An Examination of the Processes of Student Science Identity Negotiation within an Informal Learning Community

Author: Sheron Mark

Persistent link: http://hdl.handle.net/2345/2601

This work is posted on eScholarship@BC, Boston College University Libraries.

Boston College Electronic Thesis or Dissertation, 2012

Copyright is held by the author, with all rights reserved, unless otherwise noted.
An Examination of the Processes of Student Science Identity Negotiation within an Informal Learning Community

Dissertation by

SHERON L. MARK

submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

May, 2012
Dissertation Committee Members

Committee Chair: G. Michael Barnett, Ph.D.

Associate Professor

Teacher Education, Special Education, and Curriculum and Instruction Department

Committee Member: David L. Blustein, Ph.D.

Professor

Counseling, Developmental, and Educational Psychology Department

Committee Member: Curt Dudley-Marling, Ph.D.

Professor

Teacher Education, Special Education, and Curriculum and Instruction Department

Committee Member: Patrick McQuillan, Ph.D.

Associate Professor

Teacher Education, Special Education, and Curriculum and Instruction Department
Abstract

Scientific proficiency is important, not only for a solid, interdisciplinary educational foundation, but also for entry into and mobility within today's increasingly technological and globalized workplace, as well as for informed, democratic participation in society (National Academies Press, 2007b). Within the United States, low-income, ethnic minority students are disproportionately underperforming and underrepresented in science, as well as mathematics, engineering and other technology fields (Business-Higher Education Forum, 2011; National Assessment of Educational Progress, 2009). This is due, in part, to a lack of educational structures and strategies that can support low-income, ethnic minority students to become competent in science in equitable and empowering ways. In order to investigate such structures and strategies that may be beneficial for these students, a longitudinal, qualitative study was conducted. The 15 month study was an investigation of science identity negotiation informed by the theoretical perspectives of Brown's (2004) discursive science identities and Tan and Barton's (2008) identities-in-practice amongst ten high school students in an informal science program and employed an amalgam of research designs, including ethnography (Geertz, 1973), case study (Stake, 2000) and grounded theory (Glaser & Strauss, 1967). Findings indicated that the students made use of two strategies, discursive identity development and language use in science, in order to negotiate student science identities in satisfying ways within the limits of the TESJ practice. Additionally, 3 factors were identified as being supportive of successful student science identity negotiation in the informal practice, as well. These were (i) peer dynamics, (ii) significant social interactions, and (iii) student ownership in science. The students were also uncovered to be particularly open-minded to the field of STEM. Finally, with respect to
STEM career development, specific behaviors were indicative of students’ serious consideration of STEM careers and two major patterns in STEM career interests were uncovered. The findings are discussed in relation to existing research in science education, as are implications for future research and practice.
Acknowledgements

This work undoubtedly would not have been accomplished had it not been for the tremendous support given to me by doctoral adviser, Dr. Mike Barnett. I have thoroughly enjoyed working, learning and growing with you. You have plotted out a professional trajectory for me long before I realized it such that much of my CV wrote itself!

Right there with Mike is Dr. David Blustein, for the dissertation and from very early on in my doctoral program. I have grown and will continue to do so as a direct result of your guidance and mentorship.

The two remaining members of my dissertation committee, Drs. Curt Dudley-Marling and Patrick McQuillan, you have impressed me with your knowledge and research expertise. I greatly appreciate your willingness to guide me in this final project.

I have been granted the opportunity to work with so many extraordinarily smart, talented and driven people at Boston College and beyond. Dr. Eric Strauss, now far away in Los Angeles. Under your wing, I have participated in numerous research and teaching opportunities. Youjin Lee, soon to be Dr. Lee. My good friend and valuable statistics support. The Boston College-College Bound-Urban Ecology Institute research, STEM Education and Urban Outreach team that continues to be so committed to enhancing the educational experiences and all-round lives of underserved and misrepresented young people: Catherine Wong, Dennis Debay, Lindsey Cotter-Hayes, Steve Prudent, Dr. Laura O'Dwyer, Preston Achilike, James Huerta and Jim Haley. The tremendously accommodating College Bound Instructors: Andrew, Janey, Justin, Kate, Yinnette, Constance, Eddie, Marla,
Carly and Lisa. The fantastic Boston Public School teachers and guidance counselors: Dewitt Tolbert, Jeff Goodman, Cynthia Villanueva, Tim Gay, Andy Trossello, Adam Falzano and Paul Kemp.

The key drivers of this work was and continue to be the kids, the high school students who are so smart, driven, funny and talented. Their energy and wit have kept me focused and determined in this work. Young people have so much enthusiasm and potential. It is our jobs as educators, allies and adults to support them in all ways possible. A special thank you to all of my College Bound youth participants over the years.

This dissertation is dedicated to my family and friends, near and far, who have encouraged and motivated me and have kept me smiling. First, my parents, Merle and Michael Mark, and my grandfather, Cecil Quintin. Also, my brother, Sean, my New York-based extended family including my aunts, Debra, Lyn and June, my cousins, Crystal, Camille and Ann-Marie and my Trinidad-based extended family including my grandmother, Jean Mark, and my cousins, Malachi, Machaela, Jason, Abina and Nicola. My boyfriend, Hassan (Time2Ball) Fofana, a tremendous and consistent support. Last, but certainly not least, great friends: Tahirah David, Andhra Maraj, Kamla Brathwaite, Colette Hosten, Jessyca Jackson, Nana Bulaba Sang-Bender, Anthony Guilford, Theresa Lungu, Dzifa Job, Dewan Andrews, Sam Prescod, Falon and Fern Gray, Ayana Riviere, Geneisa Marshall, Charisse and Caleigh Bacchus, Rhonda Watkins, Krystle and Candace Ince, and Joel Batson.
# Table of Contents

<table>
<thead>
<tr>
<th>Front Matter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissertation Committee Members</td>
<td>i</td>
</tr>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>iv</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xvi</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xvii</td>
</tr>
<tr>
<td>CHAPTER 1: Introduction</td>
<td>1</td>
</tr>
<tr>
<td>The Research Problem</td>
<td>1</td>
</tr>
<tr>
<td>Importance of Teaching Science</td>
<td>1</td>
</tr>
<tr>
<td>National Talk has Historically Emphasized Science Education</td>
<td>2</td>
</tr>
<tr>
<td>Critiques of and Recommendations for Science Education</td>
<td>3</td>
</tr>
<tr>
<td>Specific Timely Considerations for the Importance Placed On Science Education</td>
<td>3</td>
</tr>
<tr>
<td>The Economic Fall-Out</td>
<td>5</td>
</tr>
<tr>
<td>Concerns in the Science Industry</td>
<td>6</td>
</tr>
<tr>
<td>Topic</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Demographics of Science Achievement in the United States</td>
<td>7</td>
</tr>
<tr>
<td>International Comparisons of US Science Education</td>
<td>10</td>
</tr>
<tr>
<td>Empirical Research on Science Education Problems and Interventions</td>
<td>12</td>
</tr>
<tr>
<td>Interest and Motivation In Science</td>
<td>13</td>
</tr>
<tr>
<td>Impact of Science Instruction on Interest</td>
<td>16</td>
</tr>
<tr>
<td>Informal Science Education</td>
<td>20</td>
</tr>
<tr>
<td>Connections between Informal and Formal Science Experiences</td>
<td>21</td>
</tr>
<tr>
<td>Utility and Relevance of Science</td>
<td>23</td>
</tr>
<tr>
<td>Background and Contextual Impacts on Science Interest</td>
<td>24</td>
</tr>
<tr>
<td>Institutional Support for Low-Income, Ethnic Minority Science Students</td>
<td>31</td>
</tr>
<tr>
<td>Research Problem Revisited</td>
<td>34</td>
</tr>
<tr>
<td><strong>CHAPTER 2: Theoretical Framework</strong></td>
<td>35</td>
</tr>
<tr>
<td>The Role of Identity Research in Science Education</td>
<td>36</td>
</tr>
<tr>
<td>Science as a Practice</td>
<td>37</td>
</tr>
<tr>
<td>Theoretical Framework of Identity Development</td>
<td>40</td>
</tr>
<tr>
<td>Discursive Identity</td>
<td>40</td>
</tr>
<tr>
<td>Identities-in-Practice</td>
<td>43</td>
</tr>
<tr>
<td>Definition of Science Identity Development in the Present Study</td>
<td>49</td>
</tr>
<tr>
<td>Specific Research Question</td>
<td>50</td>
</tr>
<tr>
<td>Specific Research Sub-questions</td>
<td>51</td>
</tr>
<tr>
<td>Youth Agency in Science Identity Development</td>
<td>51</td>
</tr>
<tr>
<td>Institutional Positioning in Science</td>
<td>57</td>
</tr>
<tr>
<td>Negotiating between Institutional Power and Individual Agency</td>
<td>63</td>
</tr>
<tr>
<td>Institutional Space Made for Student Authoring of Science Identities</td>
<td>65</td>
</tr>
<tr>
<td>Summary</td>
<td>69</td>
</tr>
</tbody>
</table>

