Pathways of Knowing:

Integrating Citizen Science and Critical Thinking

in the Adult ELL Classroom

by

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of the Requirements for the Degree
Doctor of Education

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This action research study examines what common perceptions and constructs currently exist in educating adult immigrants in Arizona and considers how might the integration of citizen science with the current English curriculum promote higher order thinking and educational equity in this population. A citizen science project called the Mastodon Matrix Project was introduced to a Level 2 ELAA (English Language Acquisition for Adults) classroom and aligned with the Arizona Adult Standards for ELAA education. Pre and post attitudinal surveys, level tests, and personal meaning maps were implemented to assess student attitudes towards science, views on technology, English skills, and knowledge gained as a result of doing citizen science over a period of 8 weeks.
DEDICATION

In memory of my mother, best friend, gifted musician, and seeker of knowledge Ann Horstick. She often said, “Wisdom comes when at the end of your search you realize you have more questions. . .”

I would also like to dedicate this work to my family and a special friend, mentor, and visionary Sue Alexander who has accompanied me on this very fascinating journey as a fellow lifelong explorer. . .
ACKNOWLEDGMENTS

This study was possible due to the contributions and insights of many people. I would like to thank the staff and teachers at Rio Salado College who supported me in multiple ways through the process. I would especially like to acknowledge the director Linda Putnam who from the very beginning shared my vision of alternative methods and ways of teaching our students. I would also like to acknowledge Alice Jung, Educational director at the Arizona Museum of Natural History for making it possible for my students to engage in learning that took them beyond the classroom. I am also very grateful to have as a mentor and advisor Dr. Carlyn Buckler from the Museum of the Earth/ Paleontological Research Institution in New York who gave valuable insight regarding the Mastodon Matrix citizen science project. Her guidance, encouragement, and support throughout the project was greatly appreciated.

I am especially fortunate to have worked with Dr. David Carlson who in serving as my dissertation chair believed in my research from the start. In spite of all the stops and starts and twists and turns that I experienced while undertaking this study he kept me on track and was a major influence in my pursuit of critical social theories. I am also grateful to my other dissertation committee members Dr. Paul LePore and Dr. Michelle Jordan for their kind support and feedback as I progressed through this study.

Lastly, this study would not have been possible at all without my students. I was their teacher, but in reality they taught me. . .and that I will forever be grateful.
TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................... vii
LIST OF FIGURES ......................................................................................................... viii

CHAPTER

1 INTRODUCTION ............................................................................................................. 1
   Research Questions and Situational Context ...................................................... 3-4
   The English Only Agenda ............................................................................... 6
   Standardize and Categorize ........................................................................... 9

2 THEORETICAL FRAMEWORKS
   Citizen Science . . .What is it? .............................................................. 15
   Ecoliteracy and the Theories of Freire ......................................................... 17
   Cognition as Liberating Education ............................................................ 19
   Other Voices: Critical Ontology and Science ........................................... 20
   The Case for Critical Thinking ................................................................. 23
   Everyday Language . . .Is it Enough? ......................................................... 28
   The Quest for Deeper Learning ................................................................. 31

3 METHODOLOGY
   The Setting ............................................................................................................. 34
   The Participants ............................................................................................... 37
   Student Demographics and Cultural Contexts .......................................... 38,39
   The Sampling .................................................................................................... 40
   The Intervention: The ELAA 2 Explorers .................................................... 41
## CHAPTER 4 THE RESULTS

Data Analysis .................................................. 66  
Threats to Validity and Reliability .......................... 73  
Quantitative .................................................. 74  
Qualitative ................................................... 88

## CHAPTER 5 FINDINGS

........................................................................ 112

## CHAPTER 6 FUTURE IMPLICATIONS

Conclusions .................................................... 134

## REFERENCES

........................................................................ 144

## APPENDICES

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>PRE AND POST ATTITUDINAL SURVEY 151</td>
</tr>
<tr>
<td>B</td>
<td>STUDENT SURVEY RESULT PERCENTAGES 158</td>
</tr>
<tr>
<td>C</td>
<td>PRE AND POST INTERVIEW QUESTIONS 165</td>
</tr>
<tr>
<td>D</td>
<td>INTERVIEW CODING 167</td>
</tr>
<tr>
<td>E</td>
<td>INTERVIEW FREQUENCY OF CONSTRUCTS 171</td>
</tr>
</tbody>
</table>
## APPENDICES

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>OBSERVATIONAL NOTES CODING</td>
<td>174</td>
</tr>
<tr>
<td>G</td>
<td>PERSONAL MEANING MAP RUBRIC AND CODING</td>
<td>177</td>
</tr>
<tr>
<td>H</td>
<td>PMM CHART SUMMARIES</td>
<td>179</td>
</tr>
<tr>
<td>I</td>
<td>POST SCIENCE KNOWLEDGE CONTENT FROM GAME</td>
<td>184</td>
</tr>
<tr>
<td>J</td>
<td>STUDENT INFORMATION LETTER</td>
<td>187</td>
</tr>
<tr>
<td>K</td>
<td>STUDENT RECRUITMENT LETTER</td>
<td>190</td>
</tr>
<tr>
<td>L</td>
<td>IRB APPROVALS</td>
<td>192</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1.</td>
<td>Student Demographics</td>
<td>38</td>
</tr>
<tr>
<td>2.2</td>
<td>Open-ended Survey Questions</td>
<td>39</td>
</tr>
<tr>
<td>3.1</td>
<td>Methodology Chart</td>
<td>55</td>
</tr>
<tr>
<td>3.2</td>
<td>Instrument Timeline</td>
<td>56</td>
</tr>
<tr>
<td>4.1</td>
<td>PMM Rubric</td>
<td>70</td>
</tr>
<tr>
<td>4.2</td>
<td>Alpha-Cronbach Reliability</td>
<td>73</td>
</tr>
<tr>
<td>4.3</td>
<td>Pre and Post Survey Results by Construct</td>
<td>74</td>
</tr>
<tr>
<td>4.4</td>
<td>Views on Science</td>
<td>75</td>
</tr>
<tr>
<td>4.7</td>
<td>Views on Learning and Technology</td>
<td>78</td>
</tr>
<tr>
<td>4.10</td>
<td>Intercorrelations between Survey Subscales</td>
<td>80</td>
</tr>
<tr>
<td>4.12</td>
<td>Pre and Post T-test in Grammar Content</td>
<td>84</td>
</tr>
<tr>
<td>4.14</td>
<td>Correlations between Post Level Tests in Science and Grammar Content</td>
<td>86</td>
</tr>
<tr>
<td>4.16</td>
<td>PMM Coding Table</td>
<td>88</td>
</tr>
<tr>
<td>4.20</td>
<td>Interview Summaries</td>
<td>94</td>
</tr>
<tr>
<td>4.22</td>
<td>Frequencies of Student Emotional Responses</td>
<td>99</td>
</tr>
<tr>
<td>5.2</td>
<td>Overview of Research Process and Results</td>
<td>124</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Current Needs in ELAA programs</td>
<td>14</td>
</tr>
<tr>
<td>4.5</td>
<td>Pre and Post Survey Construct on Science</td>
<td>77</td>
</tr>
<tr>
<td>4.6</td>
<td>Pre and Post Survey Construct on Views of Being a Scientist</td>
<td>77</td>
</tr>
<tr>
<td>4.8</td>
<td>Pre and Post Survey Construct on Views of Computer Difficulty</td>
<td>79</td>
</tr>
<tr>
<td>4.9</td>
<td>Pre and Post on Use of the Internet</td>
<td>79</td>
</tr>
<tr>
<td>4.11</td>
<td>Pre and Post Level Test Scores</td>
<td>82</td>
</tr>
<tr>
<td>4.13</td>
<td>Scatter plot showing Correlations between Grammar and Science Content</td>
<td>84</td>
</tr>
<tr>
<td>4.15</td>
<td>Scatter plot Summary of pre and post CLAS-E Testing</td>
<td>86</td>
</tr>
<tr>
<td>4.17</td>
<td>Pre PMM Frequency Chart</td>
<td>90</td>
</tr>
<tr>
<td>4.18</td>
<td>Frequency of Constructs in the Pre and Post PMM</td>
<td>91</td>
</tr>
<tr>
<td>4.19</td>
<td>Frequency of Pre and Post PMM Subscales</td>
<td>92</td>
</tr>
<tr>
<td>4.21</td>
<td>Frequency of Prompted and Unprompted Critical Thinking</td>
<td>96</td>
</tr>
<tr>
<td>4.23</td>
<td>Pre PMM of Student 10 on Extinction</td>
<td>108</td>
</tr>
<tr>
<td>4.24</td>
<td>Post PMM of Student 10 on Extinction</td>
<td>109</td>
</tr>
<tr>
<td>5.1</td>
<td>Comparison of Correct Answers between Cognitive Constructs in Game and Test</td>
<td>119</td>
</tr>
<tr>
<td>5.3</td>
<td>Model representing current English language programs</td>
<td>137</td>
</tr>
<tr>
<td>5.4</td>
<td>Bridging the gap between the academic and the everyday</td>
<td>138</td>
</tr>
</tbody>
</table>
Chapter 1

INTRODUCTION

*National science education standards state that: the commitment to science for all implies inclusion of those who traditionally have not received encouragement and opportunity to pursue science -- women and girls, students of color, students with disabilities, and students with limited English proficiency.*


Currently in the Arizona Adult Education State Standards we can find science and the social sciences as part of the curriculum for ABE (Not sure what this is, might need to write it out) and GED English speaking students. This however is not an option for Adult ESL learners who make up 75\% of the students attending the Rio Salado 7th Avenue Green Learning campus. In the 2007 AZ Adult Educational Standards it states,

- The purpose of including standards in Science and Social Studies is to ensure that students who so choose would have access to instruction in these disciplines. As adult literacy education in Arizona is not compulsory, adult learners choose to take the courses that enable them to reach educational goals that further their ability to function in the family, the community and the workplace.
- Making available to adult learners a solid foundation in the physical, natural, and social sciences enables them to invest in their own personal and professional development (AZ Adult Educational Standards, 2007).
Yet it is unclear to what classification of adult students this statement is referring. Does it or should it include all students or is this option primarily aimed for only ABE and GED students?

This is perhaps a political issue as much as it is a pedagogical issue in that one might argue that there is an exclusion of certain groups from content based primarily on perceptions on the potential capabilities of this population. This current mindset in adult education can be viewed as a mirror to what is also currently seen in K-12 education. The logic that currently exists implies that English should be the focus and that other content should not be introduced until they are proficient in English. As a result, immigrant children are not exposed to certain content areas such as science to the same extent as the English speaking students. Unfortunately in the state of Arizona this mindset is driving current education policies. Most content area teachers in K-12 are not language teachers and have a difficult and challenging task in teaching content standards to ELL students. Florin Mihai, a professor in multicultural education states this is largely due to the current mindset of teachers that ELLs need to be fully proficient in English before they can learn other content in mainstream classrooms (Mihai, pg 93). Mihai however points out that this is not acceptable in that the NCLB holds schools accountable for all students in all content areas. “The state requires ELLs to be assessed in the content areas while they are learning English, not after they have reached full proficiency in English (Mihai, pg 93). This should be no different for adult ELAA learners. The National Science Education Standards also supports this view in that science should not be taught only to a select group
of students. In section Standard E it states all students in K-12 science must have equitable access to opportunities in science. “All students regardless of age, sex, culture, ethnic background, physical or learning disabilities, future aspirations, or interest in science, should have the opportunity to attain high levels of scientific literacy” (National Science Education Standards, 1996. pg 221). The National Science Teachers Association (NSTA) asserts that all students, including those identified as English language learners (ELL), can and should have every opportunity to learn and succeed in science. Science instruction should recognize and respect the linguistic and cultural experiences that English language learners bring from their home and community environments, articulate these experiences with science knowledge, and offer sufficient educational resources and funding to support science learning. When this happens, students learn to value their linguistic and cultural identities and develop their identities as science learners (Garcia and Lee 2008; Warren and Rosebery 2008).

In Figure 1 we see some of the key issues as related to language acquisition in adult learners. Recognizing these issues, this study was guided by the following research questions.

**Research Questions**

The overarching question behind this study was to explore how might citizen science promote educational equity and higher order learning. Secondly, what mediated tools of learning would most effectively create pathways to
learning science to a marginalized adult population who have had little to no formal education or exposure to science.

- How might engagement with citizen science promote multiliteracies in the ESL adult learner while promoting new attitudes towards one’s ability to do science?
- How might science promote higher order thinking in the ESL classroom?
- What specific mediated tools of learning or accommodations would create effective pathways to learning science for ELAA students?

Before addressing these questions and subsequent intervention, one first needs to understand more fully the backdrop and climate from which this proposed study will be implemented.

**Situational Context**

This writer currently works as an educator serving adults and older adult refugees and immigrants at the Rio Salado 7th Avenue Adult Learning Center, now known as the Green Learning Campus. My present questions came about as the result of working with my Level 2 English language students who in the course of doing some units in science demonstrated to me an interest in things related to the natural world and that they were capable of thinking critically and in doing problem-based tasks that I would define as scientific inquiry.

I began to ask how might a pedagogy promote multiliteracies and higher order thinking and promote what Mezirow calls “perspective transformation” or to gain meaning from their learning experiences (Mezirow, 1981). My aim was to learn about the views and attitudes of my students in relation to learning new
content, as well as the environment and mindsets of the institution that these students were intrinsically a part of. As an anthropologist by training I was also interested in knowing how the institution and existing structures of power might serve as barriers in the promoting of critical thinking in the adult ESL learner. To explore to what extent do our state policies and educational institutions perpetuate and reinforce the skilled labor mindset of the adult English language learner?

While working as a research assistant with the Office of the Vice President for Education Partnerships at ASU, one of my first assignments was to research and contribute to a grant proposal on the impact of Arizona’s new immigration policies on education on both documented and undocumented Hispanic populations. It was in the course of this research that I came to understand the magnitude of how a much debated immigration policy can seriously impact the everyday lives of a specific population. Before Arizona’s recent immigration policies, adult immigrants could freely take English classes and obtain valuable work related skills without needing to show documentation. This however changed when Proposition 300 passed a ballot stating undocumented immigrants were now barred from participating in government-funded English classes. In 2007 12 percent were denied instruction because they could not prove they were in the country legally according to the Education Department (Gonzalez, 2007). Knowing English is a requirement in gaining U.S. citizenship yet accessibility to these programs is increasingly becoming a barrier for many immigrants. With recent budget cuts formerly available resources and educators no longer in place to serve the hundreds of refugees and immigrants placed on long waiting lists.
Currently there are around 700 students on the waiting list where this study took place. A student in my class stated she had to wait almost a year to get into the program. Once students get admitted they are faced with a battery of tests and new policies which require more stringent attendance rules. Currently this facility is requiring 75% class attendance or students will be placed back on the waiting list. This is unfortunately an unrealistic expectation. This past rotation only two students in my current class met that criteria. In addition, students who do not make any gains in the state testing within a year will likewise be put back onto the waiting list. Options for those students who cannot show proof of citizenship or legal documentation are especially grim. Students must pay out of state fees to attend college, ESL, or ABE classes offered through a college. ESL learners who would like to learn English via a distance program in Arizona have the option to sign up for Rio’s online ESL program. However this program is offered strictly online and at a price of $243.00 per class or $966.00 for nonresidents. Arizona is only one of four states in the country that does not offer in-state tuition rates to immigrants.

The English Only Agenda

Whenever students break into their native language in the classroom teachers can be heard chanting their slogan “English only English only!” Geneva Smitherman presents the case that languages should be recognized as co-equals and that there should be a national policy to counteract the “English only” requirement enforced in many programs. Smitherman believes to do so will
bridge the gap between the “have’s” and the “have not’s”. (Smitherman, 2002, pg 172, as cited by David Carlson, 2007). Sadly, this mindset appears even in children. A student from Mexico and a mother of two young girls stated, “I decided to learn English when my 7 year old daughter told me that if you speak only Spanish you are a Mexican, not an American.” In 1994 Proposition 187 and 227 which passed in California ended bilingual programs in K-12 and promoted an English only agenda in spite of research showing that English only is highly ineffective with only 11% of students achieving academic progress (Mahoney & Thompson, 2004). This agenda carried over into adult education and is still enforced in K-12 education in California and Arizona and other states. In Arizona (Proposition 203, 2000) was voted in favor of the "English for the Children Initiative" that essentially bans bilingual education and requires that English be used as the only language of instruction in public schools (Beykont, 2002). Beykont states that to accomplish this students are taught English in pull-out classes that are separate from the content-based classes for a designated number of hours a week. All materials are in English and parents can even sue teachers who use a language other than English in the classroom (Beykont, 2002).

Cognitive psychologist Reuven Feuerstein adamantly believes that the key to integration into a new culture is by providing immigrants with a cognitive intervention or bridge that will “help them to act on an equal basis in society as contributive members and valued producers of culture and science” (Feuerstein, R., et al, 1999, pp ii-vi). In addition, the immigrant should not abandon his or her
own native culture or language in favor of assimilation into a new culture as he states it weakens the family unit and the cultural tradition for which the family is built on (Feuerstein, R., et al, 1999, pp ii-vi). This also challenges the current policy in many adult ESL programs that require teachers to enforce in the classroom an “English only” policy.

Auerbach states that the spread of ESL instruction first appeared in the first quarter of the 20th century and was a direct outcome of the Americanization movement which emphasized English only methods. In the early 1920’s English teaching methods included practical every day lessons such as how to open bank accounts, making doctor appointments, asking and giving directions, etc. (Auerbach, 1993) Henry Goldberger developed this approach and enforced the English only policy stating that students who speak in their native language would “delay the work of Americanization” (Baron, 1990, p. 160, as cited in Auerbach, 1993). Auerbach states that it was the resurgence of nativism and antiforeign political sentiment in the late 19th century that signaled the decline of bilingual education. The practices that we take for granted are often rooted in ideologies of power and control. Unfortunately the no English policy is also used as a means for classroom management and discipline. Adult learners with little formal education often do not understand or follow basic classroom etiquette which can be really challenging for the ESL teacher. Students are more likely to converse and socialize in their native language so restricting native language use in the classroom is frequently used to help the teacher keep control in the classroom. A
teacher and co-worker stated once that she put out a coffee tin and had students put in a nickel every time they spoke in their native language that was not related to translation.

A survey of programs offering literacy instruction to linguistic minority adults and out-of-school youth conducted by the National Clearinghouse for Literacy Education (NCLE) indicated that only 68 of the almost 600 programs who returned the questionnaire offer classes in learners' native languages; of these, all but 10 have been started since 1980 (Gillespie, 1991, as cited in Auerbach, 1993, pg 6).

**Standardize and Categorize**

Foucault states, “The examination, surrounded by all its documentary techniques, makes each individual a case...which at one and the same time constitutes an object for a branch of knowledge and a hold for a branch of power” (Foucault, 1995, pg 191). Adult educators of English and Adult Basic education are often faced with teaching immigrants and refugees who when coming into our country may be illiterate in their first language, are unable to match pictures with concepts, have difficulties in spatial-orientation, and difficulties in taking tests due to a lack of formal education. Yet these students are tested and re-tested in order to place them in designated categories and levels. The problems encountered with all of this testing are many as many state these tests are not culturally or cognitively appropriate for these learners and further perpetuates the categorization of individuals based on their perceived abilities.
The state of Arizona presently requires the TABE test called the CLAS-E to assess ESL efficiency in adult learners in all adult learning centers and is aimed to assess overall program effectiveness and compliance, but not necessarily individual student progress. The state encourages instructors to implement their alternative assessments but will not accept alternative assessments as a substitute for standardized testing. Although adult in orientation these tests are frequently identified as being “distinctly middle class and academic in orientation. . .with only a modest portion of them being about everyday events in the lives of a low-income adult” (Sticht, 1990). Weinstein-Shr states that older adults, and especially older refugees and immigrants, are rarely considered in the designing of literacy curriculums (Weinstein-Shr, 1995). She goes on to ask the question that I also ask. “To what extent are existing adult literacy efforts cognitively appropriate to the needs of older adults?” (Weinstein-Shr, 1995, pg 18). When talking with some of the ESL instructors about their challenges, it was stated that the older immigrant and refugee were most likely to have to repeat the same levels over and over and it was stated that the only way that these individuals could keep up with the rest of the class is if they had individual mentors.

There is a belief amongst educators that alternative and performance-based assessments for English learners is imperative as standardized tests are not sufficient or even accurate measures of English language learning (Korbakis & Clark, 2006). Alternative types of assessments are viewed as being more informative for English language learners in that they allow learners to demonstrate what they know about language and how they are able to use it
(Tannenbaum, 1996, as cited in Korbakis & Clark, 2006). In spite of the believed benefits of alternative forms of assessment there continues to be a rise in the use of standardized testing at all levels of education which is required in order to receive federal funding.

An ASU study was done in 2010 on the assessment of young English language learners in Arizona as part of a wide scale evaluation of English instruction with the Civil Rights Project. Children who test at or above the proficient level in English are placed in mainstream classes without English language support. Children who obtain scores below the proficient level receive English language support services in the required Structured English Immersion classes. The study concluded that the standardized test AZELLA was not an effective tool for predicting academic achievement at the higher grade levels. This has created serious miscalculations in the transferring of students prematurely into English only curriculums resulting in educational inequity (Garcia, Lawton, Diniz de Figueiredo, 2010).

Recently I attended a workshop on implementing the CLAS-E standardized test that is required by the state of Arizona for adult ELL. Several instructors raised questions as to the dignity issue in requiring preliterate students to sit through two separate exams that they struggle to take. There was almost a palpable vein of rebellion in the room as state educators and test publishers presented their reasoning to frustrated teachers who work in the trenches. State testing is required every two months for both incoming students as well as for
continuing students who did not receive any gains in the previous testing cycle. With all of this testing it has been brought up in several recent teacher meetings the problem of students being able to cognitively understand the test taking process. There appears to be little awareness that these issues are related to cognitive issues, and not necessarily related to the student’s English skills or the skills of their teacher. Students are told how to take the test minutes before the test, but for many this is not adequate enough time. Recognizing this problem, teachers are now asked to devote more time in teaching students how to take tests. Some of the issues that students encounter include not being able to stay on track on their test page, not understanding the relationship between the top and the bottom of the page, relationships between questions, pictures, numbers, and letters. Nor do they understand that they are to choose only one answer or that the answer is related to the above question or picture. I believe these problems are spatial orientation problems largely seen in Level 1 students and which frequently carries over into Level 2. Other problems are encountered when taking the listening portion of the test. Students are told how to choose from a number of choices by selecting and writing in the blank A, B, or C after listening to someone present a short story or passage on a CD. Unfortunately the time between the questions and when the student is to reply is too short. It does not allow the students time to cognitively translate, comprehend, and then write their answers. Teachers are instructed to not stop or replay the CD.

Dr. Reuven Feuerstein, a world renowned cognitive psychologist and leader in cognitive modifiability and mediated learning published a report on a
research project he conducted with Ethiopian immigrants in 1999. In this report he talks about the obstacles and limitations of teaching immigrants from the Israeli perspective and it is interesting to note these issues are not unlike what educators experience here in the U.S. He viewed that the greatest difficulties confronting immigrants and their children are related to the evaluation process which has the tendency to create static cognitive labels on these individuals which does not reflect their true potential (Feuerstein, R., Feuerstein, Ra., Kagan, A., Kaufman, R., Kozulin, A., Ofir, E., Yachimowich, S., Yosef, L., 1999). Feuerstein sees a real danger with millions of immigrants who are placed in low skilled jobs or placed in special education programs all because of an IQ score or other testing score which labeled them as low functioning and was not based on their true potential. Along with the scores there is a mindset with the teachers of the Ethiopian children who believe these children are not capable of higher order thinking. This was based on observed resistance of their students when learning problem-solving skills and scientific concepts.

Van Dijk states that power has a major cognitive dimension in that an institution can create dominance and inaccessibility through the control of knowledge and can directly impact beliefs, thinking, and learning (Van Dijk, 1993, pg 257). In attempts to gain greater control of content, many students will ask for homework so they can work on their own outside of the classroom. The few who have computers have also been known to write down Internet addresses of exercises done in the computer lab. To be able to apply what is learned in the ESL classroom and transfer it to the student’s home, culture, and community is an
important component of a student-centered curriculum and would contribute to their empowerment.

An overview of some of the key issues facing adult English learners appears in the below figure.

