and all participated." My job satisfaction is improved when the students have a positive and constructive attitude. The enthusiasm of both myself and the students is better. One student said during treatment unit 2, "I love biology. Everyone has so much fun here."

INTERPRETATION AND CONCLUSION

Overall, the data show a difference between the nontreatment and treatment units. The biggest difference was the attitude and motivation of the students. Students had a much better time during the treatment units. All of the students recommended the con-

tinuation of the teaching strategies. The feedback from the students was very positive, but it may have been because they were more involved in the teaching strategies that were being used and were aware that I was collecting data. As far as my overall feeling about the social constructivism concept, I do feel stronger than ever that it works, but more from my personal observations of student engagement than from increased test scores. Students enjoy class more, and have more passion for Biology, but I am not sure that they understand it any better. I would certainly like to continue to test the ideas and am happy to have passionate students that are likely to continue in science. In terms of my teaching strategies, the increase in positive attitude and motivation on the part of the students will make me consider using socially constructive techniques as often as possible. Even after the project ended, the social nature of the class was different and that open family feeling carried on through the end of the course. Students continued on their own to make labs and activities more like the treatment units. To make a complete curriculum that is socially constructive will take many years of lesson design. The earlier in the year that these lessons occur, the greater I think the impact will be.

There are many things I can see to improve. I would like to interview students throughout the year, not only to get more feedback but to get to know the students better and to improve my personal relationships with them. Also, the few students that I interviewed felt that they had some say in the lesson design and that the lessons were not written in stone. I had a continued rapport with them and I would like to interview all of my students over the course of the first semester. I also see the need to make careful choices about all the assessments during the units. I chose to focus the assessments on conceptual

understanding and some students who I realized had learned quite a bit did poorly on the assessments because they had not quite mastered the material.

Giving students a chance to show off their skills and to be cheerleaders for each other does not meet all the requirements of a socially constructive piece but it does help the students have a positive attitude about learning. I do like my interview questions and think they do give me a clear picture of students' attitudes and motivation.

VALUE

There are some real implications of this study for myself as well as for my students. As an instructor, until only recently I had never given any thought to social constructivism as a teaching tool. I was always more concerned with application and rigor of units, and because of that there are many students who fall through the cracks, never getting involved in my activities. The results show me that the greatest change occurs in terms of students' willingness to become actively involved in class lessons. They did have an improved attitude and that is a big start. These ideas could be incorporated into more lessons that are available for other teachers to use and share. Students do perform for peers and can be positively motivated by each other. I will be very much involved in creating a socially constructive atmosphere in all of my future classes. It would be interesting to look at the age of students; I have a feeling that the teacher is more of a motivator for very young students, and peers take on a larger role during the teen years. Perhaps we become more self-motivated as adults, but this is conjecture that I did not research but it would be interesting to look at.

For me as a teacher, this new outlook is very different. I have always put science and the fun of science as the foremost design aspect of my lessons. I have always considered having lessons be fun and enjoyable for students; however, I have never really analyzed what makes a lesson fun for a student. I have always thought that as long as they have to figure out strategy and get to play with new things that would stimulate their curiosity and motivate them. Not until this year when I began to “close the feedback loop” did I realize how many students did not think the same things were fun that I thought were fun.

I think that my capstone project has had a huge effect on my understanding of student motivation. I am excited at the possibilities of this unexpected turn. This is not what I thought I would be doing as a capstone, I just stumbled upon it by just a few things that students had said as I was finalizing my capstone project topic during the 509 Action research course. I’m glad I was listening.

There are also implications for other audiences. I have shared both my lessons as well as my findings with colleagues in my department during the study, and I will share these findings with the rest of the faculty in a more formal presentation in the upcoming year. I certainly would not have been able to express my findings without the help of this capstone project. I have made so many great improvements to my teaching throughout the entire MSSE program, but I think the greatest impact will be the improved ability to have positive relationships with my students, and to be able to create positive relationships between peers using science.