**CHAPTER 3: Research Design**

<p>| Research Context | 71 |
| The Informal Science Program: Teens for Environmental and Social Justice | 71 |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Projects and Activities: STEM</td>
<td>73</td>
</tr>
<tr>
<td>Student Projects and Activities: Career Development</td>
<td>76</td>
</tr>
<tr>
<td>Demographics Data for 2010 – 2011 Student Enrolment</td>
<td>78</td>
</tr>
<tr>
<td>Participants’ Educational Context</td>
<td>80</td>
</tr>
<tr>
<td>Rationale for Research Study Design</td>
<td>83</td>
</tr>
<tr>
<td>Data Collection Methods</td>
<td>84</td>
</tr>
<tr>
<td>Data Analysis Methods</td>
<td>89</td>
</tr>
<tr>
<td>Determining Science Identity Development</td>
<td>89</td>
</tr>
<tr>
<td>Within Cases</td>
<td>90</td>
</tr>
<tr>
<td>Across Cases</td>
<td>90</td>
</tr>
<tr>
<td>Exploring and Identifying Cross-Cutting Factors</td>
<td>90</td>
</tr>
<tr>
<td>For Explaining the Significance of Each Cross-Case Factor</td>
<td>92</td>
</tr>
<tr>
<td>Trustworthiness</td>
<td>92</td>
</tr>
<tr>
<td>Limitations</td>
<td>93</td>
</tr>
<tr>
<td>Chapter 4A: Results</td>
<td>94</td>
</tr>
<tr>
<td>---------------------</td>
<td>----</td>
</tr>
<tr>
<td>Science Identity versus Time Plots for Cross-Case Analyses</td>
<td>94</td>
</tr>
<tr>
<td>Cross-Case Analyses of Student Science Identity Development</td>
<td>99</td>
</tr>
<tr>
<td>Discursive Identity Development in Science</td>
<td>102</td>
</tr>
<tr>
<td>Smart and Knowledgeable</td>
<td>103</td>
</tr>
<tr>
<td>Summary: Smart and Knowledgeable</td>
<td>108</td>
</tr>
<tr>
<td>Urban and Ethnic Minority Youth Identities</td>
<td>109</td>
</tr>
<tr>
<td>Summary: Urban &amp; Ethnic Minority Membership</td>
<td>111</td>
</tr>
<tr>
<td>Funny and Social</td>
<td>112</td>
</tr>
<tr>
<td>Summary: Funny and Social</td>
<td>114</td>
</tr>
<tr>
<td>People-/Service-Oriented</td>
<td>115</td>
</tr>
<tr>
<td>Summary: People-/Service-Oriented</td>
<td>118</td>
</tr>
<tr>
<td>Summary: Discursive Identity Development in Science</td>
<td>118</td>
</tr>
<tr>
<td>Language Use</td>
<td>119</td>
</tr>
<tr>
<td>Use of a Traditional Scientific Discourse</td>
<td>120</td>
</tr>
<tr>
<td>Summary: Use of a Traditional Scientific Discourse</td>
<td>128</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Developmental Transition from Non-Traditional to Traditional Scientific Discourses</td>
<td>129</td>
</tr>
<tr>
<td>Summary: Developmental Transition from Non-Traditional to Traditional Science Discourses</td>
<td>136</td>
</tr>
<tr>
<td>Hybrid Discourses</td>
<td>136</td>
</tr>
<tr>
<td>Summary: Hybrid Discourses</td>
<td>146</td>
</tr>
<tr>
<td>No Notable or Demonstrated Use of a Scientific Discourse</td>
<td>146</td>
</tr>
<tr>
<td>Summary: Language Use in Science</td>
<td>147</td>
</tr>
<tr>
<td>Summary: Strategies used in negotiation of science identities</td>
<td>148</td>
</tr>
<tr>
<td>Factors Supporting Student Science Identity Negotiation</td>
<td>149</td>
</tr>
<tr>
<td>Peer Dynamics: Leadership, Kinship and Friendship</td>
<td>150</td>
</tr>
<tr>
<td>Leadership</td>
<td>150</td>
</tr>
<tr>
<td>Summary: Leadership</td>
<td>162</td>
</tr>
<tr>
<td>Cultural Kinship</td>
<td>163</td>
</tr>
<tr>
<td>Provision of a Safe and Protective Space</td>
<td>164</td>
</tr>
<tr>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Support in Students' Use of English</td>
<td>168</td>
</tr>
<tr>
<td>Participation in the Larger TESJ Practice</td>
<td>171</td>
</tr>
<tr>
<td>Summary: Cultural Kinship</td>
<td>173</td>
</tr>
<tr>
<td>Friendship</td>
<td>174</td>
</tr>
<tr>
<td>Summary: Friendship</td>
<td>176</td>
</tr>
<tr>
<td>Summary: Peer Dynamics</td>
<td>177</td>
</tr>
<tr>
<td>Significant Social Interactions</td>
<td>177</td>
</tr>
<tr>
<td>Transformative Expansion of Negotiated Student Science Identities</td>
<td>178</td>
</tr>
<tr>
<td>Continued Development of Science Identities Already Under Negotiation</td>
<td>181</td>
</tr>
<tr>
<td>Maintenance of Alternative Science Identities</td>
<td>184</td>
</tr>
<tr>
<td>Summary: Significant Social Interactions</td>
<td>186</td>
</tr>
<tr>
<td>Student Ownership in Science</td>
<td>187</td>
</tr>
<tr>
<td>Summary: Student Ownership in Science</td>
<td>195</td>
</tr>
<tr>
<td>Student Reactions to the TESJ Practice</td>
<td>195</td>
</tr>
<tr>
<td>STEM Career Development</td>
<td>198</td>
</tr>
<tr>
<td>Chapter Title</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Passionate STEM Career Interests</td>
<td>198</td>
</tr>
<tr>
<td>Pragmatic STEM Career Interests</td>
<td>199</td>
</tr>
<tr>
<td>Summary: STEM Career Development</td>
<td>200</td>
</tr>
<tr>
<td>Results Chapter Summary</td>
<td>201</td>
</tr>
<tr>
<td>Chapter 4B: Individual Case Study Analyses</td>
<td>204</td>
</tr>
<tr>
<td>Chapter 5: Discussion</td>
<td>210</td>
</tr>
<tr>
<td>Discursive Identity Development and Language Use in Science</td>
<td>211</td>
</tr>
<tr>
<td>Peer Dynamics and its Impact on Science Identity Development</td>
<td>214</td>
</tr>
<tr>
<td>Significant Social Interactions</td>
<td>216</td>
</tr>
<tr>
<td>Student Ownership in Science</td>
<td>218</td>
</tr>
<tr>
<td>Open-Minded Reactions to the TESJ Science Practice</td>
<td>220</td>
</tr>
<tr>
<td>STEM Interest and Career Development</td>
<td>221</td>
</tr>
<tr>
<td>Conclusion</td>
<td>223</td>
</tr>
</tbody>
</table>
Chapter 6: Implications

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance of the Present Study Design and Findings</td>
<td>225</td>
</tr>
<tr>
<td>Out-of-School Science Programs</td>
<td>226</td>
</tr>
<tr>
<td>Out-of-School Science Program Design and Development</td>
<td>228</td>
</tr>
<tr>
<td>In-School Science Education</td>
<td>230</td>
</tr>
</tbody>
</table>

Chapter 7: Future Research

References

Appendices

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix A: Summary of Findings</td>
<td>244</td>
</tr>
<tr>
<td>Appendix B: Demographics</td>
<td>247</td>
</tr>
<tr>
<td>Appendix C: Calendar of Events 2010 – 2011</td>
<td>250</td>
</tr>
<tr>
<td>Appendix D: Interview Protocols</td>
<td>251</td>
</tr>
<tr>
<td>Appendix E: Definitions of Science Proficiency</td>
<td>259</td>
</tr>
<tr>
<td>Appendix F: Screenshots of the ArcGIS and Community Viz Urban Planning Technology</td>
<td>262</td>
</tr>
<tr>
<td>Appendix G: Graphical Output Calculated Based on the Site Design</td>
<td>267</td>
</tr>
<tr>
<td>Appendix H: Samples of Student Physical Science Data Collection and Microsoft Excel Graph Output</td>
<td>269</td>
</tr>
</tbody>
</table>
**List of Tables**

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Gender Distribution</td>
<td>78</td>
</tr>
<tr>
<td>Table 2</td>
<td>Racial/Ethnic Diversity</td>
<td>79</td>
</tr>
<tr>
<td>Table 3</td>
<td>Class Year</td>
<td>80</td>
</tr>
<tr>
<td>Table 4</td>
<td>School District and State Profiles</td>
<td>81</td>
</tr>
<tr>
<td>Table 5</td>
<td>Data Collection Methods</td>
<td>86</td>
</tr>
<tr>
<td>Table 6</td>
<td>Frequency of Data Collection (2010 – 2011)</td>
<td>87</td>
</tr>
<tr>
<td>Table 7</td>
<td>Demographic Data for Research Study Sample</td>
<td>88</td>
</tr>
</tbody>
</table>
# List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Business-Higher Education Forum. (2011). The STEM interest and proficiency challenge: Creating the workforce of the future.</td>
<td>9</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Bar Chart Representing the Gender Distribution in TESJ From July 2010 – September 2011</td>
<td>247</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Bar Chart Representing the Racial and Ethnic Distribution in TESJ From July 2010 – September 2011</td>
<td>248</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Bar Chart Representing the High School Class Year Distribution in TESJ From July 2010 – September 2011</td>
<td>249</td>
</tr>
</tbody>
</table>
To my family and friends.
CHAPTER 1: Introduction

“A view of science as a culturally-mediated way of thinking and knowing suggests that learning can be defined as engagement with scientific practices” (Brickhouse, Lowery, & Schultz, 2000, p. 441)

The Research Problem:

From international educational statistics, it appears that the United States falls in the average range in science (National Center for Education Statistics, 2009). This makes the state of science education in the US appear less dire; however, when the data are examined more closely, parsed out based on socioeconomic status and ethnicity, low-income, ethnic minority students are overrepresented in the underperforming range of proficiency levels in science (National Assessment of Educational Progress, 2009; National Center for Education Statistics, 2007).

Importance of Teaching Science

The Committee on Science Learning, Kindergarten through Eighth Grade, comprised of experts in science and science learning, summarized the importance of teaching science as follows:

Science is a significant part of human culture and represents one of the pinnacles of human thinking capacity; It provides a laboratory of common experience for development of language, logic, and problem-solving skills in the classroom; A democracy demands that its citizens make personal and community
decisions about issues in which scientific information plays a fundamental role, and they hence need a knowledge of science as well as an understanding of scientific methodology; For some students, it will become a lifelong vocation or avocation; The nation is dependent on the technical and scientific abilities of its citizens for its economic competitiveness and national needs (National Academies Press, 2007b).

**National Talk has Historically Emphasized Science Education**

The US has always been concerned about the quality of its education system in science and more generally (National Commission on Excellence in Education, 1983). Back in the Sputnik era of the ‘50s and ‘60s, a fiercely competitive focus was placed on science education (Lagemann, 2000). Science and scientists were seen as the keys to winning a major war (Lagemann). Scientific knowledge and skill were prioritized and revered. The current intense focus on science is reminiscent of that time. In *A Nation at Risk* (1983), the rigor and academic standards of US schools were critiqued for declining over time and for a lack of urgency from students, their parents and the public at large. Emphasis was placed on the content of the curriculum, the standards held for the students, time spent on schoolwork, quality of teachers and the educational leadership within schools. The report targeted the quality of education, in general, but mentions were made of increasing the time committed to science instruction and the science content background of science teachers. While the *Nation at Risk* (1983) report focused on the discipline and focus lacking amongst students and their parents, *No Child Left Behind* (U.S. Department of Education, 2002), focused on teacher quality in US schools. Regarding science education, science
teachers were critiqued for inadequate science study in their own education and schools critiqued for allowing out-of-field practitioners to teach science.

**Critiques of and Recommendations for Science Education**

Overall, the current argument regarding the science education of US youth today is as follows: Education is suffering because low standards are set for students; students are not turned on, interested in or committed to the study of science and technology; the K-12 teaching force is weak and unqualified in science; and educational issues at the K – 12 level are transferred over to university education (National Academies Press, 2007a). Recommendations based on this argument include that the US must strengthen science education by providing a larger number of qualified and appropriately prepared teachers; and the US federal government must invest in basic research in order to market cutting-edge products and technology first, thus creating new knowledge.

**Specific Timely Considerations for the Importance Placed On Science Education**

Additional present day factors draw even more attention to science and technology education. First, given the increasingly global nature of the job market, competition has been extended across many more nations beyond the US. Significant proportions of the US-based scientists and engineers were born and have earned their highest educational degrees outside of the US (National Science Board, 2008). Second, low wages for employees and low costs of investment and production attract businesses to countries abroad rather than the US. It is expensive to house and finance business ventures in the US given the relatively high costs of maintaining workers, for instance due to healthcare and pension
plans, and the risk of litigation in the US, for example, the “US industry consistently spends three times more on litigation than on research” (National Academies Press, 2007b, p 63).