Figure 1.1

Current Needs in ELAA programs serving Immigrants and Refugees

<table>
<thead>
<tr>
<th>Need for Alternative Learning</th>
<th>Options to address...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long waiting lists</td>
<td>Transportation issues, child care, etc.</td>
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</tbody>
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</thead>
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<td>To computers and Internet skills</td>
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<th>Need for Educational Equity</th>
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</thead>
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<td>Student-centered learning</td>
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</tbody>
</table>

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<thead>
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<th>Need for Higher Order Learning</th>
</tr>
</thead>
<tbody>
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<td>Critical thinking Skills</td>
</tr>
</tbody>
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<tr>
<th>Need for Learning that Promotes Multiliteracies</th>
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<td>English literacy, functional, computer technology, numerical, ecoliteracy, and science literacy</td>
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The theoretical framework that guided this study and to address some of the above issues appears in the next chapter.
Chapter 2

THEORETICAL FRAMEWORKS

Citizen Science. . .What is it?

“Citizen science as an informal learning science has typically been evaluated without a theoretical framework”, (Crane, 1994, Falk & Dierking, 2002 as cited in Brossard, Lewenstein, & Bonney 2005).

Clearly citizen science has the potential of contributing to transformative learning both at the individual and the community level. Leonardo states, “In order to provide students with a sustainable education, educators are encouraged to forge a language of transcendence, or what Giroux (1983) calls a language of hope” (Leonardo, 2004, pg 15).

There have been few formal evaluations conducted on citizen science projects involving marginalized populations. A few of these have been documented and involved either informal science programs or citizen science projects with Latino populations.

In 2006 Washington State University began a project called Accesso la Ciencia (Access to Science) that addressed informal science education and accessibility to rural Latino youth and parents. All the materials were bilingual with the curriculum focusing on agriculture and the life sciences which was of interest to rural Latinos and was integrated with what was being taught in the schools of their children.
The *Salal Harvest Sustainability Study* at UC Berkeley and the NW Research and Harvester Association ran from 2001 to 2004. This project took place in Washington and involved harvesters of the Sala plant which is an evergreen shrub harvested as a forest product in the floral industry. The increasing harvest of this plant caused concern about the impact on the habitat. Approximately 35 harvesters took part in the project and most were undocumented Latinos who were learning English. For most of them this was their full-time job. Working as harvesters in this region of Washington they developed extensive ecological knowledge about harvest practices and a deep understanding on what types of conditions the plants thrived in the best. This knowledge often surpassed that of forest professionals (Bonney, et al, 2009, pg 33).

Over the course of four years these harvesters developed an understanding and practice of scientific concepts. Some expressed increased concern for the environment, learned to collect field data to record and observe, and how to use measurement instruments. In addition they learned how to read graphs, draw conclusions from evidence, and explained results (Bonney, et al, 2009, pg 34). Like the *Projeto Seringueiro* project in the Amazon, the knowledge of the harvesters were valued first and foremost and recognized as knowledge important to science.

As a result of their experience in the project two harvesters showed interest in applying to several USDA Forest Service jobs so that they could further advance their skills. They however did not apply due to their illegal status
What perhaps was the most important end result according to this CAISE report was the shift in the collaboration of harvesters with the community and scientific community leading to an increase in credibility of the knowledge that the harvesters demonstrated to the local forest rangers. A change in perception and in power relations occurred as forest managers began to view the harvesters more than just skilled labor. They began to view the harvesters as individuals who had significant ecological knowledge with valuable skills that could contribute to further understanding of forest sustainability and the care of the Sala plant (Ballard, 2008 as cited in Bonney, et al, 2009, pg 34).

**Ecoliteracy and the Theories of Freire**

In this study the theories and views of Freire served as the leading theoretical framework with some of his key ideas identified below.

1. Freire repeatedly presents themes on the interconnectedness of man with our environment and makes parallels with how this relates to liberatory education and social justice.

2. His views on liberation as praxis. Transformation comes only through becoming aware and then taking steps to create the change we wish to make. A major emphasis in environmental education.

3. The need for problem-posing education that promotes cognitive-based learning and the promoting of consciousness.

4. The idea that educational equity is related to acts of cognition, and not the transferring of information.
5. The idea that people teach each other mediated by the world and that educational equity promotes co-learning experiences.

6. That mediated learning is accomplished through objects and content that belong to the world, not objects that are owned and controlled through a teacher or publisher. As related to this study “objects of the world” could refer to objects of nature or even the Internet.

Paulo Freire states, “Liberation is a praxis: the action and reflection of men and women upon their world in order to transform it. . .” (Freire, 1993, pg 60). Freire in his critical approach to adult literacy states that before transformation there is the process of becoming conscious (conscientizacao) or aware of what change is needed. Being aware of the connection between our environment and social injustice is especially important amongst indigenous cultures and other marginalized populations who often find themselves in a power struggle in solving environmental issues that can directly impact their health, the future of their communities, and the survival of their culture.

The theories of Freire fit well with the goals of environmental education in that Freire does not view man as an isolated detached being from the world and his environment, but rather an authentic reflection of man and his interconnectedness with the world. In this interconnectedness, consciousness and the world are interchangeable (Freire, 1993 pg 62). In quoting Fromm, Freire compares “banking education” with necrophily, or a lover of destruction. To take this further one could conclude that what he is suggesting is that the current power structures in education tends to treat students as objects rather than nurture their
full potential. “The necrophilous person can relate to an object, a flower, or a person only if he possesses it; hence a threat to his possession is a threat to himself. . .he loves control and in the act of controlling, he kills life. . .” (Fromm as cited in Freire, 1993, pg 58). I think it is interesting to note the close parallels Freire makes with environmental stewardship with what is happening in our classrooms. Just as control and domination of our natural world can lead to its destruction, so too can the present powers in education stifle creativity and cognitive enrichment in developing minds.

**Cognition as Liberating Education**

Within the teacher student relationship Freire talks about problem-based learning versus “banking education” as another component of liberating education. He states, “Liberating education consists in acts of cognition, not transferrals of information. . .” (Freire, 1993, pg 60). Freire viewed problem-based learning as a means to break the structures of power relations as both teacher and student work together to solve a problem and are jointly committed and active in creating. In a sense his views are much in align with Vygotsky and Feurestein in that they also viewed the importance of the teacher serving as a facilitator with the cognitive tool serving as the mediator. Freire states, “People teach each other, mediated by the world. . .or by cognizable objects. . .” (Freire, 1993, pg 61). Freire views one of the key problems with “banking” education or the feeding of knowledge by a teacher in an authoritative role is that students are not required to practice cognitive thinking but are to merely be receptive vessels. According to Freire, in the problem-based learning scenario the teacher always
has cognition at the forefront and engages students so that they are co-investigators in dialogue. This interaction will ultimately lend itself to a constant revealing of truths in a dynamic exchange (Freire, 1993, pg 62). Unfortunately with standards-based education there is little room for in-depth understanding, critical thinking, or cognitive enrichment which has impacted K-12 and adult education alike.

The theories of Freire I propose can be implemented and enhanced within the context of doing citizen science. However before a “dynamic exchange” and “revealing of truths” can occur, one must consider other ways of knowing.

**Other Voices: Critical Ontology and Science**

Kincheloe is probably one of the most well known authors in the field of critical ontology. He states Western views throughout history frequently labeled indigenous perspectives as enemies of monotheism with science labeling them as views that were primitive and uncivilized. He states, “A critical ontology involves the process of reconnecting human beings on a variety of levels...to a living cosmos,” (Kincheloe, 2006). Kincheloe further suggests that educators should be in the business of helping students to connect with all living systems that should include the political, the social, the natural, as well as the realm of knowledge production. Critical ontology suggests that all views need to be represented because it is only in the differences that greater insights can be made (Kincheloe, 2006). The more we are aware of these differences, states Kincheloe, the more difficult it is to produce “naïve universal knowledge”. This “naïve universal knowledge” can be applied to many areas of Western culture.
Phenomenological theory as founded by the German nineteenth-century scholar Edmund Husserl is an attempt to explain the individual experience and perception in response to an object, space, or event. The phenomenologist is interested in how these different perceptions appear in the human experience whether through thought, memory, emotion, embodied action, or linguistic activity. Science however has always been known for taking the positivist perspective and has long held the position that it can explain the world for us. Scientists want more quantitative evidence as to the effectiveness of citizen science programs, but this has proved to be problematic. In evaluating participatory science one really has to find a middle road as we are not only interested in how learners perceive and understand the natural world, but also in teaching the scientific process that will prompt the learner to think critically, to deconstruct, to categorize, and to apply their observations into the forming of meaning and in drawing conclusions. So in a real sense there is both an internal process and an external process. Physicist Piet Hut sees the need to, “evaluate the very notion of what science is and the role of science among other ways of knowing (Hut, 2001). There in fact does seem to be a shift in the role of science as it moves more and more from the realm of black and white to increasingly more areas of gray. Hut states that the method of phenomenology can be found everywhere in science, even in the way scientists engage in scientific research. Hut (2001) gives the following example,
Galileo, when looking at how the Sun seems to revolve around the Earth, bracketed the common belief that the Earth itself is immovable. It was then easy to see that a rotating Earth and a fixed Sun would give rise to exactly the same phenomena. By separating the phenomena from the belief structures in which these phenomena had always been embedded, he found new interpretations which opened new doors for scientific exploration. . .(Hut, 2001, Section 4, ¶ 2).

Hut proposes a “middle” ground when he discusses Husserl’s “epoche” in that one needs to first let the phenomena speak by suspending all judgment and all presuppositions (Hut, 2001). Hut further states, “The idea of stepping out of the world so to speak, in order to observe the world and your own role in it better, makes a lot of sense” (Hut, 2001, Section 7, ¶ 2). Hut defines Husserl’s epoche as “that of an eternal beginner,” or “someone who approaches reality with a true beginner’s mind.”. . .a childlike innocence that shows the world new and fresh in each moment. . .” (Hut, 2001, Section 12, ¶ 1). This I believe presents a powerful metaphor as we look at how participants in citizen science engage with a phenomenon from which they were not aware of the preexisting frameworks. In this study my Level 2 ELAA students approached the world with a beginner’s mind and yet were required to think as a scientist. To think as a scientist of course requires the ability to also think critically.
The Case for Critical Thinking

“If the appearance and essence of things were similar, there would be no need to have science.”

(Marx as cited by Vygotsky, pg 173, 1986)

Critical thinking encompasses a wide range of skills that can include creative thinking, organization, scientific thinking, and problem solving (Kirby, Goodpaster, and Levine 1999, as cited in Moore, 2010). Critical thinking can occur whenever one judges, decides, or solves a problem; in general, whenever one must figure out what to believe or what to do, and do so in a reasonable and reflective way.

In the realm of cognitive psychology other definitions of critical thinking includes understanding the principles of cause and effect, temporal sequence, comparison and contrast, the ability to describe, categorize, and analyze. Critical thinking is stated to also build a student’s confidence for “when teachers value thinking in the classroom, they are also valuing their students’ identities, and this is perhaps the greatest motivator of all” (Chamot, 1995, pg 4, as cited in Pally, 1997, pg 296).

In a study by Presseisen and Kozulin they make the case for critical thinking by stating that one’s ability to identify and to deal with contradictory information is essential for successful learning (Presseisen, Barbara, & Kozulin, Alex, 1992). The ability to compare and to contrast information is of course the foundation of scientific inquiry. Vygotsky implies that if a student’s knowledge...
of content is organized around everyday experiences, or is non-scientific, then the student’s ability to implement cognitive thinking is limited and that everyday experiences actually interferes with the logical train of thought that assists with the identification of contradiction (Presseisen, et al, 1992, pg 30). This puts into question and perhaps challenges the current approaches in English instruction that emphasizes daily living skills, repetition, and lower track learning.

In the current ELAA 2 Arizona Standards we see below the suggested activities to meet the core competencies in critical thinking.

SUGGESTED CRITICAL THINKING ACTIVITIES for ELAA 2

1. Learners hear a series of apologies and excuses, e.g., Maria couldn’t go to work today because… which they match with the corresponding picture.

2. Comparatives and superlatives (safe, safer, safest) or joined construction (more, less, most)
   “What do you like better about living in the United States than in your native country? What do you like better about living in your native country than in the United States?”

3. Past and present perfect tense – Writing complaints

4. Learners take turns complaining about working conditions.
   Q: What are some problems where you work?
   A: I only work 6 hours a week.
   B: I work 10 hours and don’t get overtime.
   C: I’ve been there 5 years and I trained a guy who’s been there only 2 years and he got promoted recently

   Next, learners brainstorm as a group and make a list of working conditions that need to be improved. Learners take turns going to the board to write down the complaints contributed by classmates.

5. Present tense in affirmative/negative
Learners read a short passage about rules and responsibilities for workers, e.g., creating rules for the classroom.

Learners discuss why they agree or disagree with the rules.

6. In small groups, learners will brainstorm what is required to register a child in school. Spokesperson from each group will report to class.
7. Learner describes a task and gives multi-step directions.

(Arizona Adult Education Standards, 2007)

Although critical discourse analysis is not the main focus of this study one can clearly see in the above section a stereotyping or labeling of the adult immigrant to that of a low-skilled laborer. The student is to be taught how to complain, how to follow rules, how to improve working conditions, etc. Nothing implies that the immigrant ESL learner might be, or has the potential to be, a manager, a business owner, a teacher, or a scientist. One however might also argue that the above section could also be adapted into a curriculum for the promoting of awareness or “conscientization” of current working conditions and as an impetus for creating change.

In Jeannie Oakes book *Keeping Track*, she discusses how social stratification can be reinforced and legitimized by the educational system by placing students in “low track” and “high track” pedagogies based on test scores which she assessed in 25 junior and senior high schools. Her conclusions show how these tracks promote inequality and create limited access to enrichment and academic pathways to higher education for minority and lower socioeconomic
students. I found it particularly interesting that some of her observations support well my proposed study as related to higher order thinking and cognition.

She found that in the higher track curriculums there was a greater emphasis on critical thinking, problem solving, interactive learning, computers as learning tools, creating independent thinkers, and more enrichment. In the lower track the emphasis was on lower level facts and skills, emphasis on following rules, more worksheets, and little enrichment (Oakes, 1985, pg 228). I easily identified with how she described English classes in the lower track curriculum. “. . .the acquisition of standard English usage and functional literacy skills (filling out forms, applying for jobs) were frequently mentioned as course content in low-track classes. . .” (Oakes, 1985, pg 76). She states that the differences in intellectual processes used in the tracks were substantial. In the high track classes teachers promoted critical thinking, and drawing conclusions while low track curriculums focused on memorization of facts (Oakes, 1985). Her point clearly is stated in that not all students are taught the same things. Not all are exposed to the same levels of enrichment. We assume everyone is exposed at some point in their education to the arts, to culture, and the sciences, but in truth they are not.

Her case is further supported based on questionnaires she gave to students from both the low and high tracks to assess their views on what they have learned. I focused on the responses as related to science which I have quoted below.

**High Track Responses**

“I have learned to do what scientists do. . .”
“ Probably the most important thing I’ve learned is the understanding of the balance between man and his environment.”

“Things in nature are not always what they appear to be or what seems to be happening. . .”

**Low Track Responses**

“To be honest. . .nothing.”

“I can distinguish one rock from another.”

“Worksheets. . .”

“Nothing I’d use in life. . .it will take a better man than I to comprehend the world.”

(Oakes, 1985, pgs. 67-72.)

Likewise in the subject of English, the responses were similar reflecting differences in the curriculum and tracks. I view these differences as “cognitive categorization” based on the presumed beliefs of what a student may or may not be able to achieve. I often struggle when teaching my ESL students to stay within the level I am suppose to teach and I’m constantly having to ask myself, is this Level 2 or is it Level 3? Are they to know this now? Does it matter if they are ready to learn it now? These decisions are based on the standards and the “track” the student has been placed in. The teacher is not supposed to get off that track and on more than one occasion other teachers have challenged me with my content. “You’re not supposed to teach that. . .they aren’t supposed to learn that until they are promoted into my class. . .” This
mindset I propose is limiting a student’s full potential, promotes inequity, and enforces a delay in what they may be able to achieve today. This was especially observed in the computer lab when I was confronted one day by the computer lab instructor and director that what I was asking students to do on the computer might be too difficult. It is my belief that perhaps it was not so much whether they thought they were capable or not, but rather they were not learning within the established protocol created by the preexisting mindsets of administration. It was explained to me that these students needed to learn these tasks in a formal structured computer class designed for Hispanic students and taught in Spanish. This class is fee-based and it does not consider those students who are not Hispanic. I witnessed on several occasions a look of frustration on the faces of those immigrant students who were told “sorry, you have to go somewhere else.”

Everyday Language. . .Is it enough?

Mihai refers to the work of Cummins in explaining the differences between the everyday or “the language used in social interactions” with language that is needed for more academic or higher order thinking. The gap between these two types of language acquisition can be so wide that many ELL K-12 students are sent to special education classes when they appear to be able to speak English in social contexts but fail in the classroom. Clearly there is something more going on that is not related to one’s ability to learn a language for everyday communication. Cummins presents these two constructs of thinking and learning as BICS (basic interpersonal communication skills) referring to language acquired
through social interactions, and CALP (cognitive-academic language proficiency) which refers to language learned in content-based academic learning (Cummins 1994 as cited by Mihai, 2010). According to Cummins BICS takes only about 1-3 years to learn while academic language proficiency needed to learn academic content can take 5-10 years to learn (Mihai, 2010). Mihai states that for the ELL educator one needs to be aware that just because the student can communicate in social situations does not mean they will function well in the academic classroom. Cummin’s research supports well what Vygotsky also proposes in recognizing two very different thinking processes. Vygotsky states that scientific concepts are both abstract and general compared with everyday concepts that are related to direct experience, or the world of the concrete (Wells, 1994). Vygotsky also makes the distinction that learning based on everyday experience tends to develop spontaneously through social interaction that begins when we are a child, while higher order learning (or the development of scientific concepts) has to be taught through instruction. The definition of instruction according to Vygotsky however may be viewed as more along the lines of mediated methods of instruction utilizing cognitive tools versus a teacher-centered pedagogy. In our current adult education system it is believed that scientific concepts and inquiry belongs only in upper divisions or levels of instruction with higher order learning neither encouraged nor offered in the lower levels.

Both Vygotsky and Feuerstein emphasize the fact that our educational systems are putting ceilings on the individual potential. Vygotsky calls this the zone of proximal development which is defined as instruction that moves ahead of
one’s development. Instruction according to this theory should force the individual to carry out activities that rises above one’s own potential (Vygotsky, 1987, pg 212, as cited in Wells, 1994). As mentioned earlier, to do so an educator risks confronting resistance not so much from the students but rather the structure set up by the institution. So what is the pathway to inquiry and self-directed learning for the adult learner? For Vygotsky and Feuerstein it is about connecting the learner through semiotic and mediated tools of meaning. Vygotsky believed the development of scientific thought could be achieved through the merging of thought, language, and instruction, and that the most powerful semiotic tool that can be used is language (Wells, 1994). Vygotsky states, “The development of concepts and the development of word meanings are the one and the same process (Vygotsky, 1987, pg 180 as cited in Wells, 1994). Language or the word in this sense can serve the function of a mediated or semiotic tool to higher order thinking. A scientific concept as related to an object also requires mediation in order to gain its full meaning. The obvious difference between the two, states Vygotsky, is that for the scientific concept the meaning is often not part of one’s schema or prior knowledge and so must be taught.

This further supports the fact that to achieve CALP or more cognitive-based thinking students need to be given the tools that will prompt them to engage critically. For educators teaching content-based English in K-12 this requires taking an integrative approach in creating a curriculum and assessment that will be adaptive to the current English language level of the student (Mihai, 2010). He further notes that these differences are not considered in current standardized
testing creating inequity in results and suggests low performance for ELAA
students in the classroom.

Like Vygotsky, Mihai states that what is really needed is for these students
to be taught academic language (Mihai, 2010, pg 96) and that much research is
needed in knowing what accommodations are the most effective in bridging the
gap between everyday language and academic language. Research results to date
are very mixed in that one type of accommodation may be effective for one
student and not another (Mihai, 2010, pg 81). Mihai stresses the need for
alternative forms of assessment beyond the current standardized methods which is
discussed in the next section.

The Quest for Deeper Learning

Feuerstein, asks the question, “When does the stimulus become a source
for learning and in what way does the exposure to this stimulus modify an
individual’s way of thinking?” (Feuerstein & Falik , Feuerstein Ra.S, & Falik,
2010, pg. 27). Is it enough to expose an individual to the world, nature, and other
enriched environments and expect deep learning to occur? (Feuerstein, et al, 2010,
pg 27). What is wrong with the stimulus-response model and theory according to
Dr. Feuerstein is the fact that human mediation does not happen and he uses the
museum experience to make his point. Objects and nature cannot intrinsically
mediate, only people can. It is also stated that the ability of verbal and pictorial
tools to serve as mediators is limited if there is no mediation of meaning
(Presseisen, et al, 1992, pg 29). Students in the Amazon who constructed hand-
made books of animals and plants found meaning only when their stories were attached to it.

At the ASTC museum conference held in Philadelphia in 2009 I was able to witness a rather heated discussion between presenters from *Explora*, (a museum based in Albuquerque, New Mexico) and other museum educators who were debating this very question. Are objects in themselves intrinsically interesting and meaningful? *Explora* commented that using bubbles in their demonstrations created the same results whether the audience was children in Africa or in an urban school in the U.S. They implied that items and objects in fact could be intrinsically meaningful in that they can represent symbolic archetypes. Regardless of cultural, social, economical status, and age, these archetypes will elicit similar responses. . .everyone will respond to bubbles pretty much in the same way. My argument however, (and based on the observations of Dr. Feuerstein in his example of the museum experience), is that in order to understand more deeply why we see colors in bubbles and what this tells us about how light waves works, requires more cognitive resources in order to get a response that is more than a simple reaction to a stimulus. *Explora* having a very materials-based approach to museum education do not rely on or use formal curriculums that are aligned with state standards. This was troubling to the other educators who argued one cannot learn from objects alone without some kind of structured framework. *Explora* educators however make the claim that one only needs the basic minimal information to prompt engagement, critical thinking, and self-directed learning.
Andragogy is defined as “an organized and sustained effort to assist adults to learn in a way that enhances their capability to function as self-directed learners” (Mezirow, 1981, pg 21). Knowles defines self-directed learning as occurring when individuals take the initiative for their own learning in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes (Knowles 1975, pg 18. as cited in Smith, 2002).

Knowles recognized that there was the need to develop the skills of inquiry but only through self-directed learning. He also points out that if adult learners do not have these skills, they will become anxious and frustrated along with their teachers. Knowles however does not really address how the educator should teach self-directed or inquiry-based learning like the adult immigrant with no formal education and who has never been taught how to think critically. Likewise, when referring to Bloom’s taxonomy we acknowledge different cognitive levels that progress to higher order thinking but how one should go about teaching higher order thinking is not really an emphasis in Bloom’s work (Ivie, 1998). One could argue that without these higher order thinking skills, self-direction may prove to be very difficult as the art of inquiry is an abstract process and requires a higher cognitive demand.
Chapter 3

METHODOLOGY

In this action research study I implemented using a mixed methods approach (Gay, Mills & Airasian, 2009) with data gathered from pre attitudinal surveys, personal meaning maps (PMM), semi-structured interviews, audio recordings from classroom participation, and concluding with the post-surveys, post PMM evaluations, and post interviews. Case study methods have frequently been used in the study of special populations and their relation to an institution especially when one is asking questions related to the role of a social institution and their impact on society as applied to special groups (Busha and Harter as cited in Zach, 2006). Through the pre and post interviews I attempted to gain a deeper understanding of the context and backgrounds of several of the students involved in the study which created more insight into their views of science and their experience.

The Setting

Rio Salado 7th Avenue Green Learning Campus Downtown

Rio Salado 7th Avenue Green Learning Center is the largest adult learning center in the state of Arizona. Currently the college is going under a major renovation and new construction with the goal of becoming a “green campus”. Part of the college’s present initiative is the implementation of content-based English instruction to introduce the concepts of sustainability, environment, and
the natural sciences to their adult learners and to expose them to possible career paths in this field. A unique partnership between Tempe-based Rio Salado, the City of Phoenix, the nonprofit organization Brighten a Life, and Cause and Effect Evolutions plans to create two new sustainable green schoolhouse buildings with 7,000 square-feet of classroom space to house the nation’s first green charter high schools. Sustainability and environmental topics will be integrated into the curriculum and will focus on improving and using energy more efficiently. Rio Salado’s two existing buildings on the 7th Avenue site will be retrofitted to make them sustainable and environmentally responsible, while the two existing modulars will be torn down (Rio News, 2009). Rio Salado College President Linda Thor states that, “This campus also will offer green jobs training programs” (Rio News, 2009). Rio Salado has joined forces with the City of Phoenix, and together they are seeking federal stimulus funds for this new model in education (Rio News, 2009).