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APPENDICES

APPENDIX A

PROJECT TIME LINE

Overall Project Timeline: Seven weeks

Nontreatment Unit

Day/Date	Topic	Activity
January 10		Collect preunit nontreatment data through preunit assessment.
January 11	Genetics	Lecture on genetics. Pass out Corn, Lab
January 13		Lab groups, do Corn Lab Data collection Share Data with lab group member and class
January 18	Genetics Problems	Lab groups work on genetics problems, share with class.
January 20	Sex linked factors, fruit fly experiment	Pass out Mock fruitfly Lab with mock data Work in Lab groups to write up fruit fly lab. Chi square problems, go over in class
January 21	Genetics review	Lab write ups due Practice test done in groups to review
January 25		Post nontreatment unit assessment with survey

Treatment Unit I

Day/Date	Topic	Activity
January 27	Biotechnology	Collect preunit treatment I data through preunit assessment Pass back graded lab reports and assessments Grade Essay question in class.
January 28		PPT Lecture on biotechnological trends, PCR, Bacterial transformation, Cloning Students take notes, ask questions.
Feb. 1	Listening skills, evaluating aptitude, social constructivism	Cooperative Learning activity. Group members chosen for individual Laboratory skills training. Students Assign roles using socially constructive methods to chose rolls.
Feb. 2	Bacterial transformation	Bacterial transformation lab. Glow-in-dark gene into bacteria along with antibiotics resistance. Pour and streak plates. Set up incubator.
Feb. 3	PCR / Electrophoresis	Students select transformed bacteria and colonize new plates. Start PCR lab using restriction enzymes and electrophoresis equipment. Each member doing area of expertise.
Feb. 4	no class	Students come in on own time to check results and collect data.
Feb. 7	Biotechnology	Students work on Lab write ups, having members explain purpose of each part.

Feb. 8		Post treatment unit assessment Follow up assessment of nontreatment unit.
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Treatment Unit II

Day/Date	Topic	Activity
Feb.10	Evolution	Pass back unit assessment. Class scoring of essay questions Collect preunit treatment I data through preunit assessment Discussion of Darwinian view
February 11	Population Genetics	Cooperative learning activity Hardy-Weinberg Lab
February 14	Natural Selection Genetic drift Gene flow	Cooperative learning activity adaptive radiation game.
February 15	Reproductive Barriers	PPT Lecture on Reproductive Barriers Socially constructive group activity on speciation
February 17	History of life on Earth	Students Assign Eras to each group member. Become experts on Period, Epoch and Age. Come up with methods to learn important events.
February 18	Geologic Record	Groups compete in class game to earn points for their group.
February 22	Adaptive Radiation	Endemic species in Hawaii each group member selects one plant, insect, bird, other animal.(not insect or bird) and researches how they came to be. Finds pictures for PowerPoint.
February 24	Hawaii's adaptive radiation	Quick PowerPoints presented by each group on their four species.
March 1		Postunit assessment Follow up on long term assessment from treatment unit I Posttreatment Survey and Questionnaire Begin postunit interviews-ongoing during lunch periods
March 3		Collect delayed treatment assessment

March 15		Follow up on long term assessment from treatment unit II Finish interviews.
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APPENDIX B

NONTREATMENT UNIT ASSESSMENT

Genetics

Name _____

1. What are genotypes and phenotypes?

2. Distinguish among complete dominance, incomplete dominance, and codominance.

3. The black coat color in horses is caused by the dominant allele (B), the brown coat color is caused by the recessive allele (b). Trotting gait is due to a dominant gene (T), while a pacing gait is recessive (t). A homozygous black trotter is crossed to a brown pacer.
 - a. What are the probabilities of the possible outcomes for the F1 and F2 generations?

 - b. Which genotype will be most common in the F2?

 - c. Which phenotype will be most common in the F2?

 - d. Which of the potential offspring will be certain to breed true?

4. A husband sues his wife for divorce, saying that she was unfaithful. His wife gave birth to a girl with a fissure in the irises of her eyes. This is an X-linked recessive trait. Both of the parents have normal eyes. Does the husband have a case? Explain your rationale, genotypes and phenotypes for all parties involved.

APPENDIX C

POSTUNIT SURVEY

Post Unit Survey

1. Pick the lab partner that you know the best.

How long have you know him or her?

_____ Since class started

_____ More than a year

_____ More than four years

2. Pick a the lab partner that you know the least well.

How long have you know him or her?

_____ Since class started

_____ More than a year

_____ More than four years

During this unit on Genetics, rate the following using this scale (for other units, Biotechnology and Evolution was substituted for Genetics)

1. rarely or never
2. sometimes
3. the same as the others
4. very often
5. always

3. _____ Listen to what all of your lab partners had to say.