As a result, the US economy suffers in comparison to other burgeoning nations such as China, Russia, Brazil and India (Fox, 2009). The following summarizes the frustrations of the American business, science, technology, engineering and mathematics (STEM) and education sectors:

Meanwhile, our competitors have not been standing still. The World Economic Forum dropped America from first to seventh place in its ranking of nations’ preparedness to benefit from advances in information technology; the number of US citizens entering engineering school declined still further; the remnants of the legendary Bell Labs, the birthplace of the laser and the transistor and the home of many Nobel laureates, were sold to a French firm; a new generation of semiconductor integrated circuits—the mortar of the modern electronics revolution—was introduced; the largest initial public offering in history was conducted by a Chinese bank; another $650 billion has been spent on US public schools while the performance of its students on standardized science tests of those about to graduate declined further; American companies once again spent three times more on litigation than on research; and in July, for the first time in history, foreign automakers sold more cars in the United States than American manufacturers (National Academies Press, 2007a, p 3).
The Economic Fall-Out

The US economy suffers as a result of its shrinking STEM capital and the expanding global competition. Individuals’ quality of life is also affected, in terms of the socioeconomic status of the jobs available to them based on their educational qualifications, which in turn exacerbates the national problem. Additionally, in the present increasingly technological world, knowledge of science and scientific methodologies is increasingly critical for access to high-quality careers. The Committee on Science Learning, Kindergarten through Eighth Grade concluded as follows:

The thrust of the [National] Academies [of Science’s] findings is straightforward. First, the report concludes that individual prosperity depends predominantly on individuals having high-quality jobs. It also observes that the same is true of a nation’s collective prosperity, in that if there are few high-quality jobs, there are not likely to be sufficient tax revenues to ensure homeland security, provide health care, pay Social Security, or educate the nation’s children. Second, the report concludes that the creation of new, high-quality jobs is today disproportionately dependent on advances in science and engineering (National Academies Press, 2007b, p 15).

The science industry is particularly advantageous for individuals’ quality of life and social mobility. For instance, over the years, science career opportunities have grown rapidly. From 1950 to 2000, science and engineering careers grew at an average annual rate of 6.7%, well above the 1.6% average annual rate for all employment (National Science Board, 2008). Additionally, science and engineering careers can provide much needed
economic aid during recessions. For instance, in 2006, unemployment in science and engineering career fields declined to 1.6% from its 20-year high of 4% in 2003 (National Science Board, 2008). The problem still remains, however, when the data are examined with respect to ethnic sub-populations, it is seen that Blacks and Latinos are still represented in the STEM industry at levels well below their proportions in the total population, despite data that show that, at the undergraduate level, Black, Latino and White students choose science and engineering fields at the same rate, i.e. about one third of each group chose science and engineering fields (National Science Board, 2008). Therefore, although the proportions of Black, Latino and White representation correspond with their respective proportions in the total population at the undergraduate level, which might indicate comparable interest in and choice of a STEM major, in the STEM industry, which then indicates the successful completion and attainment of a STEM industry position, the Black and Latino representation falls relative to their overall proportion in the population.

**Concerns in the Science Industry**

In the increasingly technological and globalized world, now, more than ever, science education permeates multiple fields of study and occupations. With respect to the STEM industry specifically, however, this field faces unique challenges regarding future scientists and engineers and the US’ STEM innovation for global competitiveness. For instance, the number of students en route to science study or careers dwindles at each educational transition (i.e. from high school graduation to being college-ready to declaring a science college major to pursuing post-graduate science study to entering a science career) (CRS Report for Congress, 2008; National Science Board, 2008). Three major aspects of this
problem, also known as the “leaky STEM pipeline” problem, are that, first, a significant number of students are not successfully graduating from high school; second, from those graduates who are college-ready and who do enter college, many of them do not choose to study in a STEM field; and third, of those students majoring in STEM, there is significant attrition from STEM majors by the time of college graduation (NCES Digest of Education Statistics, 2008). Finally, a significant segment of the professional science labour force is nearing retirement, (CRS Report for Congress, 2008; National Science Board, 2008) making the need for new competent and innovative STEM professionals even more pressing.

Overall, a strong educational foundation in science is important for an informed, democratic citizenry, particularly as science is increasingly involved in various aspects of people’s everyday lives (Bereiter, Scardamalia, Cassells, & Hewitt, 1997; Organization for Economic Co-Operation and Development, 2006). Additionally, science knowledge capital and technological advancements contribute to the attainment of a middle class lifestyle to which many Americans aspire (National Academies Press, 2005). Finally, there are serious concerns about America’s economy and national security due to international labour competition which increasingly involves science (National Academies Press, 2007a).

**Demographics of Science Achievement in the United States**

The following data have been derived from the National Assessment of Educational Progress (NAEP, 2009) report. With respect to different racial and ethnic student populations, White and Asian/Pacific Islander twelfth-graders performed most proficiently on national science assessments. Within these groups, 72% and 73% (White and Asian/Pacific Islander, respectively) performed at or above the basic level and 28% and
27% of these students, respectively at below basic levels of science proficiency (definitions will be located in the appendix). Next, were American Indian and Latino twelfth-graders with 53% and 42%, respectively at or above the basic level and 47% and 58%, respectively below basic proficiency in science. Worst off were Black/African American twelfth-graders with only 29% at or above basic proficiency in science and 71% below the basic level. Furthermore, White and Asian/Pacific Islander students were the only students with representation in the advanced level of science proficiency with 2% and 4%, respectively.

A more current report presents just as bleak a picture for African American, Latino and American Indian students in the US in terms of readiness and interest in STEM study (Business-Higher Education Forum, 2011). In the graph depicted below, amongst African American, Latino and American Indian students, the percentages of students who are both not proficient and uninterested in STEM, shown here in purple, are significantly higher than the percentages of students who are proficient in Math and interested in STEM, here in red, who are proficient in Math but not interested in STEM, here in green, and those not proficient in Math but interested in STEM, here in blue. Significant as well is that the percentages of African American, Latino and American Indian students who are both not proficient and uninterested in STEM (purple) is much higher than the percentages of White and Asian American students who are proficient in Math and interested in STEM (red).
Similarly concerning is that, amongst White students, the number of students proficient in Math, if you sum the red and green bars, is higher than that of each African American, Latino and American Indian students similarly proficient in Math (summing the red and green bars for each group). Finally, it is only amongst Asian American students in which the percentage of students who are proficient in Math and interested in STEM is the highest compared to students who are Math proficient and uninterested in STEM (green bar) and students who are both interested and uninterested in STEM, but not proficient in Math (blue and purple bars, respectively).
International Comparisons of US Science Education

The following have been derived from The Trends in International Mathematics and Science Study (TIMMS, 2007) data. United States’ 4th and 8th grade students performed at above average levels in science (539 and 520, respectively, compared to the international average of 500). The US 4th graders outperformed 25 of 35 countries and the 8th graders, 35 of 47. Furthermore, most of the other countries did not score statistically significantly higher than the US, i.e. only 4 countries performed significantly ($p < 0.05$) better than the 4th grade students and 6 countries better than the 8th graders. Additionally, the US students performed above average at each benchmark (at or above intermediate, high and advanced levels in science; definitions will be located in the appendix). The percentages of US students performing at each of these levels increased from 4th to 8th grade.

Looking across 2009 NAEP and 2007 TIMSS data, at both the 4th and 8th grade levels, TIMSS data show that the US students are above average in science. In 2009 NAEP data, ethnic minority high school students are shown to be performing below average in science. So, it appears that across ethnicity, and likely socioeconomic class lines, there are differences in science performance and proficiency to the disadvantage of low-income, ethnic minority students and, thus, differences in the related career development and livelihood benefits of a sound science education.

The following have been derived from the 2009 Programme for International Student Assessment (PISA) report (Organization for Economic Co-Operation and Development, 2010). The US was ranked 23rd in the 2009 PISA science assessments. When statistically significant differences in student scores were considered, the US ranked 19th
overall (being not significantly different from the higher ranked Poland, Ireland, Belgium and Hungary). The US’ score was not significantly different from the OECD average, along with 5 other countries, but 22 countries scored significantly above the OECD average. Very few US students were at levels 6 and 5 of science proficiency; most were representative of levels 2 through 4 (definitions will be located in the appendix). Almost 20% of US students were at or below level 1 (OECD average = 18%) while top-PISA-ranked Shanghai-China had 3.2% representation here. Additionally, more than 20% of Shanghai-China’s students performed at or above level 5. At or below level 1 science proficiency is troubling since “[s]uch students will have serious difficulties in using science to benefit from further education and learning opportunities and participate in life situations related to science and technology” (Organization for Economic Co-Operation and Development, 2010, p. 150, http://www.oecd.org/document/53/0,3343,en_32252351_46584327_46584821_1_1_1_1,00.html).

Looking across PISA, TIMSS and NAEP data, it appears that the PISA 2009 science achievement data are the most troubling for the US’ international comparisons. The US is ranked as average in both TIMSS 2007 and PISA 2009, but the TIMSS data position the US as much more competitive than do the PISA data. The PISA results for the US might also be more disconcerting as PISA is not only more recent, but it utilized the OECD (Organisation for Economic Co-operation and Development) and non-OECD countries specifications with the OECD being an organization of countries committed to advancing the economic and social well-being of their nations and countries all across the world with education being one aspect of their strategy. In 2009, the PISA assessment included 65 countries (34 OECD countries and 31 partner countries or economies) So, both PISA and TIMSS confirm the US’
non-leading position in science worldwide; however, PISA makes the case more urgent than does TIMSS. The US is ranked 13 – 22*¹ in science proficiency amongst OECD countries and 19 – 29* overall. Three of the top 4 performing countries/regions, Shanghai-China, Hong Kong, China and Singapore, are non-OECD countries/regions. Finland is the only OECD country in the top 4. Additionally, NAEP 2009 indicates that ethnic minorities were performing much more poorly than White and Asian/Asian American students. Class issues can be assumed to be involved, as well, given that low-income populations are over-representative of ethnic minorities (American Psychological Association, 2011; Hayward, Miles, Grimmins, & Yang, 2000).

Empirical Research on Science Education Problems and Interventions

Science and science education has been argued as critically important for the well-being of the U.S. Furthermore, from the above data analysis and considerations of science in society, low-income, ethnic minority students, specifically, are under-performing, falling behind or staying behind in science and do not reap the socioeconomic and vocational benefits of a sound science foundation. A number of problems have been identified as the source of this educational predicament and a number of intervention strategies have been tested in order to address these problems, as well. I will now review the literature with respect to the educational problems identified and the measures taken to enhance interest and proficiency in science and science careers in the United States.

¹ As a number of countries are determined to not be statistically significantly different from other countries, individual countries have a range of ranking rather than a definitive rank. Therefore, across all 65 participating PISA countries, the US ranks as high as 19th and as low as 29th; amongst the 34 OECD countries, the US ranks as high as 13th and as low as 22nd.
Interest and Motivation in Science

A lack of interest in science amongst students is often named as a major contributing factor. Interest is high amongst young children, but declines with increasing time spent in school (Falk & Dierking, 2010). Science education interventions, typically informal and immersive in design, have been shown to re-stimulate interest in science and science careers (Gibson & Chase, 2002; Jayaratne, Thomas, & Trautmann, 2003; J. E. Stake & Mares, 2005). Gibson and Chase (2002) implemented a two-week inquiry-based summer science exploration program from 1992 to 1994 for middle school students. The researchers found that in each year, amongst all students, accepted and non-accepted program participants and a control sample of middle school students, interest in science decreased from middle to high school; but the science program participants’ interests remained highest over time and eventually the non-accepted applicants’ science interests fell to the level of the control students who did not apply to the program. Stake and Mares (2005) reported on a similar informal and immersive summer science-enrichment program run from 1999 to 2001 for gifted, ethnically diverse, high school boys and girls. They found a significant positive impact on the students’ science motivation in the long-term, i.e. three to seven months following the program, but not immediately following the program. Exemplifying the on-going discussion that sub-populations differentially experience and benefit from science education is Jayaratne, Thomas and Trautmann’s (2003) study. Here, the researchers investigated the impact of a science intervention, this time in the form of a two-week, residential program for high-achieving 8th grade girls at a university, on science interest. Science interest was stimulated similar to the other studies, but the researchers also found that the program was more successful with enhancing
science interest amongst the White participant than the ethnic minority participant. The same effect was seen with respect to enjoyment, self-concept and career aspirations with respect to science.