Currently for students there is only one computer lab that is used one hour a week for each class and is supervised by Spanish speaking facilitators who assist the Spanish speaking students using the lab. They also offer additional computer classes for Spanish students for a small fee but as previously mentioned, do not currently offer anything for students who are not Spanish speaking and currently refer these students to another learning center. Other classes are also offered to the more advanced English students who are getting ready to go through the Transition program where they obtain their GED and prepare for college level courses and/or career and vocational training.
For clarification purposes I need to at this point define the various acronyms used in adult education within the Rio Salado College system. ABE stands for Adult Basic Education and refers to English speaking students who have a 0-8th grade reading level. The ABE curriculum is designed to assist students in learning to speak, read, and write the English language, master basic arithmetic, or improve these skills up to their potential. It is a continuing education for adults who are believed to lack sufficient training that will enable them to function effectively in our society and may also include training for citizenship and other family and civic responsibilities. Adult Secondary Education (ASE) programs are designed for students who did not complete high school and are age 16 and older. Rio’s Transition Program is aimed to provide guidance to Rio Salado College adult GED and ESL students as they transition into post secondary opportunities within the Maricopa Community College District. ELAA stands for English Language Acquisition for Adults and represents approximately 75% of the student population and has six different levels. 25% of the students are studying for their GED.

I teach a Level 2 ELAA class four times a week that lasts about 2.5 hours a day with one hour of computer class time a week. I believe with only one hour of computer lab time per week these students will not gain the necessary technical skills needed to enter higher paying jobs. At least fifty percent of ESL instruction should include computer accessibility that would also integrates listening, writing, and reading skills in order to address both digital literacy and basic English literacy. Most of my students do not have basic typing skills to proficiently use a
computer and is something I have enforced as part of their computer lab time. To currently survive in today’s economy anywhere in the world technological literacy is as important as reading and writing. This is especially important when there is a growing concern that there are not enough jobs for the new refugees and immigrants still coming into the Phoenix area with 1 in 3 reported in 2009 as unable to find jobs---the lowest in three years (Sanders, 2010).

According to Kasper to be considered multiliterate, students today must “acquire a battery of skills that will enable them to take advantage of the diverse modes of communication made possible by new technologies that will enable them to participate in global learning communities” (Kasper, 2000, pg 105). Arizona state law requires computer literacy to be incorporated into the teaching of adult education along with English but is presently nonexistent in the classrooms at this present time. Although the new facility will have technology for instructor use, students will still largely be restricted to one hour of computer instruction a week.

The Participants

Hispanic immigrants make up the majority of ESL adult learners at the 7th Avenue Green Learning center. According to the Pew Hispanic Center, the relatively poor education of Hispanic immigrants reflects the fact that most Hispanic immigrants are educated not in the U.S. but in less developed countries. Hispanic immigrants who arrive in the U.S. early in childhood and are enrolled in
U.S. elementary and secondary schools are much better educated. Of those who arrived under the age of 10, only about one-quarter were high school dropouts in 2008. Most immigrant Hispanic adults arrive in the United States after age 14 (80%), and a majority of them were high school dropouts (Fry, 2010). 41% of adult Hispanic learners over 20 years of age do not have a high school diploma versus 23% of blacks, and 14% of whites (Fry, 2010). As of 2008 there were 29 million Hispanics aged 20 and older and of this group 41% were born in the U.S. with 59% foreign born (Fry, 2010). With these statistics it is clear that the majority of Hispanic immigrants are arriving into our country with little to no formal education and little to no marketable skills.

**Student Demographics**

Table 2.1

*Percentages of ethnic groups in the ELAA 2 class*

<table>
<thead>
<tr>
<th>ETHNIC CATEGORY</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic/Mexican</td>
<td>14</td>
<td>56%</td>
</tr>
<tr>
<td>Latin American</td>
<td>1</td>
<td>.04%</td>
</tr>
<tr>
<td>Burmese</td>
<td>4</td>
<td>1.6%</td>
</tr>
<tr>
<td>African</td>
<td>2</td>
<td>.08%</td>
</tr>
<tr>
<td>Vietnamese</td>
<td>1</td>
<td>.04%</td>
</tr>
</tbody>
</table>

*Percentages of ethnic categories in current ELAA 2 Class n=22*
An open-ended section of the attitudinal survey was created to collect information on technology, former education, views about science, and the environment which were collected from the whole class (See Appendix A).

These constructs provided insight into entry skills, prior knowledge, and academic motivation, and as related to the goals and objectives of the curriculum. Table 2.2 shows results of the open-ended questions.

Table 2.2

<table>
<thead>
<tr>
<th>Student ID</th>
<th>Sex/Age</th>
<th>Native Language</th>
<th>Native Country</th>
<th>How long have studied English</th>
<th>Years of Formal Education</th>
<th>Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M/31</td>
<td>Spanish</td>
<td>Mexico</td>
<td>6 months</td>
<td>College</td>
<td>Former accountant in Mexico</td>
</tr>
<tr>
<td>3</td>
<td>F/65</td>
<td>Sudanese</td>
<td>Sudan</td>
<td>4 years</td>
<td>0</td>
<td>housekeeper</td>
</tr>
<tr>
<td>4</td>
<td>M/50</td>
<td>Burmese</td>
<td>Burma</td>
<td>2 months</td>
<td>NK</td>
<td>NK</td>
</tr>
<tr>
<td>5</td>
<td>M/50</td>
<td>Spanish</td>
<td>Ecuador</td>
<td>1.5 years</td>
<td>8</td>
<td>Business/store owner</td>
</tr>
<tr>
<td>6</td>
<td>F/22</td>
<td>Karen</td>
<td>Burma</td>
<td>3 months</td>
<td>NK</td>
<td>Artist -Not employed</td>
</tr>
<tr>
<td>7</td>
<td>F/35</td>
<td>Spanish</td>
<td>Mexico</td>
<td>1 year</td>
<td>8</td>
<td>Unemployed</td>
</tr>
<tr>
<td>8</td>
<td>F/62</td>
<td>Spanish</td>
<td>Mexico</td>
<td>8 months</td>
<td>8</td>
<td>Housekeeper at a High School</td>
</tr>
<tr>
<td>9</td>
<td>M/29</td>
<td>Spanish</td>
<td>Mexico</td>
<td>2 years</td>
<td>8</td>
<td>Butcher/Mechanic</td>
</tr>
<tr>
<td>10</td>
<td>M/53</td>
<td>Kirundi</td>
<td>Burundi</td>
<td>7 months</td>
<td>0</td>
<td>Dietary at a hospital</td>
</tr>
<tr>
<td>11</td>
<td>F/35</td>
<td>Spanish</td>
<td>Mexico</td>
<td>9 months</td>
<td>9</td>
<td>NK</td>
</tr>
<tr>
<td>13</td>
<td>F/54</td>
<td>Spanish</td>
<td>Mexico</td>
<td>1 year</td>
<td>NK</td>
<td>NK</td>
</tr>
<tr>
<td>14</td>
<td>F/?</td>
<td>Vietnamese</td>
<td>Vietnam</td>
<td>9 months</td>
<td>NK</td>
<td>NK</td>
</tr>
<tr>
<td>16</td>
<td>F/30</td>
<td>Spanish</td>
<td>Mexico</td>
<td>0</td>
<td>11</td>
<td>Waitress</td>
</tr>
<tr>
<td>17</td>
<td>F/30</td>
<td>Spanish</td>
<td>Mexico</td>
<td>3 months</td>
<td>12</td>
<td>NK</td>
</tr>
<tr>
<td>18</td>
<td>F/?</td>
<td>Spanish</td>
<td>Mexico</td>
<td>3 months</td>
<td>College</td>
<td>Accountant</td>
</tr>
<tr>
<td>21</td>
<td>M?</td>
<td>Spanish</td>
<td>Mexico</td>
<td>3 months</td>
<td>6</td>
<td>Baker</td>
</tr>
<tr>
<td>24</td>
<td>M/26</td>
<td>Chin</td>
<td>Burma</td>
<td>2 years</td>
<td>NK</td>
<td>Grocery</td>
</tr>
</tbody>
</table>
In the above table we can see that the students in this study represent a wide range of ages, level of formal education, and length of time they have studied English. Most have skilled labor jobs with some looking for job advancement while others are currently unemployed. The sampling also represents a wide range of countries that includes Africa, Burma, Vietnam, Ecuador, Mexico, and Cuba (not appearing in table). The interviews and qualitative data will provide a more detailed and thicker description of some of these students in regards to their backgrounds, their perceptions, and their understanding of science.

The Sampling

Initially my focus was going to be on a purposive sampling of 12 Hispanic students gathered from my own class with half of those randomly selected to participate in interviews. This, however, changed very early on in the study when it became clear that there were other voices in the classroom that needed to be heard. These voices included the Burmese and African refugees who contributed much in sharing their perspectives of the natural world and existing knowledge. I also wanted to challenge the existing mindset that I have held and other teachers based on experience working with this population is that African refugee students are the most challenging students to work with as they often come without any formal education, and may have no written literacy as many of their languages are oral based. Other characteristics that often appear prominent in this population are cognitive challenges. Tools often used in the ESL classroom such as various
games may be familiar and easily mastered by Hispanic students but African refugees often struggle in making sense of it.

The Intervention

The ELAA 2 Explorer Project

At a recent Visitor Studies conference I met with the director of Program Development and Evaluation at the Cornell Ornithology Lab, Rick Bonney who is the co-founder and creator of the “citizen science” concept. In his presentation he talked about how he credits his father with being the inspiration of the present citizen science movement. As a boy, whenever he asked his father a question about why something was, his father would never give him an answer but instead encouraged him to try and figure it out for himself. Sometimes they would work together as co-learners in finding answers to some of our world’s most puzzling mysteries. This Bonney states greatly impacted him in that it taught him as a young boy the power of asking questions and the importance of developing problem solving skills that led him to pursuing a career as an ornithologist and co-founder of the current citizen science movement. This growing movement is defined by the Cornell lab of Ornithology as, “projects in which volunteers partner with scientists and answer real-world questions.”

Citizen science as it is known today actually began with the Audubon Society's Christmas Bird Count in 1900. Prior to that, citizen observations of weather and meteorology had been incorporated into editions of the Farmers' Almanac. The last 20-25 years have seen substantial growth in citizen science
participation, with Cornell University's Ornithology Lab at the forefront of this movement. Further evidence of the gaining popularity of citizen science is seen by the number of available funding sources and organizations that support these projects. This past year the National Oceanic and Atmospheric Administration (NOAA) announced that $8 million worth of new grant money was awarded to educational and non-profit institutions across the United States to support programs that connect the public to science appreciation and interactivity. The NOAA's Environmental Literacy Grant program focuses to enhance informal educational opportunities at museums and through family and teen programs, as well as expand citizen science networks. One particular project was funded $400,000 and was a collaboration between the College of Exploration in Virginia and Literacy Volunteers of America. The title of this project, “A collaborative project: Engaging ESL adult and youth learners in technologically facilitated outdoor experiential learning to improve environmental, ocean, climate and English literacy”.

The main objective of this action research project was to address some of the issues seen with English learners and to explore how one might integrate science with the present English curriculum.

Is science only for those who have acquired a high level of English, or have acquired as Cummins stated, an academic language?

As mentioned, presently English teaching methods for adult learners focuses largely on life skills, themes related to holidays, U.S. culture, and citizenship, or everyday language. English instruction does not emphasize
academic language that includes cognitive or problem-based methods of learning typically found in science. The implementation of this curriculum was focused on addressing these issues and how they are related to literacy, accessibility, and equity.

The citizen science project chosen for this study was the Mastodon Matrix Project affiliated with the Paleontological Research Institution and Museum of the Earth in New York. The Mastodon Matrix Project was voted the number one citizen science project by SciStarter in 2011. The project started in 2000 as a joint partnership between PRI and the Department of Earth and Atmospheric Sciences at Cornell University and involves the recruitment of citizen science participants to assist in sorting through the earth or matrix that surrounded the remains of several mastodon sites with the first mastodon found in a pond in New York in 1999. Sorting through the sediment is very labor intensive and requires large numbers of people to sort and identify rocks, bone fragments, seeds, and pollen that can tell the scientist much about paleoclimate and the environment. The Paleontological Research Institution has done several formal evaluations of their Mastodon Matrix program with K-12 students but have not as yet done any formal evaluations as to the impact this type of citizen science project might have on ESL adult populations. Research conducted in 2003 concluded that as for educational value, “it is dependent upon the teacher in providing context to make the project meaningful. . .” (Ross, R., Harnik, P.G., Allmon, W., Sherpa, J.M., Goldman, A.M., Nester, P.L., Chiment, J.J. 2003, pg 44). This report also concluded that teachers commented that it really was less about science content as
it was about impacting student attitudes about science and in promoting a sense of
discovery (Ross, et. al, 2003, pg 44).

Working in groups students were involved in both English and numerical
literacy with the analysis, weighing, measuring, categorizing, identifying, and
documenting of organic and inorganic materials that they found in their earth
samples. Materials found were then magnified and projected onto a large screen
with the use of a digitized microscope for group discussion and identification.
Students were prompted to analyze ancient plant materials found then working as
paleobotanists reconstructed what they thought the environment might have
looked like at the end of the Ice Age. Before embarking on the MMMP
(Mastodon Matrix Project) students were first introduced to animal classification,
concepts of extinction, change over time, and biodiversity. At the conclusion of
the project students applied what they learned from the mastodon to gain insight
as to what factors and influences may be threatening our modern African
elephants of today. Students appeared to gain a new understanding as to how
man, species, and the environment are all part of a delicate interconnected web.

Technology when possible was an important part of the process as
students learned how to use Google map, and observed a global simulation of
glacier movement from 20,000 years ago to the present via myNASA. This
helped them to understand that much of the United States was covered in ice
during the Ice Age as well as a means to visualize what the climate was like at the
end of the Ice Age during the time that the mammoth and mastodon went extinct.
Students also learned how to use Wikipedia and to research and translate content to their native language serving as a bilingual resource.

**Citizen Science as Aligned with the ELAA 2 AZ State Standards**

Developing the curriculum for this project resulted in a 40 page teacher’s manual which served as a general guideline on how the content could align with the Arizona State Standards for English learners. This curriculum is still in draft form and was too lengthy to include here but Unit 3 is provided below as an example.

**Unit Three: What’s the Difference? Asking Questions about Mastodons and Mammoths**

I. **ELAA Standards:** Identifies and states similarities and differences, reads and writes detailed sentences that describe, to identify basic interrogative wh-questions, to use comparative adjectives, and relates pictorial concepts with written words by demonstrating writing, speaking, and listening skills.

II. **Science:** Science as inquiry, comparing, contrasting, and describing. Science and technology, and scientific concepts and processes.

**Objectives:**

Students will apply Basic English skills as they learn about the differences between mastodons and mammoths. Students will learn new vocabulary words as related to the mastodon and be introduced to the “Wh” questions and other question words that will encourage students to ask their own questions. What is a mastodon? When did they live? What did they eat? Where did they live?

**Discovery Lab:**

1. Students will examine mastodon and mammoth teeth and tusks and other materials related to these creatures of the Ice Age at various stations and will in writing describe and document the differences.
2. Students will make a concept map to list the differences using adjectives of comparison between mastodons, mammoths, and modern African elephants.
3. Students will identify and label the body parts of a mastodon.

**Computer Lab:**

1. Students will work in a group of 2-3 in the computer lab.
2. Students will learn how to use Wikipedia to research information about the mastodon and the mammoth. Students will learn how to use Wikipedia in their native language and in English.
3. Teacher will instruct students how to log onto WikiSpaces.com.
4. Students will contribute comments via the discussion section of Wikispace.

**Forming Inquiry:** Students will be provided with prompting questions. What is a Mastodon? When did they live? What’s the difference between a mammoth and a mastodon? Did climate change cause mammoth extinction or did humans?

Students will be introduced to the content by watching several online videos by the Discovery Channel related to the actual site they will be involved with.


**Introduction to the Hyde Park Mastodon Site**


**Understanding the differences between a Mastodon and a Mammoth.**


Show clip from the animated movie Ice Age. Are the characters shown in this clip mastodons or mammoths? Explain why.

Other examples as to how the standards were integrated with the content are provided below. These are just brief examples and do not include all the various tools used which are discussed more in depth in the results section.

**Arizona Adult State Standards for ELAA 2:**

**Standard:** The adult English learner comprehends and communicates in written and spoken English for a variety of purposes and audiences.

**Supporting Grammar and Mechanics:**

a) **Verbs in the affirmative, negative and interrogative**

**Example:** Students asked their peers content related questions and other students had to reply in the positive and the negative.

Do mastodons live today?
No, they don’t.

b) **Present progressive, future, and “to be” verbs in the past**

**Example:** Students learned how to write sentences using the correct tense when talking about things in the past, things happening to our biodiversity today, and what will happen tomorrow.

Mastodons lived 14,000 years ago but went extinct.  
Many species living today are in danger of extinction.  
Many species will go extinct in the future.

In looking at pictures of animals in various habitats students would practice using progressive verb tenses.

The frog is jumping . . .

The hummingbird is flying . . .

c) **Contractions**
Example: Students would practice writing contraction forms in sentences and in conversation.

d) Adjectives: Descriptive, demonstrative, definite (the) and indefinite (a, an) articles, the versus a and an. Comparative/Superlative

Example: Students learned how to compare and contrast artifacts by writing descriptive sentences. For example students might measure and compare two twigs that were found in the matrix. They would then have to write “Sample A is longer than sample B. Sample A is 3cm long and Sample B is 2 cm long”

They also had to describe the differences between the mastodon and the mammoth by filling out a chart and listing the differences. They would then form sentences to describe those differences. After comparing the two animals, they would then practice using the superlative form by comparing the mastodon and the mammoth with the African elephant. Usual responses would include, “The African elephant has the largest ears.”

The articles were also taught as students wrote sentences related to learning animal classification.

This is an invertebrate. This is a vertebrate.

e) Pronouns: Demonstrative (this, that, these, those) Object (me, you, him, her, it, us, them)

Example: Students worked with concrete objects and artifacts as related to the content to understand the concept of this, that, these, and those. Pronouns could be further developed by integrating concepts of “us” and “them” and how it relates to “we” when talking about our interconnectedness with the environment.
f) **Adverbs of frequency, manner and time**

**Example:** Students can use adverbs of frequency in the last unit on climate change and how our present actions will impact our future.

- I always recycle.
- I never turn off the lights.
- I sometimes take the bus.
- I usually conserve water.

**g) Prepositions of time and place**

**Example:** The integration of prepositions was used in various ways. Students would examine pictures of various ecosystems and habitats and then wrote sentences identifying the location of various animals and insect life that was observed in the picture.

- The mastodon is standing **in** water.
- A dragonfly is flying **above** the pond.
- A snake is **near** the rock.

**h) Modals: Can, would like, must, have to, may**

- have to, want to like to, need to

**Example:** When talking about environmental responsibility modal verbs were used in the following ways.

- We **must** conserve resources.
- We **need** to learn more about our past to understand the future.
- We **should** care for our environment.

**i) There is and there are**

**Example:** Students learned how to write sentences using the correct tense for singular or plural forms in describing their observations.
There are three turtles living in this habitat.  
There is a snake living in that tree.

j) **Irregular plurals**

Example: Students learned about various irregular plurals in the animal kingdom.

Mouse and mice and goose and geese.

The mastodon has only 4 teeth to chew food.  
This is a mastodon tooth.

k) Conjunctions: and, but, or

Example: Students learned conjunctions when writing or describing observations.

The starfish has five arms, but it doesn’t have any wings.  
The sponge has pores and lives in water, but it doesn’t have a stomach.

Although not in the standards the word “because” was frequently integrated into the curriculum being an important word associated with inquiry and critical thinking.

The sea level is rising because the ice is melting.  
Many animals went extinct because they lost their habitat.  
Insects are increasing in numbers because the earth is getting warmer.

**To be used in these situations**  
*indicates how this objective was integrated in this curriculum*

* Cardinal numbers (in counting data, measuring, etc.)  
* Ordinal numbers (in determining sequence)  
* Geography, directions, north, south, east, west (in determining place of mastodon site)  
* Measurements (In measuring artifacts)  
* Containers with quantities: a bag of, a carton of, a box of (in categorizing artifacts and placing them in various containers)

Family relationships
*Weather (climate change)
Food, cooking and equipment
Clothing, jewelry
*Parts of the body (animals)
*Personal description (using adjectives to describe)
Shopping
*Animals (biodiversity past and present and over time)
Transportation
Home
Occupations
*Sickness and disease (as related to environmental pollutants)
Telephone language
Holidays
Hygiene
Emotions and states of being
*Working with lists (following instructions and creating item lists)

To teach these language functions

**Listening/Speaking:**
* indicates how this objective was integrated in this curriculum

*Able to give short discourse on dates, routines, objects and people
*Likes and dislikes, agree or disagree (as used in critical thinking discourse)
*Comprehends and follows three to four step directions (follow activity directions)

Compliments, gratitude, and apologies
*Asks simple questions about the size, color, shape, and physical characteristics and number of familiar objects using descriptive vocabulary (used as part of analysis and writing descriptions in scientific journal)

**Reading**
* indicates how this objective was integrated in the curriculum

*Transitions from phonics to words and sentences. (students encouraged to write complete sentences)
*Reads numbers to the hundreds of thousands (numbers used in counting and calculating data)
*Reads print and cursive (reading comprehension skills and research)
*Uses appropriate punctuation (students learn to write complete sentences)
*Relates pictorial concepts with written words (Extensive use of visual aids that required students to identify and label)
Understands abbreviations
*Reads words to identify basic wh-questions (Extensive use and practice with the question words in promoting inquiry)
*Reads detailed sentences that describe such as height, weight and filling out forms. (students learned to write descriptions that involved measuring and weighing artifacts and entering onto forms)

**Writing**
* indicates how this objective was integrated in the curriculum

*Writes simple sentences three to five words long describing people, places, and routines. Writes numerals up to the thousands, fill in forms and write facts such as dates, weight, time, etc. (Students learned to write short descriptive sentences to express their understanding of certain scientific concepts. Numerical literacy and other data as related to weight, time, and dates was also a part of this process as they recorded things onto data sheets and the computer).

**National Science Standards**

The science content rubric was adapted from the National Science Standards Grades K-4 in the earth sciences (National Science Education Standards, 1996). The italic text indicates adaptations or additions to correlate with curriculum used in this study.

**Strand 1: Unifying Concepts and Processes**

-Systems, order, and organization

-Understanding biodiversity through animal classification

-Change, constancy, and measurement

-Evolution and equilibrium

**Strand 2: Science as Inquiry**

-Understanding and doing scientific inquiry

-Creating pathways to promote higher order thinking

**Strand 3: Content related to Life Sciences**
- Characteristics of organisms
- Life cycles of organisms
- Organisms and environments

**Strand 4: Science in Personal and Social Perspectives**

- Understanding Resources
  - *Understanding man’s impact on available resources*
- Things that can impact change in populations and species
  - *Cultural and socioenvironmental factors*
  - *Cultural ontologies of the natural world*

**Strand 5: Science and Technology**

- *Learn how to access scientific data, read charts, and graphs.*
- *Enhance reading comprehension by conducting basic research and in*
  - *learning how to use language translation tools*
- *Identify the meaning of objects by using the Google Image Search Engine*

Students were prompted to form inquiry based on the following questions:

1. Where are we in the geological timeline? What is a fossil? What does it mean to go extinct?
2. What is the Ice Age? What is a mastodon? What did they eat? What is the difference between an elephant and a mammoth? What happened to them—why did they go extinct?
3. What plant life existed in Ithaca New York 12,000 years ago? What does this tell us about the climate and environment long ago?
4. What was it like to live during the Ice Age? Was man responsible for the extinction of the mastodon and mammoth?
5. What factors threaten our biodiversity today?
Research Design

The research design chosen for this study was based on the One-Group Pretest-Posttest design in that a control group was not used (Gay, L.R., Mills, G. E., Airasian, P., 2009). The rational for this decision was due to several factors. Coming from an anthropological background my research methods tend to have a natural tendency in being more ethnographic in approach. Secondly, it is stated that more quasi-experimental designs are useful when you are in a complex and variable setting (Willigen, 2002, pgs 195-196). A fluid research design is needed to adapt to changing circumstances and still gain some control in order to effectively evaluate the effectiveness of the intervention. Within the contexts of this study I had to be prepared to deal with many uncontrollable variables in a classroom of multiple languages, multiple cultures, and a high level of student fluctuation in attendance due to changing jobs, living situations, etc. These limitations are discussed more fully in the threats to validity section.