4. _____ Spoke out loud to all of your lab partners.

5. _____ Worked together on the assignments.

6. _____ Every one knew what the assignments were.

7. _____ Saw the assignment from your lab partners point of view.

8. Having completed this unit, do you feel that you know your lab partners better? Please explain.

9. How about your lab partners, do they know you better? Please explain.

10. Do you think you have a much better understanding of Genetics because of the group activities you have done during this unit? Please explain why.
(for other units, Biotechnology and Evolution was substituted for Genetics)

APPENDIX D

ASSESSMENT FOR TREATMENT UNIT I

Name _____

Biotechnology

1. What is the ratio of guanine to cytosine in a double-stranded DNA molecule?
2. What does it mean to say the DNA replication is semiconservative?
3. What is a plasmid? How are plasmids used in genetic engineering?
4. How does bacterial conjugation differ from the process by which eukaryotic gene products are produced by bacteria?
5. How might scientists ensure that the *Escherichia coli*, one of the bacteria found in human intestinal tracts, won't be transformed into a dangerous pathogenic form and be released into the population if scientists use this bacteria in recombinant DNA experiments?

APPENDIX E

CHOOSING ROLES IN TREATMENT UNIT I

Choosing roles in treatment unit I

This unit is socially constructive before even looking at the scientific content. There are activities designed for role choosing. For person one, students compare the organizations of their backpacks and subject notebooks, each student explains the organizational method. Then students take turns explaining how their wardrobe, closet, and dresser is organized at home. Students rank as a group who is the most organized to the least organized 1 through 4. These are the candidates for the Master Planner.

Then for the second activity, cup cakes and decorating tools and frostings are passed out. Students have 15 minutes to decorate and create a design on their cupcake. Students compare in their group and judge cupcakes on intricacy, ranking the cup cakes 1 through 4. These are candidates for the Dexterity Master.

A bag with 15 items, some of them duplicates and triplicates is dumped onto the table and students have 15 seconds to memorize the items. They are then covered up while students each write down as many as they remember. The students who remember the most are ranked # 1 up to #4. These are candidates for the Accuracy Monitor.

For the last position, the Moving Director, each student is given a bag with cut up pictures that tell a story. Students have to put the pictures in order, all start at the same time and the first one done yells #1, the second #2, the third #3, and the last is #4.

Each group will have a Master Planner, The Action Director, Dexterity Master, and an Accuracy Master. A handout with these titles and a job description is passed out and roles are chosen. It is really up to the group to decide who to place where, the points and scores might help guide them but the real purpose of the activity is to discuss group dynamics, build personal ties, let everyone have a say on varied matters and to share some part of their personal experiences with one another. All titles of all group members should sound critical and important. No one is called the leader, each should have their own domain to champion.

APPENDIX F

INSTRUCTIONS FOR DESIGNATED GROUP MEMBERS

Master Planner

For this lab to be successful, the most important thing is to put the correct components in the correct tubes and onto the correct plates. Marking the tubes clearly and being prepared and organized is crucial for smooth execution of the experiment. Make sure you have a clear understanding of the over-all goings on during the course of the lab. If any individual member has a question about what they should be doing or what will happen next, it is your job to have the answer for them. Keep track of what everyone is doing. Keep in contact with the Action Director to clarify what needs to happen next.

Action Director

Your part of the lab begins with lab safety. Whoever gets directed with certain tasks should be made aware of proper safety.

1 Escherichia coli bacteria strain HB101 K-12 is not a pathogenic organism; it has been genetically modified to prevent growth unless grown on an enriched medium. You must however still use standard microbiological procedures and make sure that whoever is handling the bacteria follows procedures.

2. The ultraviolet lamps can cause damage to eyes and skin. The lamps are long wave but care should be taken. (The short wave light is in the goggle sterilizer box and is much more dangerous.)

3. Ampicillin can be dangerous. If anyone is allergic to penicillin they should not handle the ampicillin.

4. It is important to communicate with the Master Planner and see what is being done, if you need to step in and help the Dexterity Master or the Accuracy Master with any job to keep things running on time then do so.

Dexterity Master

Keeping a sterile field for all activities

Pouring plates

Using micropipettes to draw correct amounts of solutions

Using the inoculation loops to streak plates

Accuracy Master

Your part of the lab starts off with making sure that all the items listed on the inventory check list are available and that you know where each item is located and what it looks like. The vortexer, microwave, water bath, and incubator are items that need to be shared with other lab groups and should have public access for all.