Tai, Liu, Maltese and Fan’s (2006) study further demonstrates the significance of student interest in science. Tai et al. found that science career expectations for oneself formed early on in life, by age 13, and was significant in the eventual attainment of the desired science career. For instance, students who, at 13 years old, expected to have science-related careers at age 30 had 29% and 34% chances of earning life sciences and physical sciences/engineering baccalaureate degrees, respectively, compared to students not expecting to attain life sciences-related or physical sciences/engineering careers (18% and 10%, respectively). This is not simply attributed to the student, having developed interest in these relatively difficult career goals, beginning to work harder than their peers and thus performing better academically. This point is confirmed as an average math achiever in the 8th grade with expectations of a science career was more likely to earn a physical science/engineering degree (34%) than a high achieving math student without science career expectations (19%). This early interest in the science profession was thus more significant in science learning and progress in the educational pipeline towards a science career than just ability. Those who perform better academically, but do not develop increasingly self-driven science interests might just be “doing school” better than their science-interested peers.

Looking further at interest in science study, Lau and Roeser’s (2002) research demonstrated that, if motivation to learn science was stimulated, positive outcomes with
science achievement was also predicted. Furthermore, Lau and Roeser found that motivation to engage in science was more significant than science ability or self-efficacy in predicting science achievement. Science self-efficacy did not influence or enhance extra-curricular science engagement, as one would expect; but having a positive task value attributed to the science activities did. Extra-curricular science engagement also predicted long-term educational and career plans involving science. There were no demographic or background differences, i.e. no gender, ethnicity or parental education effects. Thus, extra-curricular science might work to maintain equitable educational experiences around science, maintaining students’ interest, science career development and formal school science achievement.

As with the significance of task value on extra-curricular engagement in science (Lau & Roeser, 2002), students’ perceptions of science as relevant and meaningful connected to their lives was also important in stimulating or sustaining interest (Basu & Barton, 2007; Glynn, Taasoobshirazi, & Brickman, 2007). Basu and Barton (2007) found that amongst high-poverty, urban youth, science interest was sustained when the youth perceived their science experiences as connected with how they envisioned their own future and when science activities were meaningful and useful to them and their unique interests in or intended uses of science. In an examination of whether a belief in the relevance of science amongst non-science college majors affected their motivation to learn science, Glynn, et al. (2007) found that motivation was, in fact, influenced by the students’ perception of the relevance of science to their future careers. Furthermore, students were motivated to learn science because of its relevance to their health, lives and understanding
of the world and not just because of career relevance. Finally, a belief in the relevance of science was higher for women than men.

**Impact of Science Instruction on Interest**

The ways in which science is typically taught in schools also do not boost interest. One major way is in the misrepresentation of the nature of science as a body of facts and not as a systematic inquiry process (Bianchini & Colburn, 2000; National Academies Press, 2007b). This perception of science, as facts and not as an entire practice, also leads to poor instructional science methods such as didactic, teacher-centered delivery and teachers aiming to cover a breadth of science topics rather than engage deeply in the exploration and discovery process (Li, Klahr, & Siler, 2006; Yager & Akcay, 2008). Additionally, insufficient science teacher education and preparation, particularly in schools serving low-income, underserved students contribute to subpar learning opportunities for these students (National Academies Press, 2007a; National Commission on Teaching and American’s Future, 1996; Tate, 2001).

Traditional science classrooms are text-centered (Gallagher, 1991; Yore, 1991). Lemke (1989), drawing from the academic and social purposes of language and discourse analysis said that when texts are read verbatim in order to learn, solve problems and answer questions, as often is the case in “school science,” the text itself simply becomes another actor in the classroom, rather than a resource. When science classes are centered largely on the take-up of text-quoted definitions and strategies, neither the students nor the teacher demonstrate competence with the information contained in the book (Lemke, 1989). This is important as interest is influenced by self-efficacy, one’s self-perceived
competence with respect to a task or field of study, as motivation to engage in an activity is more self-driven and focused on the enjoyment of the practice in and of itself when a person perceives herself to be skilled in that practice (Ryan & Deci, 2000). Science interest is therefore expected to be rarely high or intrinsic, i.e. students are rarely expected to engage in school science fundamentally for an enjoyment of science itself, if competence or self-perceived competence is low.

When reconstructed to be more naturalistic and authentic in design, science classes can be innately enjoyable and interesting for students. For instance, Kanter and Konstantopoulos (2010) examined the impact of project-based science (PBS) curricula on low-income, urban, ethnic minority middle school students’ science attitudes and achievement, as well as any long-term impact on college and career planning. Project-based science pedagogy centers on a realistic research problem in which students engage in a process of long-term, student-driven scientific inquiry, while collaborating with others, utilizing new technology and generating relevant artifacts, indicative of student understanding, in order to derive a solution (Marx et al., 1994). The researchers found that the frequency of the middle school teachers’ implementation of the PBS inquiry activities, for instance by supporting their students in explaining the science concepts to one another, was positively correlated with improvements in students’ science attitudes and career plans, for instance, in terms of interest in science, perceptions of the value and relevance of science and their efficacy in doing general science tasks.

In another project-based science intervention with inner city, ethnic minority high school students, Houle and Barnett (2008) stimulated interest in science, positive attitudes
towards science and science content learning. Focused on the physics of sound and bird communication in urban settings, the students were involved in authentic science practices and experimental techniques with equipment that experts would use in developmentally appropriate ways. Furthermore, the learning material was presented in a purposeful format, as opposed to one that was decontextualized and incoherent. There were two forms of assessments used for student understanding. The proximal assessment, aligned directly with the implemented curriculum, indicated an increase in students’ conceptual understanding of the central environmental science problem under investigation and in their ability to interpret spectrogram data. The distal assessment, aligned with state and national tests, indicated a significant increase in student scores; however, the total scores were still low and the students understood less than 40% of the material in the test. Houle and Barnett noted, however, that reliability analysis of the distal assessment revealed that this test might have been a poor evaluation of student understanding.

Lee-Pearce, Plowman, and Touchstone (1998) achieved similar growth in students’ science comprehension, this time regarding a more varied set of curriculum, one targeting practical applications of science, mathematics and technology in mechanical engineering, aircraft and ship operations, navigation in the air and at sea and meteorology. The authors provided an interdisciplinary, experiential learning program for 5th grade students that operated through a partnership with the US Navy. Pretest-posttest comparisons between 94 participating students and 23 control students indicated a 34 to 45% science achievement increase with the students in the program, while the control students’ gains were not significant.
Kisiel (2006) reported on a museum science education program that focused on marine biology and included hands-on activities, conversations with museum scientists, field trips to other museums and science institutions and open discussions. To assess changes in scientific understanding, a very open-ended question, “What comes to mind when you think of the ocean?” was asked at the beginning, end and 6 months after the program. At the start of the program, students discussed mainly personal experiences with the ocean and discussed animals, ocean ecology and environmental concerns. At the completion of the program, responses discussing personal experiences decreased, while discussion of the ocean as a special ecosystem, animals by specific names, animal behavior and anatomy increased. The depth of students’ discussions also increased and the discussion of environmental concerns shifted from describing the ocean as dirty or polluted to discussing human impacts on the ocean. Six months after the program, students’ answers were again more generalized, but discussions of the ocean’s ecosystem still occurred and animals were still referenced, but not by species-specific names. With the more generalized answers, the material was not necessarily internalized by the students, but the ocean was still examined from a scientific perspective. The students enjoyed the program, were positive and expressed interest in coming back to the museum. They also enjoyed the activities and meetings with scientists; however, they did not like the formal, “school-like” sections such as long lectures and worksheets to be completed. Students also discussed that they probably would not be able to get these experiences in their schools and that the museum program differed from their “school science” that was very didactic and book-centered.
Games in science are said to enhance interest in science learning by making science activities enjoyable, meaningful and relevant and by showing the applicability of science in spaces beyond schools and into more personal agendas; however, this motivation to learn science is argued to be successful only if science games are supported in the wider social context, for instance by parents (Foster, 2008).

Informal Science Education

As stated earlier, the traditional ways that science is taught in school do not encourage student interest in science study and STEM careers. Informal science education settings have been shown to be successful in counteracting this. There is a great deal of evidence in support of the educational and career development benefits of informal science education and “free-choice learning” (Falk & Dierking, 2010) in enhancing how people learn science and encouraging students to consider and then sustain STEM career interests. For instance, DiLisi, McMillin, and Virostek (2011) found that, following an informal science intervention, students with existing STEM career interests maintained these interests; however, students who were initially undecided reported higher levels of STEM career interests.

Specific characteristics of informal science programs underlie the success of these programs in supporting students’ science interest and learning. For instance, informal science learning supports the different learning styles of more learners than traditional classrooms and promotes intrinsic motivation and enjoyment of learning (Melber & Brown, 2008). In Fadigan and Hammerschmidt’s (Fadigan & Hammerschmidt, 2004) informal science intervention, the social and interactive nature of the setting was one of the program’s
strengths. In DiLisi et al.’s (2011) successful informal science program setting, described above, students were provided autonomy in their learning experiences. The high school students were allowed to design and manage displays for museum exhibits that they administered for younger students and the larger public. During this process, they were given responsibility and decision-making power as they worked with fellow high school students, undergraduates, teachers, museum staff, and visiting STEM professionals. This kind of learning environment was possible because of the informal design and the out-of-school institutional connections.

Without connections to formal school science, the impact of informal science education, however, is limited. In-school science education is more influential on students’ successful attainment of STEM careers in terms of assessment, school grades and required academic credentials. Without the connections, students might become interested in science and science careers as a result of informal science experiences, however, they might not be satisfied with the educational experiences provided in the formal classroom or might be turned off by traditional forms of classroom assessments, namely tests, thus undermining their newly stimulated science interests.

**Connections between Informal and Formal Science Experiences**

Melber and Brown (2008) describe ways in which traditional classrooms can incorporate the positive elements of informal learning settings. These include (i) providing students alternative options for assessment, including oral communication, computer presentations, group discussions, illustrations, and diagrams; (ii) incorporating first-hand experiences with objects and specimens, for e.g. animals; (iii) increasing the number of out-
of-classroom opportunities, for example through field trips to museums and nature reserves; (iv) providing students with room for autonomy in deciding what activities they do, how to structure and carry out investigations, etc.; and (v) being flexible and taking advantage of unexpected teachable moments.

In order to increase the number of students who benefit from these educational experiences, institutional support on behalf of formal school settings is important (DiLisi, et al., 2011). In other words, if schools acknowledge the work of informal science programs as valuable by, for example, providing academic credit directly linked to the students’ K-12 coursework, letters of recommendation for internships and college applications, or monetary stipends for their time and work, then larger numbers of students will be more interested in informal science programs and will reap the science educational and career development benefits.