The Data Instruments

A breakdown of the methods used and their justification appears below in Table 3.1.

Table 3.1
Methodology Chart

<table>
<thead>
<tr>
<th>Quantitative Methods</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre and post Attitudinal surveys for Level 2 ELAA class as taken from a purposive sampling of the entire ELAA 2 class.</td>
<td>To assess level of prior knowledge, views on science, and perceptions on their ability to do science.</td>
</tr>
<tr>
<td>Pre and Post Level Tests</td>
<td>Pre and Post multiple-choice Level</td>
</tr>
</tbody>
</table>
tests to assess student’s English skill level and understanding of science content.

<table>
<thead>
<tr>
<th>Qualitative Methods</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-structured Interviews</td>
<td>Interviewed six randomly selected Hispanic students pre and four post to gain more in depth views and perspectives that maybe did not appear in other assessments.</td>
</tr>
<tr>
<td>Formative and Summative Personal Meaning Maps</td>
<td>Meaning maps were constructed by students at the beginning of the project and again at the conclusion in two constructs. The first on science and the second on the concept of extinction. Used to assess level of student prior knowledge and knowledge post doing citizen science.</td>
</tr>
<tr>
<td>Active Participant Observer and Reflections</td>
<td>Ethnographic observations and reflections which was analyzed using open coded methods (Miles and Huberman, 2008)</td>
</tr>
<tr>
<td>Classroom Audio Transcripts and photos</td>
<td>Audio transcripts of classroom to assess discourse and student responses while engaged in project. Photos were used for project website and integrated into a final game.</td>
</tr>
</tbody>
</table>

The next table shows a timeline as to how the various data instruments were implemented.

Table 3.2  
*The Data Instrument Timeline*

<table>
<thead>
<tr>
<th>Date</th>
<th>Instrument/Intervention</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 2011</td>
<td>English skills level test</td>
<td>English level test to determine which students were ready to advance to Level 3. This test served as</td>
</tr>
<tr>
<td>September 2011</td>
<td>Pre Attitudinal surveys, consent forms, and letters</td>
<td>Surveys, consent forms, and letters delivered to entire Level 2 ELAA class.</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pre Personal Meaning Maps (PMM)</td>
<td>Students created two maps on two constructs. One on science and another on the concept of extinction. (Note: There was a change in target audience after initial assessment of the pre personal meaning maps.)</td>
<td></td>
</tr>
<tr>
<td>Pre Semi-structured Interviews</td>
<td>Interviewed six randomly selected Hispanic students. (Note: There was a change in target audience after assessing Pre personal meaning maps.)</td>
<td></td>
</tr>
<tr>
<td>Active Participant Observer and Reflections</td>
<td>Ethnographic observations and reflections started with the first class. Notations were made at the end of each class.</td>
<td></td>
</tr>
<tr>
<td>Audio-recording</td>
<td>Audio-recordings started with the initial introduction and with each class that involved science content. Recordings were not really referred to or analyzed until after the study.</td>
<td></td>
</tr>
<tr>
<td>Curriculum integrated various learning tools -concept maps -artifacts -games -museum trip -technology/media</td>
<td>Students introduced to concepts of extinction, biodiversity, evolution, animal classification, and observation skills using various learning tools to assess what tools were the most effective in connecting students with science concepts.</td>
<td></td>
</tr>
<tr>
<td>Photos</td>
<td>Photos taken of students as they engaged in classroom and outdoor activities.</td>
<td></td>
</tr>
<tr>
<td>Project Website</td>
<td>Photos used for project website.</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td>English and Science skills assessments</td>
<td>Students were given weekly quizzes that assessed proficiency of both English and science content.</td>
<td></td>
</tr>
<tr>
<td>October 2011 Museum Field-trip</td>
<td>Ten students signed release forms and went to the Arizona Museum of Natural History.</td>
<td></td>
</tr>
<tr>
<td>Photos</td>
<td>Photos taken by researcher/students. Photos used for game.</td>
<td></td>
</tr>
<tr>
<td>Introduction to Citizen Science Project</td>
<td>Students introduced to the Mastodon Matrix Project that spanned over 3 weeks.</td>
<td></td>
</tr>
<tr>
<td>Game/Reflection</td>
<td>Students engaged in a game that integrated slides from their museum and citizen science experience. Content covered both English and science material.</td>
<td></td>
</tr>
<tr>
<td>Post PMM</td>
<td>Class did post PMM in both constructs.</td>
<td></td>
</tr>
<tr>
<td>November 2011 Post survey</td>
<td>Students in class took post survey.</td>
<td></td>
</tr>
<tr>
<td>Post interviews</td>
<td>Conducted 4 post interviews Note: 2 of the participants did not participate in the pre interview.</td>
<td></td>
</tr>
<tr>
<td>Final Level Test and Student Comments/Reflections</td>
<td>Students took final Level Test that assessed English and Science content knowledge. A category was provided for students to draw or write about their experience.</td>
<td></td>
</tr>
</tbody>
</table>
I. Quantitative Methods

Pre and Post Attitudinal Survey in Citizen Science for Students

To assess student interests, perceptions, and prior knowledge related to science and the natural world, a pictorial Attitudinal Survey in Citizen Science was adapted from pictorial scales often used in children assessments (Fraenkel and Wallen, 2000). (See Appendix A). A pictorial method was chosen to clarify answer selections. Faces show various expressions that represent the ratings found in the usual Likert scale with a smiling face represent strongly agree and a frown strongly disagree. In addition the survey was translated by a bilingual instructor to ensure student understanding.

This instrument was used to assess the adult ESL learner’s perceptions on learning and science in the following constructs:

1. Views on science
2. Importance of science to the adult learner and their children
3. Prior knowledge of the environment and the natural sciences
4. Understanding of citizen science and beliefs in one’s own ability to do science.

Construct three was adapted from previous scales used in assessing attitudes towards science and their potential impact on the effectiveness of a citizen science program. The construct on man’s relationship with the environment was adapted from the New Environmental Paradigm or NEP scale (Dunlap & Van Liere, 1992 as cited in Brossard et al, 2005). This construct has an alpha-Cronbach reliability score of only 0.54 but was used in the 2005 study with the Birdhouse Network at Cornell Laboratory of Ornithology. They created an adaptation to the original
scale by adding a neutral point making it a four item scale instead of three along with some wording to prevent gender bias. In spite of the low reliability score on this construct the TBN study still used it due to its wide and national use in assessing environmental attitudes (Brossard, et al, 2005).

**Pre and Post Level Tests**

A pre and post Level test was implemented to assess student’s English skill level pre and post doing citizen science. The Level testing is typically done at the end of the 60 day rotation by each individual ESL teacher and is intended to assess student’s understanding of grammar concepts with a 65-75 multiple-choice question format. In addition students are also required to take the state mandated CLAS-E tests which assess English skill level but may not necessarily be connected with classroom content.

**II. Qualitative Methods**

**Semi-structured Interviews**

The original intention was to conduct pre and post interviews. However due to the erratic attendance and transient nature of these students this was difficult to obtain. Only three of the six students interviewed before the study were still in the program. In addition after the initial interviews were taken, I changed my sampling to include the whole class hence no longer wanted to focus on just the Hispanic students. In the post interviews I included one of the African refugees. The semi-structured interviews were conducted to create a “snapshot” on current attitudes and perceptions of these randomly selected students and to
gain a deeper analysis of their background, attitudes, and perceptions as related to the project.

**The Personal Meaning Map**

As stated, tools in themselves cannot mediate, but along with human mediation that is intentional, these tools are important in carrying the signs and meanings of new knowledge. One tool that will be implemented in this study will be the use of the concept map, which is considered an effective mediated teaching tool in teaching scientific concepts as mentioned in the learning theories of Novak and Ausubel’s learning theories (Ausubel, 2002, Novak, 1998, 2002 as cited in Aguilar, 2008). This has led to introducing the concept map into a theory of learning in its own right. Aguilar states that according to Vygotsky the concept map is a symbolic system that allows the externalization of human thought processes and is a dynamic process of making meaning (Aguilar, 2008). The Personal Meaning Map is a cognitive tool that may be effective in assessing meaning, ways of learning, language acquisition, and attitudes. This tool is discussed in greater depth in the methods section. The structure of these forms of experiences typically involves what Husserl called “intentionality”, that is, the directedness of experience toward things in the world (Hut, 2001). Our experience is directed toward things only through particular concepts, thoughts, ideas, images, etc. These make up the meaning or content of a given experience, and are distinct from the things they may actually present or mean.

Concept mapping used as a visual assessment tool is frequently used within the museum context. Visitors are typically asked to either fill in a map
based on what they remembered from their museum experience or would draw their own map (Hein, pg 122). The obvious benefits with any of these approaches would be that the participants are free to describe any aspect of their visit without restraint and limitations to specific survey questions. For the same reasons for using the pictorial Attitudinal Scale this would also serve the visitor who may be illiterate or communicate visually. Personal Meaning Mapping (PMM) is a variation of concept mapping developed by John Falk from the Institute for Learning Innovation based in Maryland and is used in informal learning environments. Personal Meaning Mapping (PMM) is based upon current cognitive and neural science research that shows learning is a relative and constructive process. PMM is designed to quantifiably measure how an educational experience uniquely affects each individual’s conceptual and attitudinal understanding (Falk, Reinhard, Bronnenkant, Deans & Heimlich, 2007).

PMM is viewed as an effective means to help identify and assess an individual’s prior knowledge, concepts, attitudes, and vocabulary knowledge about a particular subject. It can also be used to assess for any learning gained and serve as an effective tool in the classroom as it would assist the teacher in identifying how to adapt and align a curriculum based on the current level of knowledge of the student.

The methodological design used in this study was adapted from a study by Anthony Lelliott who used PMM to assess prior knowledge of astronomy.
before a museum visit, during, and after the visit at a science center in
Johannesburg. In Lelliott’s study he assessed 26 12 to 14 year old students across
four schools who visited an observatory as part of a class field trip. The data he
collected involved structured interviews on astronomy that was connected with
concepts such as stars, the sun, and moon. Three key prompts or words were
given “space, stars, and planets” from which the visitors built their ideas and
demonstrated prior knowledge on the subject. Lelliott (2007) states that PMM is
a relatively new technique and no analysis or evaluation of the technique has yet
been published. According to Lelliott (2007) the PMM process starts prior to a
museum visit by giving participants a sheet of paper in which a word or phrase is
written in the center of the page. The participants are then asked to write or draw
anything that comes to mind in relation to that word or phrase. This can be
anything related to prior knowledge, facts, beliefs, or opinions and is represented
by a specific color on the paper. The researcher then gives a short interview with
the participant to determine or clarify what it is the individual is trying to relay
and for any elaboration of ideas. These elaborations are drawn or written in yet
another color.

After the museum visit the participants were given their original paper
and were asked to make any changes or additions to what they have already
written on the paper. The final step involves another semi-structured interview
as the researcher points out to the participant changes in their drawings and seeks
further clarification. The researcher may write comments directly onto the map
with a different color with what is being relayed in the interview. Lelliott also
suggests that one makes sure the participants know that the PMM is not a test, that they can use drawings instead of words; that they can use their own native language, and that they have as long as 30 minutes to complete. The students would then hand in when completed and numbers would be assigned to each map for analysis. In this study the interview will be informal or unstructured with notations made directly on the map in a distinguishable color separate from the colors the student used.

Another major component of this project was the use of various tools of learning and technology which is discussed next.

**Tools and Technology**

When addressing multiliteracies, Kasper states there needs to be a pedagogy that will create critical engagement as well as create diverse forms of communication that can best be found in collaborative learning and technology (Harvard Educational Review, 1996, as cited in Kasper, 2000). Kasper states that ESL students especially benefit from learning with technology as it encourages them to spend more time on task, is suited to multiple skill levels, allows for easy content and linguistic assimilation, all while serving multiliteracy goals (Kasper, 2000). As mentioned technology was a major component of this project in spite of issues of accessibility and time needed to train students in working with Wikipedia, Google Maps, Flickr, and online databases.

There has been done some research on students contributing to and using scientific databases as part of a science curriculum in the classroom.
Exploring Databases is an example of a project that was conducted with high school students who were involved in conducting authentic research using a scientific database (Munn, Brown, Horne, Oura, Bell, Shouse, & Philip, 2010). Over a span of several years, students contributed to an epidemiological study of smoking behavior in conjunction with scientists and teachers. The goal was to help students develop an understanding of what it means to conduct scientific research. Students were involved in writing questions for the questionnaire used to collect demographic and environmental data about subjects, entered data, and researched a database. The utilization of extensive data in a database mirrored research done by many scientists and allowed students to engage in deeper scientific thinking (Munn et al., 2010). They evaluated the students with a rubric that was based on the six strands of science established by scientists and science educators by the National Research Council of the U. S. National Academies (Bell et al, 2009, Fenichel and Schweingruber, 2010 as cited in Munn et al, 2010).

Students were also assessed in their use of games, media, other forms of concept maps/timelines, and the use of artifacts.

Active Participant Observer

My role as a researcher in this action research study was both as an educator, an observer, and a co-learner in citizen science. Not unlike an anthropologist, the active participant observer is fully immersed in the project, students, and the setting in order to fully understand and connect with the
participants of study (Gay, et. al, 2009). There were times, however, I was able to take on the role of a passive observer as students engaged in self-directed or peer learning experiences or when they were working with another facilitator or teacher. Observations from the classroom and other settings related to the project were noted in a daily journal.

Writing a research journal was an act of reflection and was very helpful in shedding additional light on observations made in the classroom and the computer lab. It can also reveal any biases that the researcher may have towards observations made (Gay, Mills & Airasian, 2009). Reflections recorded revealed new insights into my role as a teacher and researcher, power relations, and other critical perspectives that would not be obvious in other assessment methods.
Chapter 4

THE RESULTS

Data Analysis

This action research study took a mixed methods approach (Gay, Mills, & Airasian, 2009) with resulting data analyzed using the following methods and instruments. As discussed in Chapter 3, this research design is based on the One-Group Pretest-Posttest design which did not involve the use of a control group. A fluid and ethnographic approach was needed to adapt to changing circumstances that was anticipated in a project that had many variables involving multiple languages, multiple cultures, and a high level of fluctuation in student attendance due to changing jobs, living situations, etc. The quantitative and qualitative instruments used appear in the following sections.

Quantitative

Pre and Post Attitudinal Survey in Citizen Science for ESL Adult Learners:

Quantitative data scores were tabulated from the frequency of responses obtained from both the pre and post Attitudinal Survey. The means and standard deviations from these variants were calculated using the SPSS tool. The mean scores were then compared between the pre and post surveys to determine if there are any significant changes in attitudes and perspectives regarding learning and learning barriers as related to the population they serve. A paired-samples dependent t-test was then performed to determine if there were any significant variables between the pre and post mean scores of the surveys. A Pearson r correlations analysis was also implemented (Gay et al., 2009) to show any
relationships between variables such as views on science and use of technology post their experience in the project.

An 18 question pre and post attitudinal survey was administered to assess the adult ESL learner’s perceptions and beliefs related to science and science learning in the following constructs (See Appendix A for survey).

1. Views on what science is.
2. Views on one’s ability to do science
3. Views on science being important for their children
4. Views on the importance and current use of technology
5. Views on man’s role with the environment

The survey was administered to the entire ELAA 2 class during class time and took approximately 10-15 minutes for students to complete. Two bilingual teachers were present to assist the students with any translations or other questions. Surveys were then collected and each student was assigned an identifier number which was used for the remainder of the study. This procedure was repeated seven weeks later. At the conclusion of the study, a paired sample dependent t-test was conducted for each construct that was previously measured using the Alpha-Cronbach Reliability scale shown in Chapter 3.¹

A Pearson r correlation was also calculated to determine any relationships between the survey subscales.

**Pre and Post Level Test**

Paired sample t-tests were conducted on the pre and post English Level tests and the CLAS-E tests to determine whether students made continued

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¹ Note: Each construct was assessed by individual subscales to determine if any of these changes could be attributed to the student’s experience in doing citizen science
progress in learning English as they learned science. A scatter plot and a Pearson correlation were calculated to examine any relationships between the science and the English content as it appeared in the Post Level test.

A scatter plot and a Pearson correlation were calculated to examine any relationships between the science and the English content as it appeared in the Post Level test.

**Qualitative**

Open and axial coding methods (Strauss and Corbin, 1998) were performed on the pre and post Personal Meaning Maps (PMM), semi-structured interviews, audio recordings from classroom participation and activities, and the observation and journal notes. Out of the collected interpretive data I analyzed overall themes and triangulated the results with other data collected in the study. Triangulation is defined as "the combination of methodologies in the study of the same phenomenon" (Denzin 1978 as cited by Jick, 1979). Triangulation of the data gained from the surveys, the PMM/interview, semi-structured interviews, direct observational methods, and other student contributions were also implemented to address the initial research questions and as a basis to form new questions and assertions.

**Pre and Post Personal Meaning Map**

The personal Meaning map was analyzed and scored based on the frequency of certain attributes that may appear in the maps using a rubric scale (Appendix H). Scores will be assigned to specific constructs that will be adapted from the rubric used by Falk (Falk 2003, as cited in Lelliott, 2007) (see Table
3.3). The means and standard deviations from these variants will be calculated using the SPSS tool. Further information on the PMM appears in the qualitative section.

The PMM served as an alternative assessment that involved looking at key constructs and themes related to the content and attitudes towards science and technology. Variances and changes in the data will be noted between the pre and post maps. This data was also analyzed quantitatively by creating a frequency chart demonstrating the number of times certain pictures and texts appear as related to the prompt given. Although Lelliott’s approach was principally qualitative in approach he found that the tool was also helpful in creating descriptive statistical data in that he was able to count the number of vocabulary words that appeared before and after the field-trip by each participant (Lelliott, 2007). While Falk suggests that PMMs can be used both quantitatively and qualitatively, most studies where they have been used have primarily used quantitative techniques (Lelliott, 2007). This aspect will be an important focus within this study as the goal will be to assess any gains in new words and their meaning as related to the content.

Falk also recommends a specific method of analyzing PMMs by looking across four dimensions of learning: extent, breadth, depth, and mastery (Falk 2003, as cited in Lelliott, 2007). These constructs are broken down into the following table.
Table 4.1

*Rubric for Personal Meaning Maps*

<table>
<thead>
<tr>
<th>EXTENT</th>
<th>BREADTH</th>
<th>DEPTH MEASURES</th>
<th>MASTERY</th>
</tr>
</thead>
<tbody>
<tr>
<td>The extent to which learning/or literacy is achieved by the presence of new vocabulary words as related to the content.</td>
<td>The degree to which new concepts are learned.</td>
<td>To what degree does the participant understand the new concepts.</td>
<td>Assesses the overall understanding, application, and transference of what learned.</td>
</tr>
</tbody>
</table>

*(Adapted from Falk as cited by Lelliott, 2007).*

As Lelliott suggests, the PMM was not used as a stand-alone method for assessment but rather was triangulated with other methods. Data gained from the PMM and other qualitative data was analyzed in a cross-case analysis (Miles & Huberman, 1994) to show patterns and themes that emerged through observation data, interviews, and student presentations as obtained from audio transcripts. Lelliott found that implementing the maps along with interviews served a very complementary role in that the visuals did not always reflect what came up in the interviews, and the interviews did not always reveal what appeared in the drawings. The semi-structured interviews with students were documented by writing student comments directly onto the map. Clarifications that arose out of the interview sometimes served as a prompt for the student to add an additional word or drawing to the map to give greater understanding and clarity to what they were trying to communicate. The pre and post PMM maps were analyzed using open coding which was assigned to both texts and drawings to gain insights as to what extent new knowledge and deeper learning occurred and at what stage of...
their learning experience. It is important to also note that the PMM is a graphic representation of an individual’s personal construct and schema as related to their learning experience and that there is no “right” map from which the data was compared or analyzed.

**Active Participant Observer**

Observations will be noted by myself and a second teacher and documented in the observation rubrics for both the classroom and the computer lab. These observations will be documented and coded and assessed for any emerging themes.

**Researcher Reflections and Journal**

A research journal was kept throughout the study along with observations. These reflections were entered as additional and supporting data along with the other instruments.

**Threats to Validity of the One Group Design Study**

Firstly reliability and validity can be a challenge in a largely interpretive study that is more related to methods used in audience or visitor studies research. Generalization is not the goal of an action research study or a case study as it examines specific issues and problems that appear within very specific settings. The results gained from this study however may have naturalistic generalizations (Stake and Trumbull, 1982). The naturalistic observations and the perspectives as told by the participants may reflect possible attitudes and belief systems of similar populations in similar settings and environments.
In addressing threats to validity I obtained data from various sources and perspectives in the analysis process in order to prevent researcher bias. Because of my role as an active researcher participant I recognize that this may create a threat to validity as my students may respond in ways that they believe would please me. Measures to minimize this threat were addressed by using the assistance of others to help collect and analyze the data from my class. Bilingual teachers were also utilized when possible to ensure student understanding when implementing both the interview and survey which were also important in enhancing the validity. In addition the survey was also translated into Spanish. Instructions as to how to implement the PMM were provided to the students in the form of a sample on the board before they constructed their own PMM. In addition piloting and testing the PMM before the project was implemented helped determine any problems with students being able to do the assessment.

A major area of study limitation was in gaining commitment from my participants while at the same time maintaining a sensitivity to their needs, interests, and preferences. Most students however were willing to engage in the project even the one or two students who demonstrated that they really didn’t have an interest in science. Most citizen science programs that have been researched have involved volunteer adults who already have an interest and or had prior knowledge in the subject. Consistency was largely a problem related to other factors as many of the participants dealt with illness, moves, job changes, family responsibilities, visits to Mexico, and one student who was Jewish and was unable to attend certain weeks due to religious observances. Consistency was
also a problem due to the testing and promotion schedule which happens every two months. Some of the students were continuing students while others were just coming in so not all students had a previous testing record from which to establish a baseline with.

**Reliability**

Reliability testing of the pre and post survey constructs as based on the Alpha-Cronbach reliability scale appears below.

Table 4.2

*Alpha-Cronbach Reliability with Attitudinal Student Survey Constructs*  N=5

<table>
<thead>
<tr>
<th>Attitudinal Survey Constructs for Students</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Views on science</td>
<td>0.63</td>
</tr>
<tr>
<td>Importance of science to the adult learner and their children</td>
<td>0.99</td>
</tr>
<tr>
<td>Attitudes about man and his relationship with the environment.</td>
<td>*0.54</td>
</tr>
<tr>
<td>Understanding of citizen science and beliefs on one’s own ability to do science.</td>
<td>1.00</td>
</tr>
<tr>
<td>Views on one’s ability as related to Computers and Technology</td>
<td>0.70</td>
</tr>
<tr>
<td>Survey Means Total:</td>
<td>0.77</td>
</tr>
</tbody>
</table>

*This rating was based on the construct as established in the study with the New Environmental Paradigm (Dunlap & Van Liere, as cited in Brossard et al, 2005).
The Results

Quantitative Data

Results from the quantitative data are presented from analysis of the pre and post survey, pre and post test scores, and the pre and post PMM. The PMM was assessed quantitatively by determining the frequency of themes that appeared in the drawings as well as qualitatively as themes appeared along with student clarifications.

Data from the pre- and post-surveys were analyzed to determine the means and standard deviations in specific constructs as related to student views on science, technology, and their ability to do science (Table 4.3). (See also Appendix B for percentages). Paired sample dependent t-tests were then conducted with individual questions on each subscale of the survey to determine if there were any significant differences between student’s scores on the pre and post test for individual questions and if any of these changes could be attributed to the student’s experience in doing citizen science (Table 4.3). The following tables examine specific subscales of the above constructs as they appear individually.

Table 4.3
Pre and post Survey Differences by Construct  Mean N=11

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Questions</th>
<th>N</th>
<th>Pre</th>
<th>Post</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Views on science</td>
<td>5</td>
<td>11</td>
<td>Mean 3.72</td>
<td>4.01</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SD 1.02</td>
<td>1.13</td>
<td></td>
</tr>
</tbody>
</table>
Based on Likert scale with 5=Strongly agree, 4=Agree, 3=Do not know, 2=Disagree, 1=Strongly disagree

No significant differences between the means were found with specific single constructs. We can infer from this that there wasn’t any one single construct which was significant but rather significant responses appeared with certain individual questions which appeared over a wide range of constructs which we can see in the following tables.