It is also your responsibility to be the time clock for parts of the lab that require accurate time keeping during Heat Shock, Recovery, Ice baths. It is also your responsibility to make sure that the temperatures are accurate in the incubator and the water bath. You can add ice or hot water to adjust and keep the water bath at the proper temperature. The two incubators have knobs that can be adjusted, make sure the temperature is stable before leaving your plates overnight.

One of the most crucial aspects of the job is to make sure that the Dexterity Master puts the correct solutions on the correct plates.

The proper micropipettes and tips should be 2-20 ul size, adjust to proper settings.

It is your job to collect data and fill in tables.

APPENDIX G

ASSESSMENT TREATMENT UNIT 2

Evolution

Name _____

1. For Natural Selection to take place, Darwin listed three things that must be true. Can you name them?

1.

2.

3.

2. Besides Darwin's Natural Selection, there are other ways that the allele frequency can change in a population. Can you name three along with a brief description of what each means?

1.

2.

3.

3. Species have mechanisms that cause reproductive isolation from other species. Can you name 5?

1.

2.

3.

4.

5.

4. Pick one of the above 5 and explain it, then pick another one of the above 5 and give an example.

APPENDIX H

SOCIALLY CONSTRUCTIVE HARDY WEINBERG LAB

Socially Constructive Hardy Weinberg Lab

This lab involved each member of the group selecting slightly different traits for survival. In this case students chose what sort of beak they wanted to use. Their choices were: forceps, beaker tongs, chop sticks, or test tube clamps. Students in each lab group had a chance to pick who will have what sort of beak with the idea of maximum survival for their lab group. This gave students a chance to practice with each tool and to compare abilities. The student who is most adept at each tool should be the one to have that beak. The first generation's food was supplied as color beads in a bowl of white beads. They had a certain amount of time to collect as many as they could. For every ten meals they collected they were allowed to reproduce. We kept track of alleles and traits and after several generations, the food changed from beads to little vials; the change of diet allowed other types of beaks to be more successful. The groups all kept track of their own reproductions and alleles for their beaks. All the data was collected and traits were mapped. The specific student instructions are as follows:

Hardy-Weinberg Lab

Name _____

Adapted from Evolutionary Agent Lab by James Perry and David Morton in the Lab Manual for Starr & Taggart's Biology 1992

Materials

Plastic dishpan

50 large red beads

50 large white beads

50 large pink beads

1 large gray bead

4000 small white beads (from an old bean bag chair)

(use your population estimation abilities from ecology to measure out)

4000 small red beads (to be used for different background if we have time)

4 Beaks (one each):

Pair of long forceps

Clothes pin

Chopsticks

Binder clip

Coarse sieve

Small bowl

Calculator (use your phone)

Clock with second hand (use your phone)

Procedure

The populations you will be working with are composed of colored beads. White beads in our model represent individuals that are homozygous for the white allele ($CwCw$). Red beads are homozygous for the red allele ($CrCr$), and pink beads are heterozygotes ($CwCr$). These beads exist in "dishpanland" filled with smaller beads. The smaller beads can be strained to retrieve all the "individuals" that make up your population. When the individuals are recovered, the frequencies of the color alleles can be determined using the Hardy-Weinberg formula. The alleles in your beadworld are co-dominant. The total number of color alleles in your population is two per individual. If there were five white beads, ten pink beads, and five red beads, the frequency of the white allele is:

$$p = \frac{(2 \times 5) + 10}{40} = 0.5$$

Because $p + q = 1.0$, the frequency of the red allele (q) must also be 0.5 if there are only two color alleles in this population.

Natural Selection disturbs Hardy-Weinberg equilibrium by discriminating between individuals with respect to their ability to produce young. Those individuals that survive and reproduce will perpetuate more of their genes in the population. These individuals are said to exhibit greater fitness than those who leave no offspring or fewer offspring. We will model the effect of natural selection by simulating predation on our population.

Beads				
	White	Pink	Red	Total
Initial Population Before	10	20	10	40
After				
Second Population Before				50
After				
Third Population Before				50
After				
Fourth Population Before				50
After				

1. Work in your lab groups. First pick the best possible total predation given that each lab group member will have a different "beak" to work with. Decide whether the easiest beak should go with the fastest person, or the slowest, come up with ownership of beaks and pick the order that hunting will occur. This should be a group decision designed to be the most successful as predators.