Furthermore, informal science experiences, particularly focused on students gaining realistic perspectives of STEM careers through internships or mentors, for instance, can inform students’ decisions in their formal school settings, including taking the necessary coursework and encouraging discipline and diligence in their schoolwork (Fadigan & Hammrich, 2004). Additionally, students learn academic content and, in some cases, inquiry and research skills that supplement their formal science classes.

Finally, science education should be considered a continuum from formal to informal settings and never an either/or (Liu, 2009). More “free-choice learning” opportunities should be incorporated into structured formal science settings, for example field trips and guest speakers for K-12 students. For older students, on-the-job training
should also incorporate a more formal component such as coursework at higher education institutions (2009).

Utility and Relevance of Science

Another research-based strategy for strengthening students’ interest in science was through emphasizing the utility and relevance of science. For instance, Fouad (1995) found that when science curricula were designed with strategic career development components embedded in the lessons, long-term exploration of science as a career option was triggered. Amongst middle school students, an intervention designed to strategically emphasize the career connections in the science curricula had resulted in an increase in science and math achievement amongst treatment students. The treatment students maintained higher grades than a control group throughout the year, although all students’ grades decreased throughout the year, and treatment students selected a high school STEM magnet program, i.e. a program specifically focused on the math or science career interest, over a general high school more than the control students.

Besides emphasizing future career options, the utility of science can also be demonstrated by identifying its everyday relevance and applications. Strategies to accomplish this include leveraging students’ “funds of knowledge” (Basu & Barton, 2007) (i.e. students’ community, family or experiential knowledge that they bring with them into the classroom) and by identifying everyday science problems that are familiar to students, for instance by exploring health issues and diseases experienced by family members, friends or neighbors (Fraser-Abder, Doria, Yang, & De Jesus, 2010). For instance, in a predominantly Dominican science class, Fraser-Abder, Doria et al. examined the effect of a
nutrition unit structured as a simple inquiry project focused on the health and nutrition impact of a culturally popular food, *plantanos*. This instructional strategy proved to be successful in stimulating interest and scientific inquiry practices amongst the students.

**Background and Contextual Impacts on Science Interest**

Lent, Brown and Larkin’s (1984) foundational Social Cognitive Career Theory (SCCT) study identified a number of important factors related to science and engineering career interests. The most significant factor was self-efficacy with respect to science and engineering. The authors examined the relationship between self-efficacy, persistence and success in science and engineering college majors amongst science and engineering undergraduates and found that students with higher self-efficacy persisted longer and performed better in science and engineering career paths than those with lower self-efficacy. Similar processes influencing interest and persistence in science were identified amongst younger, more ethnically diverse students. For instance, Quimby, Wolfson and Seyala (2007) examined the impact of social cognitive variables, brought to the research fore-front by a proliferation of studies following up on Lent et al.’s study, on environmental science interests amongst high-achieving, college-bound African American teenagers in an urban, scientific and technical high school. Investigative self-efficacy was the most significant predictor of interest in environmental science. Outcome expectations, perceived barriers, support and concern for the environment were also significant predictors. Although not significantly predictive of environmental science interests, concern for environmental issues was significantly correlated with interest in environmental science,
investigative self-efficacy and perceived support for pursuing an environmental science occupation.

Targeting particular factors of career development in science, such as self-efficacy highlighted above, can be significantly impactful because these have been shown to transcend racial and ethnic groups. For instance, math and science self-efficacy and gender have been shown to be significantly predictive of STEM career interests amongst a large number of ethnically diverse high school students (O'Brien, Martinez-Pons, & Kopala, 1999). Similarly, Navarro, Flores and Worthington (2007) tested the validity of the Social Cognitive Career Theory (SCCT) model (Lent et al., 1984) with middle school Mexican American students in math and science. The SCCT model did explain a significant amount of variance in science career development of Mexican American middle school students. For instance, past performances in math and science and perceived parental support predicted self-efficacy. Self-efficacy, in turn, positively predicted outcome expectations in science and math. Outcome expectations, mediated by interests, positively predicted goals in science and self-efficacy, mediated by interests and outcome expectations, positively impacted academic or career goals in science.

A number of other social context factors interact with interest, motivation and self-efficacy and contribute to the science learning experience and related career decisions, as well. Beginning with gender, Zeldin and Pajares (2000) examined how self-efficacy influenced the academic and career choices of women in STEM careers using Bandura's (1986) social cognitive theory as the model. In social cognitive theory, self-efficacy is the foundation of individuals’ interest in an activity and is informed by four main processes: (i)
independent mastery experiences, i.e. opportunities to become skilled in an activity; (ii) vicarious learning opportunities, i.e. role models or learning through observing others; (iii) verbal persuasion, i.e. encouragement; and (iv) individuals’ physical and emotional states related to the activity. The researchers found that verbal persuasion and vicarious learning were important sources for the STEM career women’s self-efficacy more than women in traditional, non-male-dominated, non-STEM career settings. Specifically with respect to verbal persuasion and vicarious learning opportunities, the women identified significant individuals who acted as role models and encouraged them as instrumental to their entry into and persistence in these STEM fields. In 2008, Zeldin, Britner and Pajares extended the former study on women’s STEM career development to examine how self-efficacy influenced the academic and career choices of men in STEM careers. Results indicated that independent mastery experiences were important sources of science self-efficacy for men, which was a different process of STEM career development between the genders. Vicarious learning experiences reinforced the men’s self-efficacy in STEM rather than generated it, as with the women. The men received general social support rather than the social persuasion the women received to persevere in STEM. The men appeared to interpret their own experiences and successes when developing their self-efficacy, while the women appeared to rely on relational experiences to develop their STEM self-efficacy.

Jones, Howe and Rua (2000) also examined the impact of gender, this time, on middle school students’ attitudes towards science and science careers. They found that differences in gender socialization did exist in the appeal of science to the students, their motivation to do scientific jobs and their perception of science. Finally, Miller, Blessing and Schwartz (2006) examined the impact of gender on high school, college-bound students’
attitudes towards science classes, their perceptions of science and scientists and their views about majoring in science. Traditional gender differences did exist, in favor of male students, in terms of interest in and perceived relevance of science study.

Some researchers looked at the intersection of gender and race. Post, Stewart and Smith (1991) examined the effects of gender, interest, self-efficacy and self-confidence in science on Black college freshmen’s consideration of science careers. Gender remained a significant predictor of the students’ consideration of STEM versus non-STEM careers. Amongst the Black college freshmen, science confidence was more significant for males than females with predicting science career interests and science confidence was the only predictor of science career interests across both genders. Additionally, consideration of a science career involved more factors, namely self-efficacy and interest, than consideration of a non-science career, which involved interest alone.

Buck, Plano Clark, Leslie-Pelecky, Lu and Cerda-Lizarraga (2008) examined the cognitive processes used by eighth-grade girls in identifying a science role model in a qualitative feminist study. The researchers found that the girls’ initial views of scientists made them believe that connecting with a scientist in meaningful, supportive ways was not possible. Significant with respect to differences across racial and ethnic groups was that the African American girls felt that race-matching between students and mentors was important, while the Latina and White girls did not. Buck et al.’s study expands the importance of vicarious learning/role model relationships (Bandura, 1986) for girls and women in science by specifying that the social relationship between student and mentor or role models must be caring and personal.
Carlone and Johnson (2007) aimed to develop a model of science identity formation amongst undergraduate women of color in science. Findings indicated that three major science identities formed amongst the undergraduate, ethnic minority women as a result of community experiences, motivation in science, support and recognition from significant people in the academic science communities, for example professors. The students with the most successful science identity performed the highest on tests of science achievement, persisted in the science pipeline and progressed towards post-graduate science study or science careers, were positively recognized by significant individuals in the academic science communities and were most often interested in research scientist or academic careers. The students with the least successful science identity performed the lowest on tests of science achievement, often changed their initial science career plans or withdrew from the science pipeline altogether and were negatively perceived by significant others or were not recognized as significant in contributing to the science community. Between these two groups, a third student science identity was detected. These women performed at a level lower than the first group in terms of science achievement and persisted in their science career interests; however, their motivations were described as “altruistic,” i.e. they perceived their future careers as means to help others, for instance through medicine and nursing, while the most successful and positively recognized group of students were interested in science for the pure enjoyment of it. Recognition by significant others in the academic science community was not important to these “altruistic” scientists and, furthermore, they were strongly connected to their ethnic minority communities. Science was only a subsection of their holistic identity.
Ong (2005) and Malone and Barabino (2009) conducted similar studies to Carlone and Johnson (2007). The ethnic minority university women in Ong’s study manipulated their physical appearances in order to manage within a physics science community and project the appearance of competence. They did so primarily through two main strategies. They either “fragmented” aspects of their gendered, ethnic and scientist identities by playing down or minimizing them in order to “pass” and be accepted or seen positively in the White, male science community, for e.g. wearing pants instead of skirts and acting masculine and competitive instead of feminine and collaborative. Conversely, others amplified certain attributes of their gendered, ethnic and scientist identities, for e.g. a feminine hairstyle, a stereotypically-recognized ethnic attitude or one’s high performance on science tests, in order to project complete confidence and “perform superiority” in order to manage the stressful science community.

Malone and Barabino (2009) explored issues of ethnic minority graduate science students regarding the students’ identity construction or of their being ascribed an identity as “the only one.” The ethnic minority graduate students failed to develop identities in which they satisfactorily blended their ethnic, gender and science identities and, as such, commonly struggled against feelings of invisibility or lack of recognition, exclusion and racialization or reading race in social situations.

Chinn (2002) utilized a narrative methodology in order to explore the process of becoming a scientist or engineer amongst Asian American girls. The author found that cultural norms shaped the women’s families’ gender expectations of them with respect to career choices and life, in general, even for those families in the US for many generations;
however, K-12 gender equity practices and policies were supportive of the girls’ interests and STEM career aspirations.

In a study exemplifying the additive effects of background and contextual factors, O’Brien et al. (1999) examined the relationships amongst math and science self-efficacy, gender, ethnic identity, socioeconomic status and interests in science and engineering careers amongst ethnically diverse, urban high school students. Specifically, they hypothesized that gender and ethnic identity impacted STEM career interests by affecting science and mathematics self-efficacy. They also explored the effect, if any, of family income level. Self-efficacy was significant and directly predictive of STEM career interests. STEM career interest was additionally significantly and directly predicted by gender. Specifically, a significant gender difference in favor of men was detected for interest in science careers. Furthermore, ethnic identity was significantly predictive of self-efficacy, i.e. stronger ethnic identities were correlated with higher levels of science and math self-efficacy, and, thus indirectly influential on interest in science careers. Finally, income level was significantly predictive of Preliminary Scholastic Assessment Test (PSAT) scores, a marker of college readiness. PSAT scores were, in turn, significantly predictive of self-efficacy. Although not explicitly stated in this study, past research has shown that higher income levels are correlated with higher standardized test scores (Brooks-Gunn & Duncan, 1997).

Science education can therefore be challenging or deficient for low-income, ethnic minority students, particularly due to the combination of multiple educational, background and contextual factors, such as quality and form of science instruction in school, availability of out-of-school science education opportunities and the compounding effects of gender,
race, ethnicity, culture and socioeconomic status; however, the following studies describe situations in which low-income, ethnic minority students were supported or appropriately assisted in order to persist or improve achievement in science.