Table 4.4
Views on Science  N=12

<table>
<thead>
<tr>
<th>Views on Science</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 How do you feel about science?</td>
<td>N=12</td>
<td>4.0000</td>
<td>1.20605</td>
<td>.012</td>
</tr>
<tr>
<td>Q1 Post</td>
<td>N=12</td>
<td>4.5833</td>
<td>1.16450</td>
<td></td>
</tr>
<tr>
<td>Q7 I think I would make a good scientist.</td>
<td>N=13</td>
<td>3.3077</td>
<td>1.10940</td>
<td>.040</td>
</tr>
<tr>
<td>Q7 Post</td>
<td>N=13</td>
<td>3.923</td>
<td>1.18754</td>
<td></td>
</tr>
</tbody>
</table>

Based on Likert scale with 5=Strongly agree, 4=Agree, 3=Do not know, 2=Disagree, 1=Strongly disagree
Table 4.4 shows the mean and standard deviation for items related to the construct dealing with views on science. This analysis was based on an attitudinal survey using a Likert Scale with 5 representing Strongly Agree to 1 Strongly Disagree. The highest mean score was 4.58 and refers to student views about science post their experience in doing citizen science. For Q 1 we see from the pre survey a mean of 4.0 (SD=1.20) followed by a mean response of 4.58 (SD=1.16) post which shows a statistically significant difference with a p value of .012 in a paired sample t-test with 13 students at the <.05 critical alpha level. Q7 which pertains to a student’s view as to whether or not they would make a good scientist we see from the pre survey a mean of 3.31 pre (SD=1.10) followed by a mean response of 3.92 (SD=1.19) on the post survey which shows as statistically significant with a p value of .040. Figures 4.3 and 4.4 shows these results in the following bar graphs.
Figure 4.5

*Pre and Post Survey construct: How do you feel about science? Pre n=20 Post n=18*

*Shows a statistically significant difference with a p value of .012 in a paired sample t-test with 13 students at the .05 critical alpha*

Figure 4.6

*Construct I think I would make a good scientist pre n=21 post n=18*

*Shows as statistically significant with a p value of .040.*
In Table 4.7 we will look at student views as they appeared with the construct learning and technology.

Table 4.7
*Views on Learning and Technology*  N=13

<table>
<thead>
<tr>
<th>Views on Learning and Technology</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q10 I think working with the computer is difficult.</td>
<td>N=13</td>
<td>3.4615</td>
<td>1.19829</td>
<td>.032</td>
</tr>
<tr>
<td>Q10 Post</td>
<td>N=13</td>
<td>2.7692</td>
<td>1.48064</td>
<td></td>
</tr>
</tbody>
</table>

On the construct dealing with technology we see several areas of change as related to views on computer difficulty and frequency of Internet use. Q 10 “I think working with the computer is difficult” shows in the pre survey a mean of 3.46 (SD=1.19) followed by a mean of 2.76 (SD=1.48) which is statistically significant with a p value of .032 in a paired sample t-test with 13 students at the <.05 critical alpha level.

In Figure 4.8 we see a frequency bar graph which shows student views on computer difficulty went from 0% pre to 18% post strongly disagree. This suggests that post their citizen science experience, student’s introduction to some new technology was perhaps not as difficult as originally perceived.
Although not statistically significant Figure 4.9 shows that there was a change in student’s use of the Internet before doing science compared to after.
Pre survey shows 30% of 20 students strongly agreed that they used the Internet more than once a week compared to almost 70% post. In the next section will be the results of some correlations to determine any relationships between specific survey subscales.

Table 4.10

*Intercorrelations between Survey Subscales  N=5*

<table>
<thead>
<tr>
<th></th>
<th>Post Q1</th>
<th>Post Q3</th>
<th>Post 7</th>
<th>Post 13</th>
<th>Post 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do you feel about science?</td>
<td>1</td>
<td>.612* N=16</td>
<td>.705** N=16</td>
<td>.792** N=16</td>
<td>.838** N=16</td>
</tr>
<tr>
<td>Learning science is important for my job and career goals.</td>
<td>.612* N=16</td>
<td>1</td>
<td>.855** N=17</td>
<td>.397 N=17</td>
<td>.624** N=17</td>
</tr>
<tr>
<td>I think I would make a good scientist.</td>
<td>.705** N=16</td>
<td>.855** N=17</td>
<td>1</td>
<td>.649** N=17</td>
<td>.706** N=17</td>
</tr>
<tr>
<td>I use the Internet more than once a week</td>
<td>.792** N=16</td>
<td>.397 N=17</td>
<td>.649** N=17</td>
<td>1</td>
<td>.640* N=13</td>
</tr>
<tr>
<td>Learning the computer is important for my career goals</td>
<td>.838** N=16</td>
<td>.624** N=17</td>
<td>.706** N=17</td>
<td>.640* N=13</td>
<td>1</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

A Pearson correlation coefficient was used to assess the relationship between items in the subscales as they appeared in the pre and post survey.

Between question 1 post (views on science) and question 7 post (I think I would make a good scientist) we see a strong correlation which shows as r=+.705, n=16, p=.002. To determine the common variance shared by the two variables we see a
coefficient of determination as $r^2 = .50$ or 50% of the variance in students’ views on science is shared between the two variables.

We also see correlations with question 1 and questions 13 and 14 which are both related to technology. Question 13 post (I use the Internet more than once a week) and question 1 post (views on science) shows as a strong correlation at $r = +.792$, $n=16$ $p = .000$. A coefficient of determination shows as $r^2 = .62$ or 62% suggesting that 62% of the time, student views on science also impacted the number of times they access the Internet per week. Likewise, Question 14 post (learning the computer is important for my career goals) and question 1 post (views on science) shows a strong correlation at $r = +.838$, $n=16$, $p = .000$. A coefficient of determination shows $r^2 = .70$ or 70% of the time student perceptions of science impacted their views on the importance of learning the computer and their ability to advance in the job market.

**Pre and Post Level Test Scores**

A pre and post Level test was implemented to assess student’s English skill level pre and post doing citizen science. It is important to note that the pre and post level testing and the CLAS-E sampling represents only continuing students who typically score lower than average and have more difficulties in making gains. In the post level test the science content was related to content presented in class and to their citizen science experience. In assessing English skills the science was removed from the post and compared with the English pre level test which did not contain any science content related to things learned in
class but rather was related to a reading comprehension task. In the post level test there was also an additional open-ended question that asked students to reflect on their experience in an essay or drawing and is discussed in the qualitative section.

The below Figure shows the mean percentages of the pre and post test scores and the quiz scores implemented over the course of the project.

Figure 4.11

*Pre and Post Level Test Scores*

![Test Scores Graph](image)

Results: 74% of the class achieved a passing score on the final level test compared to 67% of the class with the baseline Level test. We can’t really say with certainty that the increase is due to any specific measures due to the following possible threats to validity. Repeated testing: Gains may be associated with taking quizzes that assess the same skills.
Maturation: The increase could be due to a normal rise which results over time. Some students were new while others had been in my class for many months to even a year.

Some of the primary changes in methods and techniques that were not done for the first level test include the following.

1. An increase in number of quizzes as a means of assessment
2. Quizzes required the use of cognitive skills which initially was difficult for many. Instead of multiple choice questions they were asked to analyze sentences and find what was wrong with them.
3. Students were given concept maps called “Grammar Clocks” to help them visualize verb tenses. Some used them as a tool when taking the first few quizzes.
4. Content: The first level test contained only Grammar while the second contained some science content.

The main goal in doing this assessment was to demonstrate that students either maintained or were able to make a gain in their level test scores to support the assertion that the integration of science did not negatively impact student’s ability to learn or make gains in English.

In order to see how the two tests compared in just the grammar, the science content was removed from the final test and the results appear in Table 4.12.

Table 4.12
Pre and post T-test in Grammar Content

<table>
<thead>
<tr>
<th>Level Test</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Level Test Grammar Section</td>
<td>N=10</td>
<td>63</td>
<td>10.22</td>
<td>.560</td>
</tr>
<tr>
<td>71 questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

83
Pre and post grammar showed no significance with a total mean score showing only one point difference between the pre and the post. In the next section I looked at some correlations between the post science and grammar content to determine to what degree does a student’s ability to understand science depend on his or her level of English. A scatter plot in Figure 4.13 summarizes the results of this correlation.

Figure 4.13

*Scatter plot showing correlations between Grammar and Science Content N=10*

In Figure 4.13 we see a scatter plot showing the percentage of correct answers in science as compared with the grammar sections of the posttest as they appeared...
with each student. The scatter plot shows that 7 out of 10 or 70% did better on their science than their grammar with one student showing an equal score and two that were lower.

The science average mean score in the post test was 71 while the average mean score for the grammar section was 61.8. The correlations between the two content areas appear in Table 4.14

Table 4.14

*Correlations between Post Level Test Science and Grammar Content  N=10*

<table>
<thead>
<tr>
<th></th>
<th>Science</th>
<th>Grammar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>1</td>
<td>.777**</td>
</tr>
<tr>
<td>Grammar</td>
<td>.777**</td>
<td>1</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.14 appears to show that there was a positive and significant correlation between the percentage of correct answers in the science as compared with the grammar content or $r = .777$, $n=10$, $p=.008$. A coefficient of determination shows as $r^2 = .60$ or 60% of the time the science content was within the same range as student’s English skill levels. As noted in Figure 4.13, there appears to be a correlation between English skill levels and the ability to understand science content, at least as it relates to fact knowledge and the traditional testing environment. This correlation is further supported by a statement made by Student 5 in a Pre interview. “Things are discovered in
English. . .English applies a lot to everything dealing with science. If you understand English, you can discover many things.”

The CLAS-E test is a standardized state required test that students take every 60 days and in Figure 4.10 we compare those students who had a baseline from the previous testing to testing taken post their engagement in the project.

Figure 4.15

*Scatter plot summarizing Pre and Post CLAS-E Testing  N=11*

This scatter plot summarizes the results of the pre and post CLAS-E English skill test taken from a sampling of 11 students. Nine students out of 11, or 82% of the sampling had an increase in their score from their previous test. Five students, or 45% of the sampling achieved a high enough gain to place them into the next level. The student that appears as number 1 made a high enough gain to
place him two levels above his previous level moving him from a Level 1 to a Level 3 based on the CLAS-E scoring rubrics. Student number 2 “grayed out” at Level 3 which means she scored at a level that would not allow for any further gains and so had to be re-tested at Level 4. Two students had a drop in their test scores. Showing as number 4, this student is over 65 and has visual problems due to cataracts. The student showing as number 8 shows as an outlier with unknown factors for the drop.

**Qualitative Analysis**

Open and axial coding methods (Strauss and Corbin, 1998) were performed on the interviews, audio transcripts, and observations. The pre and post concept maps were assessed by tabulating the frequency of common themes.

**Personal Meaning Map**

Personal meaning maps were implemented to provide students an alternative means of expressing their knowledge that was not necessarily tied with their language ability. The frequencies of themes as they appeared in the writings and drawings were coded and analyzed based on a rubric that appears in Table 4.16.

Examples of the paired pre and post PMM coding as related to science and extinction appear below.

Table 4.16

*Samples from PMM Coding Results* 

---

*See full table and key codes in Appendix G and H*
<table>
<thead>
<tr>
<th>Student</th>
<th>Country</th>
<th>PRE Extinction</th>
<th>Code</th>
<th>POST Extinction</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Burundi</td>
<td></td>
<td>3</td>
<td></td>
<td>5</td>
<td>Showed prior understanding of extinction by drawing a dinosaur skeleton and a head of an elephant skull with words directed to different parts of its anatomy. Demonstrated critical thinking skills as student compared what happened to the mastodon with what could happen to the African elephant today. Used key science terms like increase, decrease, and referred to citizen science experience.</td>
</tr>
<tr>
<td>4</td>
<td>Burmese</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td>Written in Burmese. Drew a few flowers and a peacock. Drawings of various animals but now labeled in English. Only one animal the elephant was related to the content. Not clear if understood concept of extinction.</td>
</tr>
</tbody>
</table>

Results of Paired PMM: Ten students created a total of 15 paired pre and post personal meaning maps. Out of a total of 15, 67%, or 10 of the maps showed
a gain in content knowledge or other rubric area such as English and the use of new key terms. One unexpected observation appeared in six of the pre and post maps when it was observed that students wrote in their native language on the pre map but in the post map chose to write in English. They were given the option to write in either English or their native language.

In the following chart we will examine more closely student views of science as they appeared in 14 pre PMM.
Although this was initially intended to gain a perspective of student views of science it really provided an interesting snapshot into student worldviews of the universe and the natural world. It is interesting to note that the highest percentage appeared with astronomy. Man in the scheme of things appears as a mere 3% indicating perhaps a disconnectedness of man with the universe. 7% had views on evolution. Only 2% viewed science as related to a possible career.

In the following figures we can see the frequency of some specific subscales as they appeared in the pre and post personal meaning maps and as they appeared with individual students.
In Figure 4.18 we see that the highest frequency appears in the subset related to the student’s involvement with the Mastodon Matrix project. This means that whether in drawings or in text, there was made some reference to this experience when constructing their meaning maps. Other high areas were related to their knowledge of endangered species and their understanding of extinction. Attempts at animal classification also appeared in their post PMM even though they didn’t always get it correct.

It is interesting to note that in the pre PMM, the subset of classification appeared more in relation to the universe which was described in Figure 4.17 while in the post PMM they made attempts to do more difficult forms of
classification as related to specific animal species and vertebrates versus invertebrates. In Figure 4.19 we will look at the frequency of subscales as related to individual students.

Figure 4.19

*Pre and Post Frequency Subscales in PMM  N=10*

![Pre and Post PMM Frequency of Constructs](image)

Using the same subscales in Figure 4.18, we see in Figure 4.19 that students 6, 8, 11, and 24 did not have any data appear in their pre PMM. Students 3 and 5 showed the greatest gains between their pre and post knowledge in specific construct subscales.

**Pre and Post Interviews**

Semi-structured interviews were conducted with 6 Hispanic students pre and 4 post which included a refugee from Burundi Africa. For the coding, and constructs used (see Appendices C and D). A major limitation of this study has
been in getting paired responses due to the fact these learners are often transient, make frequent trips to Mexico, etc.. This risk increases the longer a study is. Since paired responses were too difficult to obtain I chose to represent the interviews collectively in three constructs. Table 4.20 focuses on three main constructs as they appeared in the interviews along with post reflections as related to specific learning tools and deeper learning.

Table 4.20

*Interview Summaries n=8*

<table>
<thead>
<tr>
<th>Pre Views of Science</th>
<th>Post Views of Science</th>
<th>Pre Views of Technology</th>
<th>Reference to Technology/tools</th>
<th>Post Views of Deeper Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Is what my children like to study.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Tells us about the world and the universe.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Need English to understand science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Helps us find answers and defines steps in getting there.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Helps us ask why things are the way they are.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Know little about.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Would like to learn more.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Involves study of different branches.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Defines way</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Made reference to life and history of animals. (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Reference to extinction. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Reference to the mastodon/mammoth. (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Awareness that there are many things we don’t know that is right in front of us. (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Doing science is a new experience. (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Reference to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Will open doors.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Need it for everything.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Enriches learning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Helps us communicate with the world and learn about other opinions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Can discover new things.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Is important as learning English.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Need to use it as a learning tool.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Reference to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-More bilingual resources needed. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Referred to an Internet activity (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Referred to an online video (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Referred to slide or media seen in classroom (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Games (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Science and games activates and awakens the brain.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Computers promote deeper learning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Science and English activates brain.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
of acting and behavior. -Involves natural sciences. -Involves earth, math, energy, and a lot of things.

the age of the earth. (2)
-Got to learn something would normally only get to see on television. (1)
-Reference to new vocabulary learned. (2)

*Note: Numbers represent the frequencies as they appear in transcript.

(See Appendices C,D,and E for interview questions, coding, and a full list of coded themes).

Results of the interviews shows a close correlation with the Pre PMM in that both assessments showed views of science as something distant and perhaps something students feel very disconnected. Key concepts that appear in the Pre views of science include “universe, systems of knowledge, defines how we should act and behave, tells us about the world, and need English to understand it.” Science is in essence viewed as a dominant discourse created by a more accepted knowledge system. In the Post we see science as becoming more personalized. It includes student’s knowledge of the life and history of animals, new concepts gained as a result of doing citizen science, reference to science being a new experience, and reference to being more connected. . .”doing science” rather than watching others do it on television.

In addition, students’ commented on tools of learning that perhaps they felt best helped them connect or make associations with science. Computers,
games, media, and bilingual resources were some of the tools mentioned. The concept of deeper learning also emerged as an unexpected response from several of the students which suggests that deeper and cognitive-based learning is something they feel is beneficial.

**Classroom Transcripts and Observations**

There emerged various themes in the classroom transcripts and observations which were analyzed using open coding methods and then further categorized by axial coding into specific sub themes. To determine as to what contexts higher order thinking appeared, the text and observations were categorized into “critical thinking that was prompted” by the teacher and those questions that were not prompted along with a third category of other cognitive tasks. This third category was added due to the fact higher order thinking involves more than just critical thinking skills. The results appear in the following bar graph.
Results: Frequency of observations of critical thinking and other cognitive tasks were analyzed as they appeared in three different delivery methods. Artifacts and media in the classroom, the use of a graphic timeline to illustrate the concept of extinction over time, and the Mastodon Matrix Project. Overall frequencies for the classroom related content showed the highest number of observations as these methods were utilized the most frequently while introducing the material. Computer related experiences were not included due to the limitations of accessibility and limited time spent using technology in this study. Likewise the game was not included as this is discussed later in the findings.

Results show that the Mastodon Matrix Project showed out of the three constructs to be highest in the “critical thinking not prompted” construct. It was
also the only delivery method to show the highest frequency in this construct when compared with the other delivery methods. However compared with the other methods, the MMP was the lowest in observed cognitive related tasks. Although students were involved in certain cognitive tasks such as measuring and entering data, the facilitator or educator will need to include more opportunities for cognitive engagement. For example the use of visual references from which students could draw from to assist in the identification of items found. The use of artifacts, media, and concept maps would also prompt comparisons and association. The availability of technology in the classroom of course also plays a major role in this.

The graphic timeline interestingly appeared to be the highest in cognitive related tasks as students were involved in matching pictures and comparing and contrasting.\(^3\) Out of the 12 total cognitive tasks observed, 5 or nearly 50% were related to association or the ability to relate, connect, or apply one concept with another. Critical thinking that was not prompted also showed to be higher than prompted thinking meaning students were engaged in asking their own questions and problem solving based on what they observed. This I think also gives further support to the benefit of concept maps in not only as a tool for assessment but also as a teaching tool in helping students connect with abstract concepts such as time.

\(^3\) The graphic timeline was published by Charlie’s Playhouse. A publisher of evolution learning materials for children.
In more structured content delivery methods via media and artifacts we see that the most frequently observed construct is critical thinking which was prompted. Cognitive related tasks and critical thinking not prompted was observed most frequently with the use of artifacts. Overall, this suggests that the delivery of structured content allows for fewer opportunities for students to think critically or to experience deeper learning that would come with doing more cognitive-based tasks.

Student emotional responses were also analyzed as a good indicator of learning motivation and engagement in the students. Emotional responses were tallied as they appeared with specific content and constructs and included incidences of humor, surprise, laughter, disbelief, cheers, memory, comments related to something being beautiful, applause, etc.

Table 4.22

*Frequency of Emotional Responses*

<table>
<thead>
<tr>
<th>Emotional Responses</th>
<th>Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction slides/artifacts</td>
</tr>
<tr>
<td>2</td>
<td>Graphic timeline/artifacts</td>
</tr>
<tr>
<td>4</td>
<td>Museum Trip</td>
</tr>
<tr>
<td>4</td>
<td>Artifacts/Intro Biodiversity</td>
</tr>
<tr>
<td>10</td>
<td>Mastodon Matrix Project</td>
</tr>
<tr>
<td>10</td>
<td>Mastodon Video</td>
</tr>
<tr>
<td>12</td>
<td>Slides/artifacts related to mastodon project</td>
</tr>
<tr>
<td>25</td>
<td>Game</td>
</tr>
</tbody>
</table>
Results: Results of student emotional responses show that the game was observed to create the most by way of motivation and emotional engagement and appeared to be effective in helping students connect cognitively with the content.

The mastodon video interestingly created an equal number of emotional responses in creating engagement which suggests the powerful influence media can have in learning. The slides and videos also appeared to serve as an anchor in creating association with time, place, and content before engaging in the citizen science project.

The following constructs focus on student ontologies which appeared in the audio transcripts and classroom observations. Student ways of knowing reflect prior knowledge and/or understanding as related to the content as well as sheds light as to their cultural beliefs and worldviews. These views when presented in the classroom often did not coincide with the scientific views that were being taught.

**Student Ontologies**

**Animal Taxonomies and Classification**

The first few weeks of the project was devoted to teaching animal classification and concepts as related to biodiversity, extinction, and species adaptation and change. It became quickly apparent that views on animal taxonomy and classification were tied largely with cultural or indigenous perspectives rather than the views of formal science which many students
had little to no exposure to.

Student 3: Is that a snake?
Teacher: Actually it’s a worm. A snake is a reptile and has a skeleton.

Student 5: (On viewing a picture of a snake skeleton). That’s not a snake.
Teacher: Actually it is a snake. Snakes are vertebrates and have a skeleton.

Teacher: That's right. Praying mantis. Does it have any bones?
Students: yes.
Teacher: Is it a reptile?
Student: An insect.
Teacher: Do insects have bones?
Student: Yes, it has five legs. (possibly confused with starfish)

Student: Frogs don’t have bones. They’re squishy.

Student 1: (Starfish) It eat meat?
Student 2: I think no eat meat.
Teacher: Actually it does eat meat. It’s a carnivore as it likes to eat clams, and other bottom creatures.

Student 10: Turtle not a reptile.
Teacher: It actually is related to the snake in that both are reptiles.
Student 10: (points to a picture of a snail) They hide in their shell. . .just like the turtle. (Implying the snail and the turtle are more related than the turtle and the snake)
Teacher: We categorize reptiles as cold-blooded animals. . .turtles and snakes are cold-blooded animals.
Student 10: A snake does not have a shell. (attempts to demonstrate why the teacher is not correct)

Student 10: (On viewing slides of the mastodon) Maybe I think now. . .In Africa don't have. . .when I see this elephant. . .are different. . .
Teacher: Yes they are very different from the African elephant aren’t they.

Student 5: (on counting tree rings to determine age) A Chinese tree can be 1,000 years old but is only this big. . .how can that be?

It is interesting that many of these ontologies were also coded as critical thinking in that students were using prior knowledge to question or challenge new knowledge. Student #10 was very adamant on his views of the turtle and the
sake which challenged this writer to examine in more depth about the role of student ontologies when introducing scientific knowledge.

**Cosmological and Religious Worldviews**

There was surprisingly few things founds in this construct. In response to examining a timeline on the evolutionary development of life we see the following.

Teacher: It says here it’s the first animal to go on land. All of these animals were underwater.
Hispanic Student: I believe in creationism.
Teacher: Well this is the perspective of science of course. ..but all opinions and perspectives are welcome. There are so many views.
Student: The earth is very beautiful.
Teacher: Yes, there is so much in the universe we don’t understand. We no comprende the vastness. . .the diversity of life that there is boggles the mind.

In a discussion on how to best grow plants.

Teacher: What do plants need?
Student 3: Prayer. Plants need prayer to grow.

The next type of frequently encountered ontology had to do with themes surrounding food and was always a popular topic in the classroom and was frequently instigated by the students and not the teacher.

**Cultural Themes Regarding the Natural World and Food**

(In reference to frogs. . .)

Student 5: (From Ecuador) Everybody eats
Teacher: (class laughs) Well some people do. . .not everyone.
Student: This one is no eat. . .(pointing to several pictures)
Teacher: Do you eat frogs?
Student Yes, sometimes. . .in Ecuador they like it

Student 5 also made reference to various plants in a drawing when reconstructing
the environment in upper state New York during the Pleistocene era when the
mastodon lived. These drawings were based on the seeds and artifacts that
students found while working with the Mastodon Matrix project materials.