Place 10 large white beads, ten large red beads, and twenty large pink beads into a dishpan filled with small white beads (about half full)

2. The first predator gets ready with their beak of choice. After the beads are mixed in, the predator gets to hunt for as much prey as they can get in 30 seconds using only their chosen beak to catch the prey.

3. Because some of the beads are cryptically colored, the proportions of beads may not reflect the original proportion. Sift the pond with the sieve, count the number of large beads still remaining and record the number in the table above. Use these counts to calculate the frequencies of p and q alleles remaining in the population after hunting and record them in the frequency table. For example if five white, eight pink and eight red beads remain, the frequency of the white is:

$$p = \frac{(2 \times 5) + 8}{42} = 0.43$$

4. Use the new values for allele frequencies, calculate genotype frequencies for homozygous white (p^2) heterozygous pink ($2pq$), and homozygous red (q^2) individuals and record them in the frequency table. For example, if p now equals 0.43, the frequency of homozygous white individuals is:

$$p^2 = (0.43)^2 = 0.18$$

Assume that 50 individuals make up the next generation, calculate the number of white, pink, and red individuals needed to create the population of a new dishpanland and record these numbers in the table. For example if $p^2 = 0.18$, the number of white beads will be:

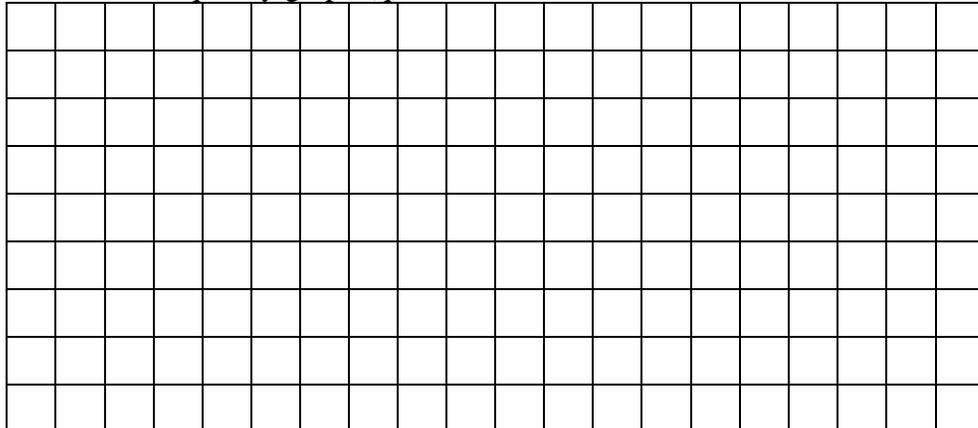
$$p^2 \times 50 = 0.18 \times 50 = 9.0$$

use 9 white beads in the next round.

5. Repeat steps 2-4 for three more rounds. Use different hunters with different beaks. Stop when you have filled both tables. When you are finished, record the frequency of the red allele and plot the data on the graph. Mark in on the master graph for class data as well.

Allele Frequencies due to simulated predation					
Population	p	q	p^2	2pq	q^2
Initial population	0.5	0.5	0.25	0.5	0.25
First generation after selection _____					
Beak type					
Second generation after selection _____					
Beak type					
Third generation after selection _____					
Beak type					
Fourth generation after selection _____			X	X	X
Beak type					

Red allele Frequency graph (q)





Generation	Selection Alone	Selection with Migration
1	q=	q=
2	q=	q=
3	q=	q=
4	q=	q=

Selection that favors one extreme phenotype over the other and causes allele frequencies to change in a predictable direction is called **directional selection**. When selection favors an intermediate phenotype rather than either extreme, it is known as a **stabilizing selection**. Selection that operates against the intermediate phenotype and favors the extreme ones is called **disruptive selection**.

Note that we looked at only one trait with two alleles and selection operates on the entire phenotype so overall fitness is based on interactions of thousands of genes. Selection is also occurring on the other organisms that interact with your organism so the interactions become even more complicated and interrelated.

If two identical populations were in different environments how would the frequency of the alleles change? Look at the group that used the red background vs. the white background.