**Institutional Support for Low-Income, Ethnic Minority Science Students**

Russell and Atwater (2005) examined the factors that influenced persistence and perseverance of African American students from high school to college in the STEM pipeline at a predominantly White institution (PWI). The most critical factor of the students’ persistence was their high school experiences in advanced math and science courses in high school and their enrolment in a college preparatory program. Additional experiences as early as elementary school included science fairs and extra-curricular science programs.

Fadigan and Hammrich (2004) examined the educational trajectories of low-income, ethnic minority, urban girls from single-parent families who participated in a Women in Natural Sciences (WINS) program during high school. The girls began with high interests in science and maintained these interests through the end of the program. Positive program features attributed to the girls’ persistence in science included the academic material and job skills learned, the information learned about college, experiences in a hands-on, interactive learning environment and social support.

In another low-income, ethnic minority and immigrant setting, Buxton, Lee and Santau (2008) reported on a university-school partnership that spanned nine elementary schools and facilitated the implementation of teacher professional development and
curriculum interventions in order to enhance science instruction to better serve language minority students. Central to the educational intervention were the year-long teacher workshops and curriculum materials provided for students and teachers, all designed to complement and reinforce each other, and to improve the teachers’ knowledge, beliefs and practices in science instruction and to support English language learning and development amongst the students while learning science, rather than as a disconnected educational endeavor. Additional goals included “…supporting teachers’ and students ‘mathematical understanding; improving teachers’ and students’ scientific reasoning; capitalizing on students’ home language and culture; and preparing students for high-stakes science testing and accountability through hands-on, inquiry-based learning experiences” (Buxton, Lee & Santau, p. 500). Essentially, the curriculum units and workshops assisted and guided the teachers in designing classes with varying degrees of inquiry-based learning and in making the links from the classwork and activities in order to ensure student understanding of key science concepts. Additionally, the curriculum guides and materials allowed teachers to incorporate English language and literacy development educational strategies, as well as incorporate mathematics in teaching. Finally, relevant science terms in the students’ predominant first languages, namely Spanish and Haitian Creole, were used in their science lessons. Findings thus far indicated that Buxton, Lee and Santau were successful in improving science achievement amongst elementary school English language learners (Buxton, Lee & Santau citing O. Lee, Maerten-Rivera, Buxton, Penfield, & Secada, in press).

Institutional support at any level of education is important. Barlow and Villarejo (Barlow & Villarejo, 2004) evaluated an enrichment program designed to interrupt the
attrition of ethnic minority college students from the biological sciences. The program was successful and important in increasing the students’ odds of both graduating with a biological science major and graduating with a $\geq 3.0$ GPA in biology were undergraduate research experiences. Additionally academic, financial and relational support from the program was also significant, despite high school GPA being most predictive of degree attainment.

Finally, Ryken (2006) examined the impact on ethnic minority, first generation college students’ career decision-making processes as a result of a career and technical education offering through a community college-STEM industry partnership. The author detected “tensions” that existed in the students’ career decision-making as they gained science knowledge and skills and became aware of increasing opportunities for their career pathways due to the career education program; but the program was also limiting in that it focused only on one career outcome due to the specific field of study; however, from this partnership and institutional support, the ethnic minority, first generation college students persisted in the pipeline towards a science career.

Despite its established importance, attempts at developing institutional support for low-income, ethnic minority science students can be unsuccessful. Lee and Luykx (2007) reported on an elementary school teacher professional development experience, for forty-three third- and fourth-grade teachers from six schools, aimed at supporting the teachers incorporate ethnic minority students’ home languages and cultures into their science classes in order to simultaneously support science and English language/literacy education. Results indicated that (i) teachers acknowledged the importance of
incorporating the students’ home language into science instruction; however, they were more unsure of their own knowledge regarding how to do so; (ii) teachers viewed the students’ home culture as deficient in prior science knowledge, inquiry skills and habits of mind necessary for science and as something to be overcome and they were similarly unsure of their knowledge or preparation to overcome culture in science instruction; and (iii) teachers believed that low-income students lacked certain science experiences and materials to which middle class students had access. In terms of teacher practices, there was no significant increase in teachers’ incorporation of their students’ home languages into science instruction. Rather, the number of teachers who did not incorporate students’ home language at all increased over the course of two years. Similarly, there was no significant increase in teachers’ inclusion of diverse cultural practices in science instruction.

**Research Problem Revisited:**

From the literature on STEM education reviewed above, the specific research problem of focus in this study is that there is a need to increase the number of interested and competent low-income, ethnic minority students in science in equitable and empowering ways. The theoretical perspective taken on this research problem will be addressed in Chapter 2.
CHAPTER 2: Theoretical Framework

“Simply stated, identity is the kind of person an individual is interpreted to be in a given context ... The term discursive identity reflects an understanding that speakers select genres of discourse with the knowledge (tacit or implicit) that others will interpret their discourse as an artifact of their cultural membership” (Brown, 2004, p. 812 - 813).

As established in Chapter 1, there is a need to increase the number of interested and competent low-income, ethnic minority students in science in equitable and empowering ways. In addressing this research problem, one must consider a number of factors including “border-crossing,” that is the gap which must be bridged between the culture of science and a student’s customary culture at home and within their other local communities, and that it is oftentimes more difficult for low-income, ethnic minority students to “border-cross” than dominant students, namely middle- to upper-class White students (Aikenhead, 1996). From a similar cultural perspective, Barton and Yang (Barton & Yang, 2000) argued that how low-income, ethnic minority students approach and engage with science is often misunderstood and overlooked. Tate (2001) has argued that low-income, ethnic minority students are disadvantaged in science education in urban schools due to limited time for science instruction due to the current pressures of high-stakes testing, tracking and purposeful discouragement of these students away from high-level science courses, a lack of highly qualified science teachers and inadequate access to educational technology, critical in science education today. Finally, from a Critical Race Theory (Ladson-Billings, 1998; Ladson-Billings & Tate, 1995) and Critical Race Pedagogy
(Ladson-Billings, 1994) perspective, Lynn (1999) argued that traditional American educational systems have not been designed to best meet the needs of African American and other non-dominant, ethnic minority students.

From these perspectives, the low numbers of interested and competent science students of low-income, ethnic minority backgrounds becomes an issue of culture and not one of capability. In other words, low-income, ethnic minority students face a number of significant barriers to successful participation in science as a result of difficulties in engaging in science learning environments, particularly in formal school settings. As such, in naming the research problem more specifically, I will state it as follows:

There is a dearth of educational structures and strategies that can increase the number of interested and competent low-income, ethnic minority students in science in equitable and empowering ways.

The Role of Identity Research in Science Education

Research in identity development and student interest has helped in answering a number of questions relevant to the research problem of insufficient equitable and empowering educational structures and strategies that can support low-income, ethnic minority students in learning science. Such answers include insight into when and why students choose to engage in an activity (Barton, 1998); what students gain from participation (Barton & Tan, 2010; Furman & Barton, 2006); and conflicts and tensions students experience during engagement in a particular environment or community (Brown, 2004). Thus, in this study, theoretical perspectives of identity development will be
utilized in examining low-income ethnic minority students’ participation, interest and career development in science. Furthermore, identities are developed in relation to practices. When a person develops an identity, she is interpreted as being a certain kind of person as a result of performing certain behaviors that are recognizable by others in a defined setting. Science, in this case, serves as the practice. In this chapter, I will develop the concept of science as a cultural practice. Next, I will define the theoretical framework of identity development, more specifically named as identity negotiation, used in this study. Finally, I will review the literature of how identity development has been researched in the field of science education.

**Science as a Practice**

Science can serve as a practice, “context” (Barton & Tan, 2010, p. 195) or “figured world” (Holland, Lachicotte Jr., Skinner, & Cain, 2003) in which students take up and experiment with different identities including that of a scientist. Science as a practice, discourse or community involves specific knowledge, skills and know-how; but participation in a scientific practice also involves feelings of inclusion and belonging and belief in the value of the scientific activities.

Being drawn to or choosing to engage in science is a decision amongst many lifelong decisions, that are more or less deliberate, that one makes in taking up a social identity which will communicate who she is and wishes to be. For instance, in performing one’s gender, one can choose to engage or not to engage in science depending on one’s perception of science as a masculine activity or subject area (Brickhouse, 2001). Similarly, in performing one’s ethnic affiliation, some ethnic minority students might perceive strong
social messages that dissuade them from long-term participation in science study. As such, they might not perceive science as a viable or available practice for them.

Participation in a science practice can be a means for one’s holistic identity development (Kozoll & Osborne, 2004). As argued earlier, science is a community of practice and more than a body of facts. It is a set of practices; but, science is and can be more than a set of practices providing an educational internship for budding scientists, doctors, pharmacists and engineers or for those who just enjoy science or see themselves as science people. As the means for individuals’ exploration of self as they develop holistically and find their place in the world, science might support the pursuit of a high-paying STEM career to escape urban poverty or a career in medicine because one sees doctors and nurses as caretakers; however, it can also provide a medium for social connections, as one works in groups for projects and sharing findings; provide an academic space in which one develops self-confidence; provide enjoyable learning experiences; or provide a worldview by which one examines and enjoys simple things in life such as grass growing where it was previously trampled away by heavy foot traffic (Kozoll & Osborne).

In schools, the practice of science is not traditionally positioned, taught and learned within a broader context in society. Furthermore, the multitude of individual purposes from which people can derive use in science are not all entertained in in- and out-of-school science spaces (Kozoll & Osborne, 2004). Additionally, some discourses are more naturally aligned with the discourse of science as taught in American school systems (Aikenhead, 1996; Brown, Reveles, & Kelly, 2005), for e.g. a belief in traditional Western medicine, as opposed to a sole belief in miracles for curing illnesses, is more aligned with the topics in
biology and epidemiology taught in American public schools. One’s position in different subcultures, including Westernized beliefs, religion or specific political affiliations, can make the practice of science more or less difficult to take up.

In Taking Science to School, a review of the literature on the nature of science and how young children learn science, science was defined as a systematic process of inquiry; a process that involves theory testing and model building; a process that relies heavily, if not solely, on evidence and the validity, consistency and coherence of arguments based on evidence (National Academies Press, 2007b). Science was said to not be an accumulated body of “facts,” but rather those “facts” are empirically-determined, reliable information on which to build future theories and models. Furthermore, those “facts” are not definitive, but rather highly plausible as determined by rigorous testing and continue to be modified based on future scientific inquiry.

The scientific method, is still not an unchanging, step-by-step procedure. It involves creativity, innovation and novelty. Despite differences in the approach and products amongst the various branches of sciences, all science communities share common features. These include that data and evidence are unwaveringly important; data and evidence are systematically and rigorously analyzed; analysis is followed by a process of argumentation linking data and evidence to theories; and developing theories, hypotheses and models must be critiqued by peers and the researchers themselves to ensure validity and consistency.

Science involves a diverse set of skills and practices. Traditional science taught in American public schools emphasizes or focuses solely on laboratory experiments; however,
observation, interview, historical analyses, analyses based on statistics and probability, as well as other non-experimental methods are empirical methods of inquiry (National Academies Press, 2007b). The science community is similarly diverse and widespread:

[Philosophers of science], as well as scholars in the history of science and the sociology of science, see scientific inquiry as model or theory based, increasingly conducted by groups and communities of scientists, and influenced by investigators’ conceptual understandings about the phenomena under study. Scholars have also shed light on the elaborate social and technical apparatus on which the conduct of science depends, including instruments, tools, charts, and graphs, research articles, journals, research groups, universities, and the larger society (National Academies Press, 2007b, p 1–6).