Teacher: What is that you are drawing on the trees?
Student: Bananas.
Teacher: Oh? I don’t think bananas grow in New York as it is a tropical
plant.

The student quickly erased some of the bananas from his drawing. On further
research I learned that the mastodon actually did eat a type of berry that is also
called the Michigan or Hoosier banana. It is formally known as the paw paw fruit
which is the largest edible fruit indigenous to the Eastern United States. Even
though it is normally associated with tropical climates, this species was able to
adapt to temperate climates at the beginning of the Pleistocene. In reviewing this
student’s drawing the fruit he drew appeared to be much like the paw paw fruit
and not the traditional tropical banana. Ecuador, which is his native country, is a
major exporter of this fruit. Other themes as related to food appeared with one of
the Burmese students.

Student: (Burmese) We don’t have any animals in our country.
Teacher: No animals?
Student: Everybody eats the animals.
Class: (A class conversation starts)
Class: Do you eat dogs?
Student: Yes, we eat.
Class: Monkeys?
Student: Yes, we eat.
Class: Snakes?
Student: Yes, we eat.
Class: Insects?
Student: Yes, we eat everything.\textsuperscript{4}

One particular discourse as related to food repeatedly came up with the African refugee student from Sudan. The subject was very relevant as we studied the mastodon and the current threats of the African elephant. The discourse was always the same and a source of entertainment as the students would laugh each time like it was their first time hearing it.

Student: Why did they kill the mastodon?  
Teacher: Good question. . .Why did they kill the mastodon?  What kind of answers can we come up with? Why do some kill elephants in Africa?  
Student 3: I eat elephant. . .  
Class: You eat?  
Student 3: Yes very good. It tastes like beef. Very good!  
Class: Laughs

Student #3 further explained that she only tasted elephant once and that it was not something she normally ate as was very expensive or was not easy to obtain.

\textbf{Concepts of Time and Place}

Time is a very abstract concept and there was some initial concern as to how one might best approach and integrate these concepts in a more concrete way. Some of the discourses that emerged as related to time and in different contexts appear below.

Student: How long ago. . .time.  
Teacher: How long ago did they live? When did they go extinct? Might also be what you are asking? Does anyone know?

\textsuperscript{4} Note: This student was a refugee from a region in Burma that was in a state of war and oppression with a scarcity of food. Several of the Burmese students talked about the violence and their experiences would often show up in writing assignments and or drawings.
Students talk amongst themselves: When...?
Teacher: When did they disappear? When did they go extinct? Both are asking the same question. When the last of a species dies or disappears. Does anyone know the answer?
Student: 10,000
Teacher: Yes, 10,000 years ago
Other Student: 10,000!!

Students during the second session of doing the Mastodon Matrix project came to a new awareness about what they were involved with. Students initially thought the earth they were working with was some dirt the teacher dug up somewhere. When they finally made the connection that the material they were working with came from the mastodon site they saw on the slides it was like an epiphany that arose in about four students at once.

Student 16: Teacher, is this dirt long ago from now...? In this time?
Teacher: No, actually around 10,000 years ago...
Student 16: Really?
Student 12: What? 10,000 years ago? Oh my God... I don’t believe it.

This same realization was seen again while viewing slides in the classroom.

Teacher: You see here all the plants we found were in or around this pond 10,000 years ago.
Student: Is it the same place?
Teacher: Yes, the material came from this place.

While working with an evolutionary time lime several students formed cognitive bridges between English, number literacy, and critical thinking skills.

Student: How old is the sponge?
Teacher: On timeline it says 650 million years
Student: This says over 500 million... (referring to an activity sheet)
Teacher: Yes another source says 600 million... over means higher. Over 500 can mean 550 or 600. Good that you’re looking for facts. You know something could be wrong so that’s why research is important. You might find something that says something different...
Student 10 made a connection between a grammar concept and in understanding the concept of extinction.

Student 10: This word here with this animal... says “was”. What mean? Teacher: This means this animal is no longer living... it lived in the past. Student 10: Oh... was... in the past.

Along with the timeline, a board game was designed which served as an effective tool in helping students connect with pictures and concepts. An unexpected outcome was various discourses like the one below.

Student 16  Dinosaur was very strong?  (student had to name an adjective to describe a dinosaur)

Teacher: Yes, you can say very strong, very tall, very big. With the T-Rex, do you think it was an herbivore or a carnivore?

Student 1: Not sure...  

Teacher: What kind of teeth did the T-Rex have?

Student 1: Different teeth... big teeth

Teacher: Do you think they ate plants?

Student 1: Carnivore?

Teacher: Yes that’s right.

Student 1: Wow... 

Teacher: With teeth like that they are going to eat meat!

Student 1: T-Rex... ate people?

Teacher: Well humans really weren’t around then... 

Student: What? Before us? (disbelief)
Teacher: Dinosaurs actually went extinct before man came. We were here at the time of the mastodon. .. remember man hunted the mastodon around 10,000 years ago. Science tells us that dinosaurs went extinct 65 million years ago.

Student: Wow. ..65 million?¹

Themes of Changed Perception or New Awareness

When introduced to the topic of biodiversity, students were asked to record observations of various animal artifacts and models then a week later students read some new information and had to decide how their initial views changed.

Student 10: (The dragonfly) It says here it eats other insects and. . .catching flying.

Teacher: Yes, it flies and catches insects in the air. So that is something new you didn’t know before. . .

Talking to Student 1:

Teacher: Something different here?
Student 1: Yes, five arms. . .not five legs.
Teacher: Really? Very good. . .
Student: Also they can see light and dark.
Teacher: Yes they have eye spots on the end of the arms that can see light and dark.
Student 1: Wow. .

Student 10 when reviewing his own work.

Student 10: Wait a minute. . .elephants have bones. Not an invertebrate. (He changed his answer on his paper.)

¹ Note: Some creationists believe that man co-existed with dinosaurs. It is unknown as to whether or not this was a religious-based worldview for this particular student.
In an observation in the computer lab student #10 made the sudden realization that the seeds he was involved in taking microscopic pictures of the week before were the same ones now appearing on his computer screen. His images were uploaded to Flickr and some of the students were involved in labeling and identifying the seeds based on a visual guide that was created. Student #10 made the comment that he remembered that the seeds were very old and showed interest in identifying them. Another African student Student #3 also became excited when she made a match between a picture of a seed on her paper with the photos of seeds that they had discovered in class.

Perhaps the best example of new awareness is related to student’s sudden awareness as to the age of the materials they were working with as mentioned previously.

Student 12: What? 10,000 years ago? Oh my God. . .I don’t believe it.

This awareness created perhaps a new level of meaning in what they were doing and that maybe it was real science.

**Man’s Destruction of the Natural World**

Environmental studies and ecoliteracy are frequently taught from the scientific perspective with not enough emphasis on the socioeconomic and issues of power that are often the root of our present ecological crisis (Gruenewald, 2004, Kahn, 2010). Student ontologies as they appear from different regions of the world can help shed much light on some of these issues.
The personal meaning maps provided much information in this construct which a few are shown here from student 10.

Figure 4.23  **Student 10: Pre Personal Meaning Map on Extinction**

Student 10 on several occasions talked about the ivory tusk trade in his country in Burundi Africa which historically has served as a major trading post for poachers throughout Eastern Africa. It is uncertain how much of his narratives were understood by others in class, but it is clear he knew much about the subject which he demonstrated also in his drawings. In Figure 4.23 we see that along with drawings of elephants he drew a dinosaur to demonstrate something no longer living which shows some understanding of the concept of
extinction. However what is perhaps the most interesting is his very scientific and anatomical drawing of a dead elephant which is so detailed it suggests a previous experience or observation. In the drawing he makes specific notations of the tusks and where the eyes and trunk once were. In working with students whose language is neither English nor Spanish, personal meaning maps can be an especially effective tool in relaying cultural views and ways of knowing. Student #3, the African refugee from Sudan also made mention of elephants without knowledge that this was to be one of our areas of focus in the program. She did not make any drawings but wrote, “man kill elephants”.

In Figure 4.24 we see the post Extinction map of student 10. His understanding of cause and effect as it relates to extinction became better defined as he moved beyond his experience of elephants to an understanding of the delicate interconnectedness of man and all species. In class he explained how the killing of one animal could create an increase or decrease of another animal. On his map he writes, “Mastodon...I think no live because man hunting...food was decreasing. Now elephant decreasing to because want money from tusks. Now man killing. Rabbits decreasing because coyotes eat.”

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Note: The concept of increase and decrease were new terms learned by students in this project. Student 10’s comment on coyotes might have been based on a class discourse on what would happen to other species if the coyote population were to decrease. Being this student often researched things on his computer at home it is possible that this was based on research he conducted on his own as we did not talk about rabbits.
Other ontologies about elephants came from the Burmese students. Student 22 raised and cared for elephants for many years as part of his occupation in clearing forests and mining work. Burma is the only country that continues to use elephants on a large scale in industry and is home to the largest number of domesticated or captive elephants in the world (Begley, 2006). He talked about how long it took for elephants to have young and was able to identify the skull of an extinct species of elephant at the museum. The skull did not have a label and we called it our mystery creature as no one knew for sure what it was. Student 22 took one look and said, “that’s some kind of elephant”. I checked with the educational director and he was right. It was an extinct species of elephant.
Man’s Inhumanity against Man

One cannot discuss man’s destruction of the natural habitat without also talking about man’s inhumanity against man as both are interconnected. This is something the refugees in the class unfortunately know all too well. During one of our discussions about threats to the African elephant Student 22 scratched out on paper a question. “Why are people being burned alive in Kenya?” He was referring to a news report regarding elderly people being burned alive for being witches in that area of the country. He was quite disturbed by this and wanted to understand why such a thing was happening. Other refugee students in the class I know are looking for similar answers to these questions. Student #3 lost a son and a husband in gunfire and she has mentioned on several occasions she had shot and killed others herself in a fight for survival. Science might tell us why things are. . .as one student commented, however it is unlikely it will ever be able to explain why humans seem to lack a consciousness for the sacredness of life.

In the next section other themes as related to co-learning between teacher and students will be discussed along with the overall findings of this study.
Chapter 5

FINDINGS

Student Overall Views and Understanding of Science

Quantitative and qualitative data as gathered from the pre and post personal meaning maps, surveys, observations, and interviews suggest that there was a change in perception towards science and in technology post their experience in doing citizen science compared to pre. In the pre personal meaning maps views and understanding of science was mainly associated with a broad classification and view of the universe. Post personal meaning maps showed a more defined focus as related to the content with a more sophisticated attempt in the classification of animals and species.

As for some preexisting beliefs, one student felt that science was important in that it defined steps in getting answers and prompted us to ask why things are the way they are. Several of the responses showed a preexisting knowledge on the relationship of science with critical thinking. Students commented also on science in their native countries. Some had no science education while others stated they really never were taught science and never really had the opportunity to go in depth with the subject. 61% of the post interviews made specific reference to content learned as related to biodiversity, age of the earth, extinction, and the mastodon.
Views in Learning English and Doing Science

In a post interview student #1 made the comment. ..” “There are so many things in front of us which we don’t even know about. . .” This student throughout the project showed great enthusiasm in doing science and this interest passed to others as he helped translate and increase understanding in the other students. In informal conversations he stated he did have an interest in science and his feedback in the program assessments also reflect this. In an open-ended question this same student wrote in Spanish,

For me the most interesting was the combining of science with learning English. . . learning the two together helped us learn science by applying the language and for me it helped to know a history of the life of the mastodons and mammoths that I was not aware. It also allowed me to see that there is a real problem for many endangered species and is an original, unique way to learn.

A Burmese student wrote. . .

When I studied science I learned that 10,000 years ago animals were very big with tusks, tall, big feet and body. Now there are animals that might not be here in the future. Maybe no animals left in the world. We need to learn about animals in history and as they are in nature today.

65 year old Hispanic student. . .

“Got to learn something that ordinarily would only see on television. . .”

Same student also stated. . .

I would like to study more science. I would like to study more science because since I was little,—Look, I [went to school] for about 6 years, just grammar school, in Mexico, and one year I had a teacher that taught me Mexican history, and I really liked history, and what we did (in class) is also history.

52 year old African refugee. . .
I remember the mastodon. . .I remember what you did about how long. . .I remember that was food for meat. The bones when they found in the backyard. That was many years . . .I remember that. I remember mastodon and mammoth. . .that they eat the trees and the grasses. Mastodon eat the trees. . .that they're different. I remember different in the ears and the different tusks.

In an interview this same student in response to whether one should just learn English and not include science replied, “No I want everything. . .with just one (English) I don't get to know the animals. . .now I know, how many years, how long ago. . . English and science together. . .is good.“

Do you think you could be a scientist? He replied, “Yes good for me because I know animals. . . I can draw animals. . .” This student depended greatly on visuals in connecting with the content and as a means to express his knowledge. It is perhaps interesting to note here that in the pre personal meaning map and in the post interview this student makes reference to seeing himself as a surgeon and doctor. His view and perception of science involved work that was of service to others. This African refugee from Burundi with no formal education demonstrated a remarkable aptitude for science which he frequently demonstrated through his questions of inquiry and independent research on the Internet. He also showed much enthusiasm when using the digital microscope as he took pictures of the plants and other materials found in the citizen science project. After all the students had left the classroom, he was still working. This I think challenges the general belief (even my own preconceived ideas) that African students with no formal education have greater difficulties cognitively and thus would have difficulty in learning science.
Appearance of Critical Thinking and Co-Learning

Perhaps the most revealing theme in the observations and classroom transcripts was the fact that teacher prompting of critical thinking did not really appear as often within the context of doing citizen science as it did in the traditional teacher centered classroom. Working with citizen science dealt largely with the unknown and it appeared in this study to level the playing field in that the teacher didn’t really know much more than the students by way of identifying what was found. All perspectives and views had validity. In the below excerpt the lines of social status is so blurred it is difficult to tell who is the teacher and who is the student.

Teacher: What’s that?
Student: I don’t know. . .maybe it’s a bone.
Teacher: Looks like it could be some kind of tooth!

Again. . .

Teacher: What is it?
Student 2: Animal
Teacher: I don’t know. . .it might be a stone or maybe a tooth.

Again. . .

Student: Is it a rock?
Teacher: Might contain plant material.
Student: Is not a plant. . .it’s a rock.

It did not take long before both teacher and students became better in the identification and classification of the items found. Photographing the items, sending samples to a paleobotanist, and viewing the photos in the computer lab allowed both teacher and students to become “experts” over the several weeks we worked with the material. Several of the students were able to identify some of
the seeds and plants that were most commonly found in the matrix such as the water lily.

Results of the observations and transcripts also indicate that co-learning appeared the most frequently when students and the teacher were working together with objects and artifacts as related to the citizen science experience. When both teacher and student were involved in problem solving or investigation there appeared to be an increase in the level of critical thinking and less teacher prompting. Co-learning also appeared while learning new technology and during the use of the digital microscope.

Teacher prompting for critical thinking was more prevalent in the traditional controlled classroom when the teacher was providing information based on prepared content with a predetermined curriculum. When students were engaged with artifacts, manipulatives, and in doing the citizen science project more critical thinking seemed to happen but getting answers to the questions of inquiry that arose proved to be a constant source of frustration without access to a computer and technology in the classroom. There were numerous incidences of this in the transcript. In spite of having quite a bit of knowledge in this subject, a teacher will still not have the level of knowledge that a scientist would have. A teacher attempting to do citizen science must be prepared to have the rug yanked out from under them and be willing to work with their students to problem solve and find answers together. This is especially challenging without access to technology as the below excerpts show.
Teacher: . . . maybe you can put a question mark next to that animal as we are not sure about it. (whether a particular bird was in danger of extinction or not). Student: Take home?
Teacher Want to work on at home?
Student: Yes.
Teacher: Do you have a computer at home to research?
Student: No. . I don’t have a computer.

Again . .
Student: Penguins? (endangered?)
Teacher: I’m not sure, we’ll have to wait and see next time we go to the computer lab. Write down questions that we can research.
Student: I don’t know about the tortoise . . want to research.
Teacher: Put your name on it . . we’ll have to look up later and find out.
Student: Buffalo?
Teacher: Put down a question mark since we don’t know for sure. We’re going to have to research.
Student: (The millipede) How many feet this?
Teacher: Good question. Many . . not sure but I think hundreds. It’s like our modern millipede but larger.
Student: Eyes?
Teacher: We would have to research that . . I’m not sure.

Of course. . none of these question got written down and they were long forgotten by the time we returned to the computer lab. Fortunately in our new building teachers now have computers in the classrooms which will definitely address some of the accessibility issues however students still will be unable to research for their own answers which is the basis for teaching critical thinking skills.

Mediated Tools of Learning and Cognitive Enrichment

One of the initial research questions pertained to what tools and methods of implementation and assessments would be the most effective in implementing science with an ELAA curriculum. In the post tests on science content knowledge
it was determined that the questions that appeared to be the most challenging were vocabulary words related to abstract concepts and the task of making associations between two ideas. The highest percentages appeared in tasks related to classification, words connected with a concrete concept, and concepts related to place and space. This study used various tools and methods to assist students in learning science concepts while learning English. A game was implemented using similar constructs that were also used in a multi-choice test assessing science content (See Appendix I). The game utilized a Jeopardy format using game buzzers and bells, manipulatives, visuals and photos contributed by the students from their museum trip, and other sensory elements to help connect students with the content.

A comparison of the means of the two forms of assessments are shown in Figure 5.1 in the form of a scatter plot.
Figure 5.1 suggests that when assessing science content those questions dealing with the ability to associate two concepts or to compare and contrast received a higher percentage of correct answers in the game than in the traditional testing format using multiple choice questions and answers. Student responses also emerged to further support the use of technology and games as an effective cognitive tool.

“English is taught differently here than in Mexico. . .games awaken the brain and helps you remember. . . “

**Views on Technology**

Students also discussed their views on how computers contributed to higher order and deeper learning. The comments emerged from interviews in response to a general question on learning and computers.
“Computers enrich the learning. . . promotes deeper learning.”

“Well I think that it is putting technology at our fingertips and knowing how to use it. Because a lot of people spend all day on the computer but don’t do anything productive. A lot of people can be on Facebook for 8 hours and the only thing that fills their brain is conversations, but they don’t learn anything. But, if we instead get on the computer to learn, well we are going to help the teacher because we’re going to understand the class better. It’s like just right now the teacher taught us something and we came here to review it. So you capture and practice what you record in your mind because you already have it in your head, and there remains a foundation. . .”

Perhaps the most interesting came from student #8, a 65 year old Hispanic woman who works as a housekeeper at a high school. In class this student often would jokingly point to her head to communicate to me that she is having problems in comprehension and is confused or forgetful. So her statement that was in a post interview on learning science and English was a particularly insightful one when she stated. . .”when doing science and English my brain became activated. . .my brain which was asleep became awake. . .”

Unfortunately it is not clear what specific thing she contributes to this “activation” of her mind as her comment was a very general response to the program as a whole.

It is clear that whether the computer, a game, or other tool, mediated tools of learning is necessary in the teaching of science and English and in the assessment of it. Students showed not only different ways of knowing, but also
different ways of learning and suggests the importance of integrating alternative forms of assessments that are not based on multiple choice questions and the usual standardized test design.

Other constructs examined in the qualitative data was the appearance of emotional responses with learning. Responses to media, working with artifacts, and the museum trip all had emotional responses associated with learning. However the highest frequency of student emotional responses appeared in the game which integrated media, content students contributed to such as photos, audio, and other sensory elements. Most all the tools used in the study had some cognitive benefit but it appears that the tools that scored the highest in helping students make connections with content were those tools that used the most sensory elements. Artifacts, graphic timelines, media, the Internet, and the game all supported the students in connecting them with science and English content.

**Personal Reflections**

“*Research in a critical ontological context changes not only what one knows but who one actually is...*” *(Kincheloe, 2006)*

The initial focus in this study was to assess for changes in student attitudes towards science and in doing science. Based on the results it did appear that at some level that students did gain a better appreciation and understanding of science and in the use of technology as a result of their citizen science experience. However what perhaps was the most surprising was the change that happened within myself. I started out with the assertion that science can be integrated with
the current ELAA curriculum and be based on the AZ state standards. I set about creating a pedagogy to establish what the content of a citizen science project should include and how the grammar content would be integrated. The aim was to use citizen science as a vehicle to promote critical thinking and higher order thinking and to determine what might be the most effective tools to do so. It was observed that critical thinking that wasn’t prompted did happen in the course of doing citizen science. This was largely due to the fact that while teacher and student were engaged as co-learners we were embarking into unknown territory with only minimal sources of reference. This was further compounded by the fact that we did not have access to technology and an existing framework to draw from. However as a result, student ontologies emerged and my role as teacher changed from the one who provided the facts to one who was also asking the questions. I started with what I thought was a critical pedagogy and ended with a critical ontology. Pedagogy involves the teacher creating content-based curriculums to be delivered to the students. Ontological based approaches to teaching involves being aware of other ways of knowing which can radically change the course and direction of a pedagogy as it becomes more student-centered. The teacher as researcher must always be in a state of assessing and reassessing one’s own role and belief system within the context of a study. Am I teaching English or am I also instilling my own cultural viewpoints and belief systems? How can the English and literacy educator who is involved in teaching other cultures move from the emic perspective to that of etic relativism? Although difficult the objective researcher and teacher must move from the
position of the person who delivers knowledge to that of a more equal and empathetic role with their students.

In review, the questions, stages, and results of this study appear below.

Table 5.2

Overview of Research Process and Results

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Assertion that science concepts can be integrated with current ELAA curriculum to promote critical and higher order thinking.</td>
</tr>
<tr>
<td>2</td>
<td>The Intervention. A curriculum based on the Arizona state standards for ELAA was presented as a citizen science protect called the Mastodon Matrix Project which was in collaboration with the Paleontological Research Institute and Museum of the Earth in New York. Students were introduced to biodiversity, concepts of extinction, age of the earth, the impact we have on our environment, and species in danger of extinction today. A large emphasis was placed on the use of visuals, technology, hands-on artifacts, and experiential learning methods. Critical thinking was often prompted by the teacher as the content was introduced.</td>
</tr>
<tr>
<td>3</td>
<td>Students were introduced to learning about biodiversity and animal classification, observation methods, measurement, data entry, and basic research. Students presented their own ontologies or “ways of knowing” as related to biodiversity, animal classification, and artifact identification.</td>
</tr>
<tr>
<td>4</td>
<td>Students demonstrated more critical thinking that was not prompted by the teacher when doing citizen science and engaging with artifacts.</td>
</tr>
<tr>
<td>5</td>
<td>Oops! Teacher no longer had the answers. A repeated theme emerged from the teacher, “I don’t know what that is...or I don’t know about that...we’ll need to look it up...”. Teacher and students become co-learners as they engaged in citizen science. Student ontologies emerged.</td>
</tr>
<tr>
<td>6</td>
<td>Students took charge of their own learning by accessing the Internet from home to further research their own questions as related to new content and discoveries made in class.</td>
</tr>
<tr>
<td>7</td>
<td>Assessment tools were implemented to assess student understanding of both grammar and science content.</td>
</tr>
<tr>
<td>8</td>
<td>Various tools of delivery and assessments were used to determine what tools appeared to best enhance or promote higher order learning and connect the students to content. The game showed the highest emotional responses and level of learning engagement, and a greater connection to content than the multiple choice test.</td>
</tr>
<tr>
<td>9</td>
<td>Personal reflection and results as researcher, observer, and participant.</td>
</tr>
<tr>
<td>10</td>
<td>The realization that citizen science can serve as a promoter of critical ontologies, promote critical thinking, and encourage teacher and...</td>
</tr>
</tbody>
</table>

123
student co-learning.
Chapter 6

FUTURE IMPLICATIONS

Pathways to Critical Ontologies

Denis Heyck in her interesting book *Schools in the Forest: How Grassroots Education Brought Political Empowerment to the Brazilian Amazon* talks about a literacy project called *Projeto Seringueiro* that focused on science and the environment which created accessible education to rural populations who were referred to as “rubber tappers”. The approach was largely based on Freirean philosophy and Heyck comments that in this project education was based on the culture and habitat of the community which empowered the students by helping them value their own knowledge, their own language, and way of life (Heyck, 2010, pg 149). Before teaching scientific concepts outside of their realm of experience the approach started by recognizing the science that was right in the forest and environment of the students. To do this teachers were involved in the creating of their own books that the students would contribute their own knowledge to. This served several purposes, but mainly it created an awareness that just because their knowledge was not in government funded textbooks, did not mean it wasn’t important. The director who trained the teachers stated that empowerment came when the students saw their stories in their own language together with the classification of animal and plant species (Heyck, 2010, pgs 48-49). From this arose the confidence for them to analyze and think critically about the political and economic conditions that they presently found themselves under.
She states, “Projeto Seringueiro helped enable the rubber tappers to become effective members of civil society. . .” (Heyck, 2010, pg 149). She continues, “This is important because the usual assumption is that those with limited formal education are neither intelligent nor articulate, much less eloquent in presenting an argument or defending their rights” (Heyck, 2010, pg 150).