Gene Flow

The frequencies of alleles in a population also change if new organisms immigrate and interbreed, or when old breeding members emigrate. Gene flow due to migration may be a powerful force in evolution. To demonstrate this effect:

1. Establish an initial population as in the first part.
 2. Begin selection as before, except in this part of the exercise add five new red beads to each generation before the new allele frequencies are determined. The beads represent migrants from a population where the red allele confers greater fitness. For each generation, record in the frequencies of the red allele obtained with both selection and migration. How do the two compare?
-

We still have Genetic Drift, Mutation, and Nonrandom mating to simulate and no time to do it. Pick one of the three, note in on the board so only two lab groups are doing each one. Design a simulation to look at these effects over time.

Be sure to look at it in terms of allele and genotype frequencies. Make tables on a separate sheet, share data with the class about what you did and what it showed.

Post lab questions.

1. What two evolutionary agents are most responsible for decreases in genetic variation?
2. How can selection cause two populations to become different with time?
3. What effect would increasing gene-flow between two populations have on their genetic makeup?
4. Through what mechanisms can new genetic information be introduced into a population?
5. What kind of an effect can nonrandom mating exert on a population?
6. Describe how the effects of directional selection may be offset by gene flow.
7. What is the fate of most new mutations?

8. If a population has three color alleles, and the frequencies are $p = 0.5$, $q = 0.3$ and $r = 0.2$, how many phenotypes are possible?

APPENDIX I

LIST OF ORGANISMS TO BE ADAPTED BY ABIOTIC AND BIOTIC FACTORS

LIST OF ORGANISMS TO BE ADAPTED BY ABIOTIC AND BIOTIC FACTORS

Raccoon	Bayan Tree	Mongoose
Lion	Coconut Tree	Duck
Deer	Banana Tree	Wolf
Rabbit	Orchid Plant	Snail

APPENDIX J

SPECIES AND REPRODUCTIVE BARRIERS LIST

SPECIES AND REPRODUCTIVE BARRIERS LIST

Species		Reproductive Barrier
Fruit fly	Hibiscus Bush	Habitat Isolation
Zebra	Palm Tree	Temporal Isolation
Parrot	Fern	Behavioral Isolation
Snake	Pine Tree	Mechanical Isolation
Dog	Corn Plant	Gametic Isolation
Tiger	Snail	

APPENDIX K

GEOLOGIC TIME QUESTIONS

GEOLOGIC TIME QUESTIONS FOR HOT SEAT GAME

Archean & Proterozoic

When did Earth Originate? 4.6 Billion years ago.

What are the oldest rocks that have been found on Earth? 3.8 Billion years old.

How old are the first fossils of cells? 3.5 Billion years old.

When does the first eukaryotic fossil appear in the record? 2.1 Billion years.

Follow up group question: How long is the time period from first cells until eukaryotes?

More than a billion years! (1.4 billion, more time than it took the first cells to appear)

When did Oxygen concentrations begin to increase? 2.7 Billion years ago.

What period do we find multicellular algae and soft bodied invertebrates? Ediacaran Period.

Paleozoic

What happened in the Devonian Period? Bony fishes, tetrapods and insects appear.

What is the name of the period when there is a sudden increase in diversity of animal phyla (explosion)? Cambrian

What is the name of the period that had terrestrial colonization by fungi, plants, and animals? Ordovician

What happened in the Silurian period? Early vascular plants.

When do seed plants, extensive forests, reptiles, and amphibians first appear? 300 million years ago. Carboniferous Period.

What happened in the Permian period? Diversification of reptiles, most present day insects, large terrestrial and marine extinction at end of period.

Mesozoic

What are the three periods in the Mesozoic era? Cretaceous, Jurassic, and Triassic.

When do the first mammals appear in the fossil record? Triassic 250 million years ago.

When do dinosaurs evolve and radiate? Triassic 251 million years ago.

Gymnosperms are the dominant land plant in which two periods? Jurassic and Triassic.

When do flowering plants (angiosperms) appear? Cretaceous 145 million years ago.

When do most dinosaurs become extinct? End of Cretaceous period 65 million years ago.

Cenozoic

Why do we have Epochs as well as period in the Cenozoic era? It is the most recent and there are more complete records.

What Epoch was there major radiation of mammals, birds and pollinating insects? Paleocene. 65-55 million years ago.

What Epoch do Angiosperms (flowering plants) begin to dominate? Eocene 55-34 million years ago.