Overall, science is defined as a process of logical reasoning about evidence; a process of theory change; and as a process of participation in the culture of scientific practices (National Academies Press, 2007b). In this study, I focus on science as this cultural practice consisting of scientific habits of minds, ways of knowing, skills and knowledge in which students can become engaged.

**Theoretical Framework of Identity Development**

**Discursive Identity**

One’s discursive identity is what she attempts to communicate to others as the kind of person she is or wishes to be in a time and place (Brown, 2004). Discursive identity is recognized or defined in relation to a community, shared practice or discourse and once a
person is able to participate competently in that community, practice or discourse, she can be considered literate in that community, practice or discourse (Brown, et al., 2005).

To be identified as a certain kind of person, one must use certain social cues with the hope that others will interpret her as that kind of person. The signals and cultural tools people use to cue their desired identities are referred to as genres of discourse (Brown, 2004; Brown, et al., 2005). A predominant genre of discourse used to communicate community membership is language. Others include content knowledge, dress, bodily gestures, communal practices, assumptions and beliefs.

Discursive identity development permits individuals the use of agency (Brown, 2004). In other words, people can more or less deliberately make decisions regarding performing the activities of a community and, thus, being identified as a member. For example, in Brown’s examination of discursive identity formation amongst ethnic minority science students, he uncovered four domains of student discursive identities in the science classroom. These included an “opposition status” in which students avoided the use of science discourse by, for instance, avoiding or refusing to use scientific and technical terms when speaking or explaining, instead allowing others to do so or denying their knowledge or understanding of a science question or problem; and a “maintenance status” in which students transiently employed science discourse and, instead, returned to non-science discourses, genres and speech patterns in order to maintain another cultural identity. An unfortunate implication of the “opposition” and “maintenance status” can be that despite students’ knowledge or competence in the science area of interest, they might deny this or curtail their explanations of science phenomena in attempts to maintain cultural identities.
outside of science or to avoid negative social interactions with peers. “Incorporation status” included incidents in which students attempted to and sometimes accurately employed and performed a discursive science identity; however, they still struggled with these and were not as yet natural in these areas; and, finally, “proficiency status” included incidents in which the students were able to naturally, comfortably and accurately engage in a science discourse extensively in their everyday classroom activities.

To ground some of the above in student action, an example of a student’s use of agency in developing a discursive identity in relation to this science classroom was one student’s choice to demonstrate his knowledge and competence via a common scientific practice of collaboration when requested by the teacher, the authority figure, versus when requested by a peer. This student enacted a maintenance science discourse status as he was capable of assisting another group member, but chose to do so for short period time and only when asked by the teacher. Another example were the choices several students made in order to resolve conflicts experienced in bringing together their language patterns with the discourse of science through their variable use of Standard English or Ebonics when describing scientific phenomena. Depending on students’ choices, they would range anywhere from opposition to proficiency discourse status.

How the students in Brown’s (2004) study came to participate in science discourse or not, therefore, ranged from a total transformation from their more native discourses to a predominant science discourse or to a blended discourse or to a discourse that completely rejected scientific practices. The identity that they developed through the use of
whichever discourse they chose or had available to them, communicated many times through language, was their “discursive identities” (Brown, et al., 2005).

**Identities-in-Practice**

Similar to Brown (2004), Tan and Barton (2008b) developed the concept of “identities-in-practice” to explain students’ use of various social cues in order to be interpreted as certain kinds of people in relation to a practice, such as a science classroom. Tan and Barton acknowledge the existence of an official hierarchical power structure in science classrooms that defines some forms of behavior, interactions, and social cues as more legitimate and recognizable in the science classroom. Power is an important issue to consider in combining or competing subcultures associated with membership in different practices as those aligned with existing recognizable behaviors are afforded more legitimacy, while those that are least recognizable are at the highest risk of being marginalized (Barton, Tan, & Rivet, 2008). For instance, the science teacher is an important authority figure and gatekeeper to success in science as she assigns tasks and rates the quality of one’s work. Additionally, some students can be recognized by their peers as the “good science students” based on their disciplined behavior in the classroom and their diligence with their schoolwork.

Although Tan and Barton (2008b) acknowledge that as students enter a practice, they encounter an existing power structure that makes available to them certain options in defining themselves, like Brown, their discussion of identities-in-practice places some of the identity forming power in the hands of individual students:
“Identities-in-practice” in the context of this research therefore refer to the identities students acquire or choose to adopt in the science classroom. On initial entry into a figured world, novices gain social positions that are accorded by the established members of that world. How novices choose to accept, engage, resist or ignore such cues shape their developing identity-in-practice and determines the boundaries of their authoring space, which is driven by a sense of agency (Tan & Barton, p. 49).

Students are said to negotiate with the official hierarchical power structure in science classrooms in developing their “identities-in-practice.” They do this by making decisions regarding how they interact with other powerful members, how they approach and handle assigned science tasks, and what they choose to ask or say in the science classroom.

Furthermore, the concept focuses on “identities-in-practice” as opposed to “identity-in-practice” as students have multiple repertoires available for social interpretation and choose to forefront or deny these as students enter and exit different practices, for e.g. the science classroom, the basketball court, or an after-school community center program. Additionally, these identities-in-practice are dynamic within individual practices, as well. For instance, the cues available in a whole class discussion might be different when a student operates within a small group, a pair, or works individually.

In their study of identities-in-practice, Barton, Tan and Rivet (2008) uncovered multiple strategies that middle school girls engaged as they participated in science. These strategies enabled them to contribute productively to the practice, in terms of
accomplishing the tasks of the science classroom. They highlighted three in their paper. First was the practice of creating “signature science artifacts” that supported the science activity and cued participation in science. Importantly, however, these also incorporated other aspects of their holistic repertoires available from membership in other practices. For example, one girl composed an original song about the skeletal system as a mnemonic device to help her remember the bones in the human body. This brought together her participation in science and her participation in practices of music and singing. Another girl created a “3D-sculpture” of a rabbit in the form of a magnet as a supportive educational resource to her poster presentation on an animal she researched. This allowed her to combine her long-term participation in art with her present task in science.

Another practice employed by the girls was the development of novel identities with respect to the science activities, such as “nerd” or “animal lover.” These kinds of science definitions were not previously assigned to any students, but over time, the girls accepted these identifiable titles for themselves and others within the science practice.

The third practice, “negotiating roles through strategic participation,” was used by some girls to change their participation in the science community over time, becoming more central or gaining more authority, while at the same time lowering the social risk of becoming more active in the science community. For example, one girl who was known for being somewhat disruptive and a classroom rule-breaker, eventually merged her ways of participating in the class and the goals of the science activity in order to remain on task and be successful. These included her still moving around the class when she should be seated, but doing so to show others her work in science. Another included the girl still refusing to
raise her hand in order to speak, but instead pointing to herself and other gestures, which was still better appreciated than simply shouting out disruptively. Her teacher also eventually began to acknowledge these as normative in the classroom activities. This circumvented the issue of decided between the girl’s compliance with classroom rules and expectations and her participation in the science activities.

Overall, at the start of an academic year, the girls in Tan and Barton’s (2008b) study entered into a new practice, that of a middle school science classroom at different levels of recognition and legitimacy in terms of doing “good science” schoolwork. Over time, the girls negotiated with the cues and routines available to them, for e.g. codes of behavior and discipline, assignments of poster presentations, learning science content for a test, and asking and answering questions. In negotiating with the cues and routines, the girls took these up and performed them as expected, combined them with cues and routines that they were already familiar with or which they better preferred, or rejected them completely for alternative signals. The official authority in the classroom, the science teacher, acknowledged these cues, made them recognizable to other students, and as such, permitted the girls’ development of science identities-in-practice, i.e. students involved in learning and doing science. The girls’ identity development processes, therefore, involved the negotiation of individual agency with pre-existing options of social cues and behaviors that comes with the practice of interest.

Continuing to emphasize the role of both individual agency and pre-existing power structures in students’ engagement in the science classroom and, therefore, in their opportunity to learn science, Furman and Barton (2006) further discuss the concept of
“voice.” “Voice” was comprised of the choices students made, what they said, did and aspired to, when engaged in science communities or practices. Furthermore, “voice” was used in students’ development in their lives, in general, and, as developed earlier, knowledge of or membership in other practices beyond science had an impact on students’ enactment of voice in science and vice versa.

In Furman and Barton’s (2006) study, two boys from a low-income, ethnic minority, urban community, involved in an afterschool science program, used “voice” to author identities-in-practice that were important to them in terms of how they saw themselves and wanted to be perceived by others. While in the science community, the boys made use of resources available in that science community of practice to author identities that communicated what they aspired to be. These resources included going to field trips, for instance, the zoo in order to learn more about animals and show others what they knew about the animals, as well as accessing the video equipment and technology to demonstrate their skill in making the videos. By performing certain tasks and behaviors in the afterschool science program, for e.g. creating a funny, but informative and scientifically accurate, video about animals at the zoo, the boys were able to be interpreted by their peers and instructors as they had desired. Specifically, they wished to be recognized as knowledgeable in science, skilled in using the technology and as funny and popular to their peers. They negotiated the pre-existing science tasks and resources with their decision-making in accomplishing the tasks to be identified as knowledgeable, skilled and popular.

In another study, Barton and Tan (2010) found that low-income, ethnic minority students similarly enacted agency when they “co-opted” science and authored Community
Science Expert (CSE) identities in order to also be seen as knowledgeable and to make science accessible to all community members in and out of school. As in the previous cases, students made use of resources and negotiated the pre-existing structures in order to communicate who they are and who they want to be as opposed to dominant expectations of them (Elmesky, 2005). The students collectively authored novel identities within and through science, using science as “both as a context and as a tool” (Barton and Tan, 2010, p. 195), and through this process they solidified their positions as knowledgeable in science, came to understand core scientific concepts and produced cultural artifacts by doing science, for example through data collection and analysis, interviews of community members and the production of a mini-documentary on urban heat islands. The students also critiqued the process of science, for instance its elitist or alienating nature, science’s language being dense and complex and science content being abstract. By authoring and enacting a CSE identity as they were engaged with and used science, the students gained significant entry into and changed the science community as they enacted the practices of an expert by mastering the technologies of the project, conducting scientific experiments and sharing their knowledge of the scientific phenomenon, urban heat island effect, with community members, expanded these perspectives by including valid insider knowledge, such as personal accounts of the phenomenon and by incorporating youth identities and discourses such as music, drama, slang and certain types of animation.

Tan and Barton’s (2008a) concept of identities-in-practice concept of identities-in-practice focused on students working within pre-existing structures equipped with resources, tools and recognizable behaviors, but who also infused their individual agency and took some amount of control over how they got recognized within a scientific practice.
Definition of Science Identity Negotiation/Development in the Present Study

The theoretical perspectives reviewed, i.e. Brown (2004) and Barton (2008b), inform the definition of identity and the corresponding process of science identity negotiation used in the present study. One’s identity is defined as the kind of person one is recognized or interpreted to be following her purposeful use of an available repertoire of behaviors and social cues associated with a practice. As such, an individual negotiates the role she plays or identity she develops through the use of agency within a pre-existing structure, i.e. within the limits of the behaviors and social cues to which she has access. Finally, an individual can bring new cultural forms and signals to the present practice as a result of membership and familiarity with other practices.