The strategy and approach taken in the Projeto Seringueiro program is indeed an important one when one is considering introducing science to a population who have never been exposed to it. Rather than starting with books and materials that were produced by publishers and experts in the field they started by creating their own materials that reflected their current knowledge and realm of experience. I found this interesting in that firstly it makes a political statement that challenges the hegemony of Western ways of thinking and knowing. Secondly, their hand-made books served as a cognitive tool by creating a pathway to higher order thinking. This was achieved when the teachers first listened to the knowledge of their students as they told stories and drew pictures about the biodiversity they knew and understood in the forest. Based on this knowledge the teachers created materials that guided the students into being able to classify this knowledge which then paved the way for knowledge that was beyond their current level of experience. This I believe clearly defines cognitive justice through mediation.

Indian scholar Shiv Visvanathan presents the idea that the rights that comes with citizenship also needs to include “cognitive justice” which he
defines as the recognition of the plurality of knowledge and the right for different
forms of knowledge to co-exist (Visvanathan, 1997 as cited in Leach, Scoones,
and Wynne, 2005). Visvanathan further states “We need to go beyond the
rhetoric of participation and move to an understanding of the democratic
implications of cognitive representation and empowerment” (Visvanathan, 1997
as cited in Leach et al, 2005, pg 42). Visvanathan argues that to accomplish this
there needs to be an alternative science that enables a discourse between several
different forms of knowledge that will inevitably lead to a more equitable and
democratic world. In this study it was observed that citizen science and
experiential learning provided a means for students to express their own views
and ways of knowing as related to the universe and its biodiversity.

Student Ontologies: Are there Butterflies in Arizona?

In a recent class a tall and large Hispanic man pointed to a picture of a
butterfly. “You know I use to see a lot of these in Mexico. . .mountains covered in
butterflies. I haven’t seen one since I’ve been here in Phoenix. Are there
butterflies in Arizona?” This I think sadly portrays how disconnected people who
live in urban areas can become from their natural world, especially those who are
not natives of this country. Thirty minutes earlier this same individual talked
about how one of the few friends he had in Phoenix was shot in a gang shooting.
He explained that the rest of his family was still living in Mexico. Immigrants
and refugees arriving to America’s urban cities from their native countries often
leave one war only to enter into another one. These individuals are at high risk
for depression as they experience a disconnection at multiple levels from family, language, culture, and an ecosystem and a natural world that they no longer feel a part of. Both African refugee students in the study frequently mentioned the life they had before they came to America. Both grew their own food and had thriving farms that served as their main source of income. In a post interview Student 10 talked about the frustrations about trying to grow African sugar cane and other plants that he once grew in Tanzania in a refugee camp. He just raised his hands and sighed, “It is different here. I tried African sugar cane and everything. .. they die. I tried cabbage and tomato. ..it would go like this. .(demonstrating a wilting plant) All died.” In previous work with immigrants I recall a story from a Russian immigrant who on arriving to America no longer ate the ethnic foods of his native country and subsequently ate cheap American fast foods. Within a year he developed diabetes.

I strongly believe that teaching adult immigrants should also be about reconnecting them to their ontologies of the natural world. Indigenous knowledge develops systems of meaning that are connected to cosmological perspectives on the nature of creation and as large living systems (Kincheloe, 2006)

**Ontological views and Science: Worlds that Collide or Coincide?**

In a recent anthropology forum there were participants from the museum and anthropological field that came together along with visiting author Dr. Hugh Raffle. I presented the theories of a new science where ontological views or ways of knowing might be included alongside that of science within the museum
setting. The response to this was a bit unexpected as I assumed anthropologists were always about representing the emic view. One curator stated,

“Certainly you must acknowledge the universal and common knowledge that exists. There is a common understanding we all understand. How can these views have equal validity when they’re not correct. . . .” Based on the theories of Kincheloe and Srinivasan, this “common understanding” may indeed be the view that is naïve and ignorant and not that of the indigenous ways of knowing. Kincheloe challenges the educator who is a critical ontologist to question any knowledge system (science or religion) that claims to have universal status or claims to have “the answers” of the universe.

For indigenous cultures, knowledge and learning is deeply tied with the natural world . . . not separate from it. This is something that science often has difficulty in understanding. In this same anthropological discussion group a geologist stated her frustration when she was trying to ask an Amazonian about the properties of healing stones found in a nearby river. No one would give her a direct answer. From their perspective, it wasn’t the properties of the stones that had the healing properties, but the prayers that were said while holding the stones. It was also about connecting with the whole river, the life in it, and the life around it that was viewed just as important. The stones in themselves or any chemical properties that they might contain were not the issue. This geologist was unable to separate the rocks from their place in the cosmological taxonomy. Science is about taking things apart and analyzing parts of the whole. Objects are viewed as specimens to be studied rather than as things embedded within a culture. Freire
would view this as an example of control and an attempt to possess an object rather than understanding its meaning within its shared and original context. As a result these interpretations and ontologies will conflict with scientific classification (Srinivasan, Boast, Furner, & Becvar, 2008 pg 8). Likewise in this study, the discourses and drawings that emerged in this study demonstrated that the students did have existing ontologies about the natural world which frequently did not match scientific taxonomies and classifications.

My first response was to correct these views which from the scientific perspective were incorrect. For example the African woman who viewed a picture of a worm and called it a snake, or the student who couldn’t believe frogs had bones because they felt squishy, or the student who viewed turtles and snails as being of the same family because they both live in shells. More recently a Mexican student claimed that peacocks walk proud because if they were to look down and see how ugly their feet were they would drop down dead. “I learned that from the Discovery Channel. . ..” states the student, “and the program was in Spanish”. One wonders if the source of this really was the Discovery Channel, or a prior way of knowing.

In another example student #10 while looking at a microscopic image of a round water lily seed interpreted it as a hatching egg. It is interesting to note that his view did not change even when the teacher presented another perspective.

Student 10: Look. . . is this an egg?  
Teacher: It needs focusing. . .there you go. . .  
Student 10: You see?  
Teacher: I think it’s a seed. . .
Student 10: (excitedly) You know. . .something is coming out from the inside. . .this is like an egg.

Of course a plant seed and an egg are not the same thing, but in theory one could argue that a classification could be created to represent both these things as seeds and eggs both bring about new life.

When students were adamant that their views were correct and that what I was proposing was preposterous I had to question my approach. All of the above examples represent student ontologies and even though were in direct conflict with scientific knowledge, they did shed light as to their worldview and classification of the universe. Scientists don’t always agree with each other on the taxonomy of species and they are frequently changing their perspectives on what to call something. Foucault talks about neglected knowledges. He defines these knowledges as “a whole set of knowledges that have been disqualified as inadequate to their task or insufficiently elaborated: naïve knowledges, located low down on the hierarchy beneath the required level of cognition or scientificity” (Foucault, 1980, as cited by Gruenewald, 2004).

There are now emerging curators and scientists who see the value of “new knowledge databases”, or community and cultural informatics which challenge or enhance existing information as found in collections in various universities and museums. The teacher as co-learner and facilitator of citizen science must be prepared to change the course of learning and consider other ways of knowing as the process unfolds. Like nature and our environment, knowledge is constantly in a state of change. To reach an absolute truth is to
make the claim that no further knowledge is needed. We can’t stop the flow of knowledge anymore than the ever changing green river of our natural world. There is always another bend to go around, another hill, and another discovery.

Citizen Science or Socioecological Education?

A researcher from the Berkman Center for Internet and Society at Harvard stated, “These people (citizen scientists) are not doing the work of scientists. . . they are doing the work of scientific instruments” (Wright, 2010). Many argue that citizen science is not really about average individuals doing science but rather average individuals just collecting data. Stephen Emmott with Microsoft Research states, “most citizen science projects tend to treat participants as high-functioning cogs in a distributed machine. . .” He further asks the question as to whether this is really about doing science (Wright, 2010). This writer has questioned this as well. Although data collecting does contribute to scientific knowledge, for the most part it really does not promote or allow for participants to contribute at a deeper level that would represent multiple knowledge systems and critical thinking skills. Accuracy of data, of course, is the main concern for scientists and some have addressed this in several ways. A citizen science project on bees in the UK wanted to identify various bee species in the country by having participants upload and geotag bee photos to Flickr. (Stafford, Collins, Kirkhope, Williams, Rees, Lloyd, & Goodenough, 2010). Flickr is a well known photo and data management system lending itself as an excellent tool in serving as a scientific database. In the UK project, once participants uploaded their photos,
trained volunteers then took over to ensure accuracy by classifying and tagging the photos.

Based on some of the theories discussed, what we may in fact be currently experiencing is the democratizing of science in an era of new technology and when new links are being formed between indigenous knowledge and that of scientific experts. This will go a long way in the eventual breaking down of hegemonic barriers between science and the citizen as we see a rise in technology and data accessibility; the participation of citizens in the scientific process, and new channels for all learners to contribute to a collective knowledge that will address the global issues that impact both scientist and citizen alike.

Citizen science has the potential of being a bridge between both the scientific critical thinker and the interpretive and cultural worldview of the citizen. Pedagogically, it can serve as a tool for promoting higher thinking. Politically it presents a pathway to a global citizenship that has no borders.

Conclusions

Assertion 1: Citizen science has the potential to promote both critical thinking and “critical ways of knowing” or cultural ontologies.

Because there was minimal access to technology along with little to no preexisting scientific knowledge or frameworks, various ontologies of the natural world emerged from a classroom representing very diverse cultures. This information was unexpected and created new questions on the role of ethnoscience and the representation of indigenous ways of knowing in existing
scientific and biological databases. How do we define scientific literacy? Who can access it, and who can contribute to it? Srinivasan states that reality, truth and knowledge are all relative. Logical and classified views of a concept do not necessarily equal reality. “Different, potentially contradictory sets of true beliefs count as knowledge for different communities of knowers” (Srinivasan, et al, 2008, pg 3). Gruenewald states that post-modern perspectives is based on the assumption that generally one can never assume one has discovered the truth (Gruenewald, 2004).

Critical thinking in this study was assessed largely by observed frequencies of questions and types of learning engagement the students were involved with. Within the controlled teacher-centered classroom, critical thinking was observed to be largely prompted by the teacher. When students were engaged in more experiential forms of learning such as citizen science, there appeared to be a higher incidence of critical thinking that was student-centered. This does not imply that the structured component or the prompting of questions is less important or is ineffective, but rather that it is less conducive for the development of student ontologies. When students ask questions based on their own observations, they are more likely to connect with prior knowledge and current ways of knowing. For example Student 10 on observation of a seed under a microscope interpreted it as an egg. This knowledge rather than be told as incorrect should be validated creating equity and a foundation for which new knowledge might be gained while engaging in science. This can lead to a change in perception or add a new level of meaning. A good example can be seen from
the Personal Meaning Map of Student 10. In the Pre map student showed prior understanding and knowledge of extinction based on personal experiences and observations of elephant poaching in his country. In the Post map he demonstrated critical thinking skills when he compared what he learned about the mastodon with what he knew about the African elephant today.

Results showed that the Mastodon Matrix Project did produce a high level of unprompted critical thinking, but in regards to cognitive-based learning mediation is required to assist students in creating links between grammar and science, and between the everyday and critical thought. As discussed in the theories of Vygotsky and Feuerstein, cognitive mediation through tools are required to accomplish this.

In the realm of citizen science, one really has to find a middle road as we are not only interested in how learners perceive and understand the natural world, but we are also interested in how the scientific process can promote cognitive-based learning, prompting the learner to think critically, to deconstruct, to categorize, and reflect giving further depth and meaning to their existing knowledge-base.

This study might be summarized in the following figures which shows the relationship and dynamics of how the spheres of the every day and the scientific might merge within the context of citizen science and through the use of tools of mediation.
In Figure 5.3 we see the current disconnect as mentioned throughout this study and as it currently exists in K-12 and adult English education. Learning English is viewed as separate and apart from science and impacts both current policy and methods of teaching.
In Figure 5.4 we see a model as to how these two “languages” were merged in this study within the context of citizen science. The outcome suggests the important role that citizen science might have in promoting a climate of co-learning, critical thinking, and ontological perspectives. All of these together contributed to new attitudes and perspectives which emerged from both student ontologies and science creating in essence a new knowledge. Like cogs in a machine, they all are interconnected, but critical thinking is the engine. Without it, change and transformation can’t happen whether politically or cognitively.
Assertion 2: Citizen science prompted new attitudes towards science and in student’s ability to do science.

Pre and post survey results, the game, quizzes, post personal meaning maps, and the interviews suggest that students gained new knowledge as related to key concepts dealing with extinction, biodiversity, animal classification, and earth’s history. Science views after doing citizen science became more personalized and reflected their own knowledge systems versus an enforced discourse and way of knowing. After engaging in doing science, 83% of the students were very interested in science versus 45% pre. Views on their perceptions of being a scientist also shifted from 19% strongly agree to 44% post. Views of technology and the use of the Internet also showed in the post surveys and observations with students reporting an increase in the use of the Internet to seek answers to their questions. Students also shared views in the importance of technology in understanding the views of others, communication, and its ability to promote deeper learning and in connecting with classroom content.

Assertion 3: Technology, games, and other adaptive tools of learning helped to promote cognitive and deeper learning and enhanced student’s understanding of science.

Based on observations, student interviews, and analysis of the game and test results, the use of the Internet, concept maps or timelines, media, and participating in the game appeared to be the most effective tools in motivation, creating emotional responses, and in helping students cognitively to connect and
make associations with scientific content. Adaptive tools of learning including access to bilingual resources was necessary in the teaching of science and English and in the assessment of it.

“Unless educators take a lead in developing appropriate pedagogies for these new electronic media and forms of communication, corporate experts will be the ones to determine how people will learn, what they learn, and what constitutes literacy” (Carmen Luke (2000) as cited by Kellner, pg 71).

It is interesting to note that just within the past few months I have seen an increase in the number of students using Smartphones and iPhones in the classroom as they search maps, look up answers, listen to pronunciations, and do translations. (This study took place before the move to our new building which now has wireless service). The potential of utilizing alternative forms of technology such as Smart phones, QR codes, tablets, iPads and iPods are limitless and has great potential for English language learners and in doing citizen science. It could also be the foundation for the development of a blended delivery program that could accommodate many of our ELLA learners, especially those who are on the waiting list or have difficulty in attending traditional classes.

Adult education will soon need to start thinking beyond the traditional computer lab and classroom setting. mLearning, or mobile learning and app development are quickly ushering in a new publishing revolution that will make teaching and learning in various settings more innovative, more democratic, and more accessible. These tools will also make it possible to create participatory content and as a platform to represent multiple ontologies alongside scientific knowledge.
Assertion 4: Both teachers and students engaging in citizen science become co-learners and critical thinkers beyond the classroom.

Teachers also need to be critical thinkers. To be innovators you must think critically in order to be in touch with serving the needs of our students. Teachers and students are in essence both the oppressed when they are not encouraged to be critical thinkers, problem solvers, or to have a voice in institutional decisions. Cultural hegemony can be difficult to recognize...as it is generally accepted as the norm, but to be a critical thinker goes beyond the ability to ask questions in the classroom. As positivist approaches such as testing, and the categorizing of students continue to be enforced with immigrant populations, (and all learners) then the issues of equity will continue to be an issue as learning becomes about passing a grammar test and not about what connects students to their world and what would empower them with meaningful learning. It also quickly became clear that critical thinking was more than about a cognitive process of inquiry as related to scientific content. Critical thinking emerged also as a political theme as related to inaccessibility and exclusion of learners from content and technology based on societal views of what scientific knowledge is, how it should be classified, and who can access it. Critical thinking became more than a student asking a question as related to content presented, but rather also as a tool in challenging the status quo. That is, after all what science has always been about. Some of the greatest discoveries in science were not accepted by the majority or by the hegemonic religious views of the time. These battles still rage today. Like Galileo, my students asked some great questions related to their citizen science
experience. Can we slow down the rate of extinction with many of our species? Is it too late? Will the elephant go extinct? Equally as important were these questions and observations. Why aren’t there books in Burmese? Why don’t we have computers in the classroom? Why are computer classes only for Hispanic students? Why can’t I take this book home? Why are those students required to take that test when they can’t do it? Why am I not allowed to know the results of the test I just took? Why doesn’t the school sell us the old computers rather than auction them off? How can I buy a book online? To answer these questions requires that current policies related to methods of instruction, instruction delivery, knowledge accessibility, and knowledge production will need to be challenged.

Recently I passed out a list of true and false trivia questions as related to animal oddities and biodiversity. When it was clear that I was not going to give them the answers right away several students said, “Can I take it home and research?” Three students agreed to research the questions at home and bring in their answers the next day. After all, the answers the teacher had might not even be correct. Even though this happened long after their citizen science experience, it showed me that they were indeed becoming critical thinkers and were taking charge of finding their own answers rather than asking the teacher for the answers.

In conclusion, it is my belief that ELAA students can learn science while also learning English if given the proper tools to do so. Citizen science has the potential to serve as an ontological model of teaching and learning in that it can
promote critical thinking, blur social boundaries, and promote multiple pathways of knowing.

This perhaps is a good place to once again recall the words of Freire. “. . . the teacher always has cognition at the forefront and engages students so that they are co-investigators in dialogue. This interaction will ultimately lend itself to a constant revealing of truths in a dynamic exchange (Freire, 1993, pg 62).
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APPENDIX A

PRE AND POST ATTITUDINAL SURVEY
CIRCLE the correct face in response to the question.

Scale: **Face 1**=Strongly agree/Very interested **Face 2**=Agree **Face 3**=Don’t know **Face 4**=Disagree **Face 5**=Strongly Disagree

1. How do you feel about science?

   [Smiley face] [Smiley face] [Neutral] [Frowning face] [Angry face]

   Very Interested  Interested  Don’t Know  Do not like.  Not really interested

2. I think learning science is difficult.

   [Smiley face] [Smiley face] [Neutral] [Frowning face] [Angry face]

   Strongly Agree  Agree  Neutral  Disagree  Strongly Disagree

3. Learning science is important for my job and career goals.

   [Smiley face] [Smiley face] [Neutral] [Frowning face] [Angry face]

   Strongly Agree  Agree  Neutral  Disagree  Strongly Disagree
4. Learning about science will allow me to help my children with their homework.

Strongly Agree  Agree  Neutral  Disagree  Strongly Disagree

5. I think learning about science is important for my children.

Strongly Agree  Agree  Neutral  Disagree  Strongly Disagree

6. To do science you must have many years of education.

Strongly Agree  Agree  Neutral  Disagree  Strongly Disagree
7. I think I would make a good scientist.

8. I learn best by doing.

9. I learn best when working with others in a group.

10. I find doing homework is helpful.
11. I enjoy learning that allows me to solve problems.

12. Working on the computer helps me to learn English.

13. I know how to use the Internet.
14. Learning the computer is important for my job and career goals.

15. There is nothing that we can do to change the environment.

16. I think learning about how to care for our environment is important for the future of my family and community.
17. I believe that we are responsible for the current environmental changes on our planet.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
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</table>

18. Demographic Information:

- Male or Female: ______________________
- Participant Age: ____________________
- Country of Origin: _________________
- Native Language: ___________________
- How long have you been studying English?: ______________
- Current English Level: 2A
- How many years of formal education have you had?: ____________

19. Technology/Resources Information

- Do you have a computer at home?
- How often do you use the computer?
- Do you use a computer other than home or school?
- How often do you use the Internet?
APPENDIX B

PRE AND POST STUDENT SURVEY RESULT PERCENTAGES
### 1. How do you feel about science?

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<td></td>
<td>Number</td>
<td>Percent</td>
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</tr>
<tr>
<td>Very Interested</td>
<td>9</td>
<td>45% N=9</td>
<td>15</td>
<td>83%</td>
<td></td>
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<td></td>
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<tr>
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<td></td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do not like</td>
<td>1</td>
<td>5% N=1</td>
<td>1</td>
<td>5.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Didn’t answer</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Total Responses:</td>
<td>20</td>
<td>100% N=20</td>
<td>18</td>
<td>100%</td>
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### 2. I think learning science and English is difficult

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</tr>
<tr>
<td>Strongly agree</td>
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<td>23.5%</td>
<td>5</td>
<td>28%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Agree</td>
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<td>35%</td>
<td>8</td>
<td>44%</td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>18%</td>
<td>2</td>
<td>11%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>4</td>
<td>23.5%</td>
<td>1</td>
<td>5.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly Disagree</td>
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<td>-</td>
<td>2</td>
<td>11%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total Responses:</td>
<td>17</td>
<td>100%</td>
<td>18</td>
<td>100%</td>
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### 3. Learning science is important for my job and career goals.

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<td>Percent</td>
<td>Number</td>
<td>Percent</td>
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<td></td>
</tr>
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<td>8</td>
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<td>42%</td>
<td>8</td>
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<tr>
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<td>2</td>
<td>11%</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>-</td>
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<td>18</td>
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</table>

### 4. Learning about science will
<table>
<thead>
<tr>
<th>allow me to help my children with their homework.</th>
<th>Number</th>
<th>Percent</th>
<th>Number</th>
<th>Percent</th>
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<tr>
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<td>5.5</td>
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<table>
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<tr>
<td>Total Responses</td>
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<table>
<thead>
<tr>
<th>6 To do science you must have many years of education.</th>
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<tbody>
<tr>
<td></td>
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<tr>
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<table>
<thead>
<tr>
<th>7. I think I would make a good scientist.</th>
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<th>Post</th>
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<tbody>
<tr>
<td></td>
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<td>Percent</td>
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<td>Pre Number</td>
<td>Pre Percent</td>
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<tr>
<td>--------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>8. I learn best by doing.</td>
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<tr>
<td>Strongly agree</td>
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<td>45%</td>
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<tr>
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<td>45%</td>
</tr>
<tr>
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<td>10%</td>
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<td>-</td>
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<tr>
<td>Strongly Disagree</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total Responses</strong></td>
<td>20</td>
<td>100%</td>
</tr>
<tr>
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<td>10%</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Total Responses</strong></td>
<td>19</td>
<td>100%</td>
</tr>
<tr>
<td>10 I think working with the computer is difficult.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>5</td>
<td>24%</td>
</tr>
<tr>
<td>Agree</td>
<td>4</td>
<td>19%</td>
</tr>
<tr>
<td>Neutral</td>
<td>5</td>
<td>24%</td>
</tr>
<tr>
<td>Disagree</td>
<td>7</td>
<td>33%</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total Responses</strong></td>
<td>21</td>
<td>100%</td>
</tr>
<tr>
<td>11 I would like to learn more things on the computer.</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>11</td>
<td>52</td>
</tr>
<tr>
<td>Agree</td>
<td>10</td>
<td>48</td>
</tr>
<tr>
<td>Neutral</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Disagree</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Responses</td>
<td>21</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12 It is important that I learn the computer to better help my children.</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>11</td>
<td>61%</td>
</tr>
<tr>
<td>Agree</td>
<td>6</td>
<td>33%</td>
</tr>
<tr>
<td>Neutral</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Disagree</td>
<td>1</td>
<td>5.5%</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Responses</td>
<td>18</td>
<td>100.0</td>
</tr>
<tr>
<td>Pre and Post</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>13 I use the Internet more than once a week.</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Agree</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>Neutral</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Disagree</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Responses</td>
<td>20</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>14 Learning the computer is important for my job and career goals.</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>10</td>
<td>48</td>
</tr>
<tr>
<td>Agree</td>
<td>7</td>
<td>33</td>
</tr>
</tbody>
</table>

161
<table>
<thead>
<tr>
<th>Statement</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neutral</strong></td>
<td>2</td>
<td>9.5</td>
</tr>
<tr>
<td><strong>Disagree</strong></td>
<td>2</td>
<td>9.5</td>
</tr>
<tr>
<td><strong>Strongly Disagree</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total Responses</strong></td>
<td>21</td>
<td>100.0</td>
</tr>
</tbody>
</table>

15. **There is nothing that we can do to change the environment.**

<table>
<thead>
<tr>
<th>Agreement Level</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Agree</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Neutral</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>Disagree</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td><strong>Total Responses</strong></td>
<td>21</td>
<td>100.0</td>
</tr>
</tbody>
</table>

16. **I think learning about how to care for our environment is important for the future of my family and community.**

<table>
<thead>
<tr>
<th>Agreement Level</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>13</td>
<td>62%</td>
</tr>
<tr>
<td>Agree</td>
<td>6</td>
<td>28%</td>
</tr>
<tr>
<td>Neutral</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Disagree</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Total Responses</strong></td>
<td>21</td>
<td>100.0</td>
</tr>
</tbody>
</table>

17. **I believe that we are responsible for the current environmental changes on our planet.**

<table>
<thead>
<tr>
<th>Agreement Level</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>15</td>
<td>71%</td>
</tr>
<tr>
<td>Agree</td>
<td>6</td>
<td>28%</td>
</tr>
<tr>
<td>Neutral</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>---------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Total Responses:</td>
<td>21</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### 18. What do you think about learning science and English in the future?