What happened in the Oligocene Epoch? Apes and many other primates originate.

When is the Neogene Period? 23 million years to present.

What do we call historical time? Holocene.

When were the ice ages? During the Pleistocene Epoch 1.8 million years ago.

Follow up group question: How far apart was the last ice age from the end of dinosaurs?
62 million years apart.
When did the genus *Homo* appear? Pliocene 5 million years ago.
When did humans appear? Pleistocene.

APPENDIX L

LIST OF POSSIBLE HAWAIIAN ENDANGERED SPECIES FOR PRESENTATION

Listed are some of the 44 animals and 273 plants listed as Endangered in the Hawaiian islands. These have interesting stories that are specific to Hawaii. Pick one to research.

Animals

Amphipod, Kauai cave (*spelaeorchestia koloana*)
 Bat, Hawaiian hoary (*Lasiurus cinereus semotus*)
 Coot, Hawaiian (*Fulica Americana alai*)
 Creeper, Hawaii (*Oreo mystis mana*)
 Crow, Hawaiian (*Corvus hawaiiensis*)
 Duck, Hawaiian (*Anas wyvilliana*)
 Duck, Laysan (*Anas laysanensis*)
 Elepaio, Oahu (*Chasiempis sandwichensis ibidus*)
 Finch, Laysan (*Telespyza cantans*)
 Finch, Nehoa (*Telespyza cantans*)
 Goose, Hawaiian (*Branta sandvicensis*)
 Hawk, Hawaiian (*Buteo solitarius*)
 Moorhen, Hawaiian common (*Gallinula chloropus sandvicensis*)
 Moth, Blackburn's sphinx (*Manduca blackburni*)
 Petrel, Hawaiian dark-rumped (*Pterodroma phaeopygia sandwichensi*)
 Seal, Hawaiian monk (*Monachus schauinslandi*)
 Snails, Oahu tree (*Achatinella spp.*)
 Stilt, Hawaiian (*Himantopus mexicanus knudseni*)

Plants

The Silversword alliance
 Silversword, Haleakala (*Argyroxiphium sandwicense macrocephalum*)
 Silversword, Mauna Loa (*Argyroxiphium kauense*)
 Silversword, Mauna Kea (*Argyroxiphium sandwicense*)
 Ma'o hau hele, (native yellow hibiscus) (*Hibiscus brackenridgei*)
 Hibiscus, Clay's (*Hibiscus clayi*)
 The Lobelias
 Lobelia gaudichaudii koolauensis
 Lobelia monostachya
 Lobelia niihauensis
 Lobelia oahuensis
 Lo'ulu (*Pritchardia aylmer-robinsonii*)
 Sandalwood or 'iliahi (*Santalum freycinetianum lanaiense*)
 Vetch, Hawaiian (*Vicia menziesii*)
 Nani wai'ale'ale (*Viola kauaiensis wahiawaensis*)
 A'e (*Zanthoxylum hawaiiense*)

APPENDIX M
INTERVIEW QUESTIONS

INTERVIEW QUESTIONS

I am interviewing you as part of research that I am doing. I hope this research will better my teaching strategies. I am doing this as part of work on my masters degree. The answers that you give me are for that research and should be honest and straight forward. There are no right or wrong answers and your answers will not affect your grades in this class, but they might help me to become a better teacher and that will help you and your classmates.

I will be looking at the last three units that we did, the one on genetics demographics with the corn lab, the one on biotechnology with the bacterial transformation, and the one on evolution with the bird beaks, and the species games.

1. Which assignment in this unit do you think you did the best on (in terms of grades)? Explain.

2. Which assignment in this unit did you find the most interesting? The least interesting? Explain.

3. Which of the assignments do you think actually helped you to understand the unit best? Explain.

4. What was your favorite activity? Why?

5. What about your lab partners? Did they help you with your understanding? Can you think of why that might be?

6. Do you think you helped your lab partners with their understanding? Can you give an example?

7. If you could decide how to teach the next unit, what sort of activities would you like to see happen during class time? What about during non-class time?

8. Did you read the text book assignments on any of the three chapters? Do you think that you learned the most from the text, me, or your lab partners?

9. Do you like to work in groups? Yes or no. Explain.

10. Are you interested in getting to know your classmates? Yes or no. Explain.

11. Is there anything else you'd like me to know? Is there some question I should have asked? What would your answer to that question be?