<table>
<thead>
<tr>
<th></th>
<th>No Pre</th>
<th>Post</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Interested</td>
<td></td>
<td></td>
<td>13</td>
<td>72%</td>
</tr>
<tr>
<td>Some Interest</td>
<td></td>
<td></td>
<td>5</td>
<td>28%</td>
</tr>
<tr>
<td>Don’t Know</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Not Interested</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don’t Like</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Responses:</td>
<td></td>
<td></td>
<td>18</td>
<td>100.0</td>
</tr>
</tbody>
</table>
APPENDIX C

PRE AND POST STUDENT INTERVIEW QUESTIONS
1. Why are you learning English?
2. What is your native country and how long have you been in the US?
3. How many years of formal education have you had?
4. What is your occupation?
5. What goals would you like to achieve? What would you like to learn more about?
6. If you have children, are they bilingual?
7. Do you currently help your children with their homework?
8. What are your views about science?
9. Do you think you are capable of learning and doing science?
10. Did you study science in your native country?
11. What are your views about learning new things with the computer?
12. Any other comments?

Post Student Interview Questions

1. What are your views about science?
2. Do you think it is possible to learn both science and English?
3. Do you think you would make a good scientist?
4. What comes to mind about your recent experience with science?
5. What did you learn about yourself when doing science and English?
6. Do you think science and English should be offered as an option?
APPENDIX D

INTERVIEW CODING
01 Challenges experienced as related to science content 01

02 Challenges experienced as related to writing, reading, or speaking 01
02 Reference to bilingual services needed 02
02 Found it was easy 03

03 Teaching Tools mentioned
   03 Refers to an Internet activity 01
03 Refers to online video/media 02
03 Refers to PPT and classroom media 03
03 Posters and printed graphics 04
03 Bilingual Resources 05
03 Peer teaching 06
03 Game mentioned 07
03 Manipulatives, objects, and artifacts 08

04 Refers to prior knowledge and ways of knowing

05 Goals mentioned
05 01 Career advancement
05 02 Learning English
05 03 Self improvement
05 04 Start a business
05 05 To help people and be able to fix my house

06 Why Learning English
06 01 Better job
06 02 Communication
06 03 Help children with homework
06 04 Self development
06 05 Necessary as a first language
06 06 To improve out life
06 07 Need at current job

07 Studied Science in native country
07 01 Yes
07 02 Some science
07 03 No training
08 Years of education
08 01 1-8 years
08 02 College education

09 Reason for leaving native country
09 01 Better jobs and better life
0902 Better education
09 03 For children
09 04 Marriage
09 05 Family here
09 06 Business opportunities

10 Views on Technology
10 01 Will open doors
10 02 Self development
10 03 Need for everything
10 04 Need skills
10 05 Enriches learning
10 06 Helps us communicate with world and learn about other opinions
10 07 Discovery new things about what people know
10 08 As important as learning English
10 09 Many people use all day but are not productive or learn everything. (like using Facebook)

11 Views on Science
11 01 Things related to the natural sciences
11 02 It’s what my children like to study
11 03 Tells us about the world and universe.
11 04 Need to learn English to learn Science. With English you discover many things.
11 05 Can learn both together
11 06 Involves different branches
11 07 Don’t know much about but would like to learn more about it.
11 08 Know a little
11 09 Involves the Earth, energy, math and a lot of things
11 10 Is important
11 11 Studies behavior and defines way of acting
11 12 Helps us get to an answer and defines steps in getting there
11 13 Helps us research and ask what things are the way they are

12 Studied Science in school?
   12 01 Yes
   12 02 No
   12 03 Yes, but not in depth
   12 04 I took only grammar and history in elementary school. I like history and we studied the past in this class.

13 Do you help children with their homework.
   13 01 Yes
   13 02 Sometimes
   13 03 No, don’t help children with homework.
   13 04 NA
14 Are children bilingual?
   14 01 Yes
   14 02 No

15 Makes reference to inquiry, higher order learning, and or cognition
   15 01 Science activates the brain
   15 02 Promotes deeper learning

16 Makes reference to what learned and the citizen science project
   16 01 Life and history of animals
   16 02 Concept of extinction
   16 03 The mastodon or mammoth
   16 04 Refers to an experience, a visual, or activity
   16 05 There are many things we don’t know that are right in front of us.
   16 06 Refers to age of the earth
   16 07 New experiences
   16 08 Got to learn something I use to watch only on television.
   16 09 Made reference to scientific terminology

17 Possible to learn both English and Science?
   17 01 Yes
   17 02 Yes, but slowly

18 Do you think you would make a good scientist?
   18 01 Yes
   18 02 I like it. Who knows. I don’t have a lot of education.
   18 03 Yes, because I know a lot about animals.
APPENDIX E

FREQUENCY OF INTERVIEW CONSTRUCTS
1. **Pre Interview Views on Science**
   - Things related to the natural sciences (1)
   - It’s what my children like to study (1)
   - Tells us about the world and the universe (1)
   - Involves the study of different branches (1)
   - Would like to learn more about it (3)
   - Know a little about it (1)
   - Involves the Earth, energy, math and a lot of things (1)
   - Is important (1)
   - Studies behavior and defines ways of acting (1)
   - Helps us get to an answer and defines steps in getting there (1)
   - Helps us research and ask why things are the way they are (1)
   - Total: 14

2. **Studied Science in native country?**
   - Yes (2)
   - No (1)
   - Took only history and grammar in elementary school. I like history and that is what we studied in this class (1)
   - Yes, but not in depth. Was not really something we engaged with or went into with depth. (1)
   - Total: 5

3. **Views on Technology**
   - Will help open doors (1)
   - Self development (1)
   - Need it for everything (1)
   - Need it to improve skills (1)
   - Enriches learning (2)
   - Helps us communicate with the world and learn about other opinions (1)
   - Can discover new things about what people know (1)
   - Is as important as learning English (1)
   - Many people use all day but are not productive or learn anything. Need to use to learn. (1)
   - Total: 10

4. **Reference to inquiry, higher learning, deeper learning**
   - Science and games activates and awakens the brain—Post (1)
   - Computer promotes deeper learning—Post (1)
   - When doing science and English my brain became activated...my brain which was asleep becomes awake—Post (1)
   - Total: 3

5. **Post Views on Citizen Science**
   - Made reference to the mastodon and age of the earth (11) 61%
   - Made reference to the concept of extinction (2)
Made reference to the many things that are in front of us that we never knew (1)
Made reference to doing science as a new experience (1)
Got to learn something that ordinarily would only see on television (1)
Made reference to some key scientific terms learned (2)
Total: 18

6. Reference to certain learning tools

Bilingual resources needed (2)
Referred to Internet activity (3)
Referred to online video/media (2)
Referred to classroom media and PPT (4)
English taught differently here than Mexico. Games awaken the brain and helps you remember (1)
Computers promote deeper learning (1)
Total: 13

7. Possible to learn English and science?

Pre Yes (4) Post Yes but slowly (1) Post Yes (3)
Need to learn English in order to understand science. Only with English can you really discover new things. (1) Pre
Total: 9

8. Do you think you would make a good scientist?

Post Yes (3)
Post I like it. Who knows. I however don't have a lot of education. (1)
Post Yes, because I know a lot about animals. (1)
Total: 5
APPENDIX F

OBSERVATION CODING
Higher order learning or attempt observed
a. Student engages in critical thinking with no prompting
b. Student makes an observation
c. Student uses categorization and classification skills
d. Student compares and contrasts
e. Students demonstrates spatial understanding
f. Student makes association between two concepts

Teacher Prompts Critical Thinking

Application of content to other situations
a. Student connects to prior ways of knowing

Student Reflection observed

Learning Tools and Methods
a. Use of Internet/online media
b. Picture Dictionary
c. Classroom Media and PPT
d. Grammar Clock Concept Map
e. Posters and printed graphics
f. Bilingual Resources
g. Peer teaching/group activity
h. Game
i. Prompting used
j. Numerical literacy and data collection
k. Wrong tool used
l. Students follow written instructions/reading comprehension
m. Manipulatives, objects, and artifacts
i. Cognitive Embodiment
n. Activity sheets
o. Reference to student using other technology, cell phone, microscope
p. Repetition Used
q. Diversified learning and student choice
r. Student narrative or presentation
s. Student uses art and drawings
t. New computer skills/tasks
u. Learning outside of the classroom
v. Adaptation of media and other content
w. Emotion-based learning

Student equity and accessibility issues

Teacher or Student Problem Solving

Student did not connect with content or had difficulty
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Teacher Perceptions and Ways of Knowing</td>
</tr>
<tr>
<td>10</td>
<td>Teacher and student equity issues as related to school policy</td>
</tr>
<tr>
<td>11</td>
<td>Student demonstrates anxiety or frustration</td>
</tr>
<tr>
<td>12</td>
<td>Assessments Used</td>
</tr>
<tr>
<td>13</td>
<td>Change in research method</td>
</tr>
<tr>
<td>14</td>
<td>Lack of time and or resources</td>
</tr>
<tr>
<td>15</td>
<td>Observation related to student attendance</td>
</tr>
<tr>
<td>16</td>
<td>Student makes a contribution or comments about the program</td>
</tr>
<tr>
<td>17</td>
<td>A change in policy or proposal for change</td>
</tr>
<tr>
<td>18</td>
<td>Co-learning between teacher and student</td>
</tr>
<tr>
<td>PRE/POST Understanding of Content</td>
<td>PRE/POST Correct Use of English</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Frequency of drawings and or words that show either prior knowledge or new knowledge as related to specific content.</td>
<td>Frequency of words showing knowledge or new knowledge as related to English skills.</td>
</tr>
</tbody>
</table>
APPENDIX H

PRE AND POST MEANING MAP CHART SUMMARIES
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>POST</td>
<td>Code 4</td>
<td></td>
<td>Text in English. Student does refer to more than 2 key science terms and refers to the citizen science project. Demonstrates a good understanding of cause and effect and the need for human action.</td>
</tr>
<tr>
<td>Student 1</td>
<td>PRE Science Map</td>
<td>Code: 4</td>
<td>Text written in Spanish. Words with no drawings. Plants, change, temperature, climate, earth, observation, animals, universe, discovery</td>
</tr>
<tr>
<td>POST</td>
<td>Code: 4</td>
<td></td>
<td>There is minimal reference to the role of man to show relationship that was clearly presented in his first extinction map. Student however did refer to citizen science project and referred to content related to extinction learned from the Internet.</td>
</tr>
<tr>
<td>PRE Extinction</td>
<td>Code 5</td>
<td></td>
<td>Student demonstrates existing knowledge and good understanding of extinction and cause and effect.</td>
</tr>
<tr>
<td>POST</td>
<td>See post Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student 3</td>
<td>PRE Science</td>
<td>Code 2</td>
<td>No drawings. Wrote science, blue, star, under, green, water. Clearly represents worldview via color.</td>
</tr>
<tr>
<td>POST</td>
<td>See post extinction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student 3</td>
<td>PRE Extinction</td>
<td>Code 3</td>
<td>Wrote text with no drawings. Made reference to prior knowledge or “way of knowing” of elephants in Africa in danger of extinction.</td>
</tr>
<tr>
<td>POST Extinction</td>
<td>Code 4</td>
<td></td>
<td>Used drawings, pictures, and text. Pollution appeared 3x, extinction, ecosystem, habitat, and hunting by man. Referred to citizen science project.</td>
</tr>
<tr>
<td>Student 10</td>
<td>PRE Science</td>
<td>Code: NA</td>
<td>Student refers to a picture of a man dressed as a surgeon. Text reads, “This is me doctor” “I will be a</td>
</tr>
<tr>
<td>Student 11 Mexican</td>
<td>Pre Science</td>
<td>Code: 2</td>
<td>Written in Spanish. Earth, universe, planets, plants, animals, water, climate, energy</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------</td>
<td>---------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>POST Science</td>
<td>Code: 2</td>
<td>Text written unclear in meaning. Drawings of animals suggests an attempt in classification.</td>
<td></td>
</tr>
<tr>
<td>PRE Extinction</td>
<td>Code: 3</td>
<td>Showed prior understanding of extinction by drawing a dinosaur skeleton and a head of an elephant skull with words directed to different parts of its anatomy.</td>
<td></td>
</tr>
<tr>
<td>POST Extinction</td>
<td>Code: 5</td>
<td>Demonstrated critical thinking skills as student compared what happened to the mastodon with what could happen to the African elephant. Used key science terms like increase, decrease, and referred to citizen science experience.</td>
<td></td>
</tr>
<tr>
<td>Student 8 Mexican</td>
<td>Pre Extinction</td>
<td>Code: 2</td>
<td>Student lists 10 animals in danger of extinction both in Spanish and English. Text only. Does not refer to any causes of extinction or the relationship of man with his environment.</td>
</tr>
<tr>
<td>POST Extinction</td>
<td>Code: 3</td>
<td>Drawings and text in English. Made reference to some key science terms, referred to citizen science project, extinction, and the age of the mastodon.</td>
<td></td>
</tr>
<tr>
<td>Student 4 Burmese</td>
<td>Pre Extinction</td>
<td>Code: 1</td>
<td>Written in Burmese. Drew a few flowers and a peacock.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------------</td>
<td>---</td>
<td>-----------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Post Extinction</strong></td>
<td></td>
<td>2</td>
<td>Drawings of various animals but now labeled in English. Only one animal the elephant was related to the content. Not clear if understood concept of extinction.</td>
</tr>
<tr>
<td><strong>Pre Science</strong></td>
<td></td>
<td></td>
<td>Unable to do</td>
</tr>
<tr>
<td><strong>Post Science</strong></td>
<td></td>
<td>3</td>
<td>Five drawings labeled in English. An elephant, mammoth, mastodon, and drew tusk. Some of the animals not related to content but did refer to citizen science project.</td>
</tr>
<tr>
<td><strong>Student 5</strong></td>
<td><strong>PRE Science</strong></td>
<td>2</td>
<td>No drawings. Text in Spanish only. Water, technology, plants, earth, planets, weather, man. Did not make reference to any animals.</td>
</tr>
<tr>
<td><strong>POST Science</strong></td>
<td></td>
<td>4</td>
<td>Mentioned key science terms. Climate change. Drew various illustrations and text that was bilingual-English and Spanish. Drew marine life and pollution and text danger of extinction. A cut tree and words habitat loss. A starfish, a picture of an elephant- in danger, and the tortoise.</td>
</tr>
<tr>
<td><strong>Student 6</strong></td>
<td><strong>Burmese PRE Science</strong></td>
<td>2</td>
<td>Text only. Wrote words clouds, sky, air, earth, moon, stars, sun, water. No mention of animals or humans.</td>
</tr>
<tr>
<td><strong>POST Science</strong></td>
<td></td>
<td>3</td>
<td>Drew a starfish, a snail, mastodon bones, a pond with a water lily, and mountains.</td>
</tr>
<tr>
<td><strong>PRE Extinction</strong></td>
<td></td>
<td>2</td>
<td>Drew a chickadee bird from a book and a duck. Wrote a description of the duck. It is warm-blooded, hatches from egg, and has a backbone. It has a beak, two legs, and two wings.</td>
</tr>
<tr>
<td><strong>POST Extinction</strong></td>
<td></td>
<td>3</td>
<td>Drew four images of different animals. A diseased fish, a deer, a peacock, and a tiger that was shot.</td>
</tr>
<tr>
<td><strong>Student 24</strong></td>
<td><strong>Burmese PRE Science</strong></td>
<td>2</td>
<td>Drew drawings from a picture dictionary. Satellite, ATM machine, watch, an airplane and pesticide poisoning, computer. All related to technology</td>
</tr>
<tr>
<td></td>
<td><strong>POST Extinction</strong></td>
<td>2</td>
<td>Drew an elephant, lion, tiger, leopard and sparrow, sea anemone.</td>
</tr>
</tbody>
</table>
CODING KEY

PRE/POST SCIENCE/EXTINCTION MAPS

5=Includes detailed identification or description. Demonstrates critical thinking/or excellent understanding of environmental science concepts such as cause and effect, and the interconnectedness of life (in English or Spanish). Demonstrates an understanding to what extinction means, causes, and the role of man. 2 or more science terms may be present. May make at least 1 or more reference to the citizen science project in post PMM. Shows a more sophisticated understanding of prior knowledge of science or extinction by making reference to some key terms and concepts.

4=Drawings may or may not be present. Clearly defines and demonstrates good understanding of key concepts (in English or native language) Demonstrates an understanding to what extinction means, the causes, and the role of man. At least 2 science terms may be present. Makes at least 1 reference to the citizen science project in post PMM. Makes reference to some key concepts in demonstrating prior understanding of science like earth, the universe.

3=Drawings may or may not be present along with text. Shows a fair understanding of concepts with at least 1 science term present. May identify an endangered animal. Might see at least 1 reference to the citizen science project. Demonstrates view of science as related to a career.

2=Drawings present with some text. Shows minimal understanding or connection with content. Animals drawn may or may not be connected with the concept of extinction. Shows only basic text, colors, or keywords as related to perceptions of the world

1=Includes drawings but with minimal to no text. Drawings are not logical nor are related to content.
APPENDIX I

POST CITIZEN SCIENCE CONTENT KNOWLEDGE WITH GAME
<table>
<thead>
<tr>
<th>Construct: Prepositions</th>
<th>Percentage of answers correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q 1 The turtles are sitting on a log.</td>
<td>100%</td>
</tr>
<tr>
<td>Q 2 The fish are under or in the water.</td>
<td>100%</td>
</tr>
<tr>
<td>Q 3 This classmate is sitting on a woman’s lap. (student photo)</td>
<td>25%</td>
</tr>
<tr>
<td>Q 4 They are standing in front of a dinosaur at the museum.</td>
<td>75%</td>
</tr>
<tr>
<td>Q 5 The bear is next to the students.</td>
<td>25%</td>
</tr>
<tr>
<td>Construct Mastodons</td>
<td></td>
</tr>
<tr>
<td>Q 6 What did mastodons like to eat? They ate leaves, trees, and plants.</td>
<td>100%</td>
</tr>
<tr>
<td>Q 7 What is this? It’s a mastodon tooth.</td>
<td>50%</td>
</tr>
<tr>
<td>Q 8 When did the mastodon go extinct?</td>
<td>100%</td>
</tr>
<tr>
<td>Q 9 What is she holding? An elephant tusk.</td>
<td>25%</td>
</tr>
<tr>
<td>Q 10 Is he standing in front of a mammoth or a mastodon?</td>
<td>75%</td>
</tr>
<tr>
<td>Biodiversity</td>
<td></td>
</tr>
<tr>
<td>Q 11 The turtle is what type of animal?</td>
<td>50%</td>
</tr>
<tr>
<td>Q 12 What do you call an animal with bones?</td>
<td>75%</td>
</tr>
<tr>
<td>Q 13 Is this dinosaur an herbivore or a carnivore?</td>
<td>100%</td>
</tr>
<tr>
<td>Q 14 A place where one type of animal or species lives.</td>
<td>75%</td>
</tr>
<tr>
<td>Q 15 What do you call an area where many animals live together.</td>
<td>25%</td>
</tr>
<tr>
<td>Q 16 What is the name of the museum we visited?</td>
<td>75% Read on screen</td>
</tr>
<tr>
<td>Present Progressive</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Percentage</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Q17 Who is everyone waiting for? (student photo)</td>
<td>75%</td>
</tr>
<tr>
<td>Q18 What are they doing? Taking pictures (student photo)</td>
<td>100%</td>
</tr>
<tr>
<td>Q19 What are they looking at? Tree rings.</td>
<td>75%</td>
</tr>
<tr>
<td>Q20 What did we do after we visited the museum?</td>
<td>100%</td>
</tr>
<tr>
<td>Q21 What is the name of this extinct animal? Dinosaur T-Rex</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Challenge Questions</strong></td>
<td></td>
</tr>
<tr>
<td>Q22 What is this? A fossil or trilobite</td>
<td>100%</td>
</tr>
<tr>
<td>Q23 What animal is this? A mastodon.</td>
<td>100%</td>
</tr>
<tr>
<td>Q24 What are these? Seeds. Extra point if can identify. Water lily plant</td>
<td>100%</td>
</tr>
<tr>
<td>Q25 What is this animal? An extinct relative of the elephant but not a mastodon or mammoth.</td>
<td>100%</td>
</tr>
<tr>
<td>Q26 Are African elephants in danger of extinction? Why?</td>
<td>100%</td>
</tr>
<tr>
<td>Q27 What happens when the last member of a species die? Extinction</td>
<td>50%</td>
</tr>
</tbody>
</table>
Dear Student,

I am a doctorate student under the direction of Dr. David Carlson at the Mary Lou Fulton’s Teacher College at Arizona State University. I am conducting a research study about science and language.

I am inviting your participation which will involve participating in an interview and a survey before the project and again at the completion. The interview will be held in a private room and will last approximately ten minutes. The questions will be given to you in your native language and will be related to your views about learning English, views on science, and on the use of technology. You have the right not to answer any question and you can stop the interview at any time. There are no foreseeable risks or discomforts to your participation. The responses to the interview will be used to answer specific research questions.

The interview will be audio-taped with your permission. Please let me know if you do not want to be taped. You can also change your mind after the interview begins. Your name will not be identified with the recording but rather assigned an identification code. The results of the study may be used in reports, presentations, or publications but your name will not be used or shared. The audiotape will be stored in a password protected drive accessible to only myself, the director, and the PI involved in the project. The recordings will be erased at the completion of the study.

You will also be asked to participate in a survey before your participation and at the conclusion of the project. The written survey will take you approximately 10-
15 minutes to complete and you will have the option of taking the survey in your native language. The survey will help us to better understand your current views about science, your beliefs about doing science, and other views and current uses of technology.

Your participation in this study is voluntary. If you choose not to participate you may withdraw from the study at any time with no penalty, nor will this have any affect on your status as a student. You must be 18 years or older to participate in the study and be registered as a student.

If you have any questions concerning the research study, please contact the research team: David L Carlson at 480-965-4849 or Melody Basham at 602-741-9621. If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788. Please let me know if you wish to be part of the study.
APPENDIX K

STUDENT RECRUITMENT
Dear Student,

You are invited to participate in a research study that will be for 8 weeks starting in September, 2011 and ending the end of November, 2011. This project will be involved in the development of a curriculum that will integrate science with the current ELAA 2 curriculum at the 7th Avenue Green Learning campus. Melody Basham, an ELAA Level 2 instructor is a doctorate candidate under the direction of Dr. David Carlson at the Mary Lou Fulton Teacher’s College department of Educational Leadership and Innovation at Arizona State University. She will be conducting a research study to explore how might science be integrated with teaching English.

Participating in the ELAA 2 Citizen Science Project will provide you an opportunity to contribute to authentic science working with the Paleontological Research Institute at the Museum of the Earth in New York and will involve the discovery and study of ancient animal and plant life. What you find may help scientists learn more about climate change and how it can directly impact our own lives and communities. For 8 weeks we will meet twice a week where we will be involved in science and students will contribute to the creating of an online learning module that will teach others about the project. A field-trip to the Arizona Museum of Natural History will also be part of the experience.

Your participation in this study is voluntary. If you have any questions concerning the research study, please feel free to contact Melody Basham at (602) 741-9621.
APPENDIX L

INSTITUTIONAL REVIEW BOARD APPROVALS
Maricopa Community College IRB has approved the protocol with the following details.
Protocol ID: 2011-07-141
Principal Investigator: Carlson, David
Department: Education
Protocol Title: The ELAA 2 Citizen Science Project
Review Type: EXEMPT
Approval Date: August 22, 2011