A student can therefore develop a science identity within a specific scientific practice by tending to the tasks of the practice and making use of the information and technology available in ways deemed successful. Success would have been defined by those who have established the scientific practice, including research scientists, science teachers, after-school science program leaders and science professionals. The student will learn how to accomplish the tasks and use the tools from them and, as such, they must come to recognize the student’s work, developing or final, as appropriate. Furthermore, a student can do the tasks and make use of the tools in traditional ways, as modeled by already established members of the practice, or in novel ways by making use of other behaviors and cues brought with them from other practices. Importantly, the science identity is developed when the student is recognized as performing or learning to perform tasks as communally established.
In this study, scientific practices in formal and informal educational settings are of interest. Based on knowledge of science education practices, a number of behaviors and cues are indicative of a science identity. A student can be recognized as a contributing and competent member of a scientific practice within a formal or informal educational setting, and thus develop a science identity, by exhibiting: (i) an increased level of engagement and participation in the science activities; (ii) a positive affect and enjoyment of the science activities; (iii) demonstrated competence and proficiency with the scientific tools, for example the technology, language and content knowledge; and (iv) development of long-term STEM career plans.

**Specific Research Question:**

Based on the definition of identity and science identity negotiation, the following research question will be pursued:

**By examining various genres of discourse, with a particular focus on language, what kinds of identities do students negotiate with respect to a specific science practice?**

This research question will allow me to examine the ways in which students develop science identities by negotiating their student agency and the available behaviors and social cues within a science practice, namely an informal science educational setting. Of additional interest are the specific factors or design features of that informal science setting that may or may not be supportive of science identity negotiation. Finally, simply doing the tasks of a science practice does not permit interpretation of the students’ behavior as
indicative of serious consideration of long-term science study and STEM career interests. Thus, examination of students’ science identity negotiation in relation to their developing or sustained career interests is also of interest in this study. **Specific research sub-questions** are as follows:

a. **In what ways did the students develop science identities by negotiating their student agency and the available behaviors and social cues within a science practice?**

b. **What factors available within a science practice supported the negotiation of student science identities?**

c. **What science identities did the students negotiate in order to be identified as considering science and STEM careers in the long term?**

As discussed earlier, an individual negotiates the role she plays or identity she develops within a practice through the use of agency within a pre-existing structure. There is, therefore, an interaction between individual agency and structural power. In some cases, students are permitted autonomy over the science identities they develop. In other cases, schools and other institutions impose specific science identities onto students. Then, there are cases in which there is neither one nor the other. In the review of the literature that follows, examples of each of these cases will be presented.

**Youth Agency in Science Identity Negotiation**

Gender, race, ethnicity, culture, nationality, religion, socioeconomic status and other individual traits and background factors are significant in influencing students’
participation in science. How students seek to perform or forefront these aspects of themselves will have an impact on the behaviors and social cues they enact as they participate in science.

In Barton’s (1998) study, students’ lived cultural experiences as a result of homelessness and low socioeconomic status shaped how they participated in an after-school science practice. Barton argued that in order for all students to engage in science in genuine, meaningful ways that educators have to acknowledge and build from the diverse ways of knowing and lived experiences of the youth with whom they work. Through conversations, the students expressed dissatisfaction and negative reactions to the city in which they lived. They found it dirty and polluted. These lived experiences of the students made entry into a science discourse around pollution a relevant and significant undertaking possible. Barton took detailed notes of the students’ issues and constructed a data table of complaints, as well as a column for people’s feelings and reactions. After the students filled out as much as they could, they then interviewed people throughout the neighborhood to learn more about what others thought about pollution. This project expanded into an 8-week endeavor and, from the research findings, culminated in the development and implementation of a neighborhood clean-up plan, the planting of vegetables and flowers and recycling programs.

In other cases, socioeconomic status, as well as intercultural fighting and the desire for freedom, were the motivations underlying young women’s agency in entering science practices (A. Johnson, Brown, Carlone, & Cuevas, 2011). In case studies of three women of color, an American Indian, a Black and a Latina woman, the women authored identities
with respect to science either because there were no other desirable identities or as a matter of urgency. For instance, intense intercultural fighting that took place at the middle and high schools in the American woman’s neighborhood encouraged her to escape to the college environment after school and to enroll in a Biology program. In another case, the Black woman was told from an early age that she will be a medical doctor in the future. Her parent had high expectations for her and her sibling and, working with that assigned “future medical doctor” science identity and a desire to be out of the house and away from the controlling parent as much as possible, she enrolled in multiple after-school programs, including one for pre-medical Black students of color. In the third case, the Latina woman, encouraged by her mother, had enrolled in enrichment programs at her school as preparation for her high career aspirations as an attempt to escape urban poverty already common as a result of her single-parent, inner-city Latina upbringing.

In authoring their science identities over the years, the women encountered significant conflicts, as well (A. Johnson, et al., 2011). Some of these were complex, yet could have easily gone unnoticed. For instance, the American Indian woman graduated high school and was then enrolled in an undergraduate microbiology program. At one point, she was forced to decide between dissecting a frog in Biology class in order to continue her microbiology major and going against her American Indian religious beliefs that did not permit dissections, particularly when pregnant, which she was at the time. In the other cases, the Black woman was afraid that doing well in science would negatively impact her hip, Black woman identity amongst her peers and the Latina chose to opt out of AP science classes during her senior and instead pursued student council which was important to her that year as she was planning to reach out to the educational
administrators and try to get classes such as African American and Latina history in order to “learn about [their] story, too...”. The woman experienced conflicts between participating in science communities while simultaneously occupying places in an American Indian religious community, a Black social circle and a Latina student activist community.

Eisenhart and Edwards (2004) uncovered similar patterns of active and purposeful student authoring of identities through agency in participation in science activities amongst low-income, urban high school girls. Eisenhart and Edwards investigated an after‐school intervention intended to increase urban, African-American middle school girls’ interest and participation in computer technology and science. What they found was that the girls’ motivation to learn and grow with respect to technology was sustained over time when they “appropriated” the technology, i.e. when they engaged with the technology in order to leverage it in personally meaningful or unique ways, most often as extensions of their gendered and ethnic identities. For instance, the girls learned to use the computer technology in order to create business cards onto which they transposed an altered image of a Black Betty Boop icon, surrounded the Betty Boop icon with hearts or adapted a dragon icon from a famous Black hip hop artist’s website. Additional technology tasks that the girls accomplished included using the internet to obtain the phone numbers of boys they wanted to contact, using the word processing software to make Valentine’s Day cards for boys, using the technology to scan, size and transfer pictures onto T-shirts for themselves or for gifts for others, being “inventors,” for instance designing temperature-controlled containers for use during a barbeque or for designing fashions, and using technology to gather information from the internet, from CDs or videos in order to discuss
topics such as famous Black women, sexual reproduction, babies, parts of the body and body size. The positive effects of "appropriation" in enhancing students’ motivation to learn science was also detected in an informal summer environmental science program for inner-city, low-income, ethnically diverse high school students (Blustein et al., pending). For instance, within a small group of friends, the boys would playfully tease each other by using new scientific vocabulary.

Eisenhart and Edwards (2004) used a design experiment methodology of curriculum design which involved iterative design and modification of the curriculum as they observed its implementation. This design helped to maintain an equitable balance between the researchers’ learning goals and the students’ and their families’ learning interests. The point at which the top-down (researchers'/university's) and bottom-up (girls'/families') science learning goals met was a “hybrid third space” (Eisenhart & Edwards citing Bhabha 1994; Moje et al. 2004; Gutiérrez, Rymes and Larson, 1995), i.e. learning spaces mutually constructed and more accessible to all of the students.

In Lewis and Collins’ (2001) study of undergraduate African American students in STEM majors, they found that the students similarly enacted agency and choice in their involvement in the practice of science. The students’ decisions to persist in science and pursue STEM careers were influenced by their deep-seated life goals and their growing body of knowledge and experiences in the various career fields of interest. Science was positioned in relation to many other aspects of these students’ social identities. If science was compatible with these other important aspects, then student interest and participation in science were sustained (Lewis & Collins). For instance, one of the students, an African
American male, came from a low-income, suburban background with family and childhood experiences that made him value time for family, strong relationships and friendships, excelling in his academic work, time for personal activities and being financially successful or stable. With additional experiences in the school of engineering and through engineering internships, the student still saw the strong possibility of financial success in the short term with a career in engineering, however, the time required for school work took away from his personal time for family, friends and personal activities such as working out and maintaining a healthy diet and lifestyle. Additionally, his work experiences changed his perception of engineering from enjoyable work with mathematics, problem-solving and robotics, which were the basis of his initial interest, to engineering involving a lot of boring office work. He liked putting “110%” into his work, but did not feel passionately enough about engineering. As his goal regarding money was the only goal satisfied by a future career in engineering, his interest was not sustained and he eventually pursued another path.

Another African American male in Lewis and Collins’ (2001) study did, however, sustain his interest in a pharmaceutical career. His initial interest in a science-related career was as a means for earning money, similar to the first African American male; however, over time, perceived aspects of and possibilities through his future career in pharmaceutical research resonated more strongly with his more deep-seated, pervasive traits of idealism and activism. For instance, he dreamed of world peace and harmony amongst men. He critiqued the STEM industry as being cutthroat, at times, and petty; however, he saw his work as a means to being able to help humanity by finding cures for diseases, for being a mentor, for being sincere and honest in his work and as being
compatible with having a family. Despite learning about some of the unattractive aspects of science careers and scientists, he aimed to change the industry from the inside. And so, his goals to do good work for humanity, to improve the STEM industry and to live an honorable life were all aligned with his pharmaceutical career goals. As such, his interests and developing science identity persisted.

**Institutional Positioning in Science**

Institutions possess the power to ascribe identities to individuals beyond their use of agency. Within practices, existing definitions of the kind of person one is can be assigned to individuals. For instance, the women in Johnson et al.’s (2011) study had to manage undesirable identities as low-income, ethnic minority people with exposure to violence or limited possibilities in careers and financial means of livelihood, as well as a host of unnecessary identities throughout their science educational and career journeys based on their ethnicity or gender. Examples included coaches and other students denying the Latina woman’s self-perceived identity as a pre-med undergraduate in an athletic training internship and instead defining her in terms of a female “groupie” wanting to be around athletes and as a student of color hanging out with athletes, who were also predominantly students of color. In order to avoid being labelled in undesirable ways as she went on a series of interviews for a civil engineering internship, the Black woman minimized certain ethnic traits, for instance by flat-ironing her hair, and “dress[ing] the part” by wearing an unattractive, but professional outfit.

The women also felt that they had to work hard and be particularly cognizant of their actions and decisions, especially when related to or triggering thoughts about race.
and ethnicity, in order to continue developing their science identities (A. Johnson, et al., 2011). They felt that these issues were unique to them as people of color and as women. For instance, on uncovering a research finding that identified the genetic difference underlying a disease’s predominance in White as opposed to Black people, the Black woman hesitated in mentioning this, afraid of calling attention to race.

Johnson et al. (2011) concluded that identities are not solely up to the individual, but result from a combination of agency and location in a “matrix of oppression” (p. 359) due to race, ethnicity, culture, gender, socioeconomic status, etc. Location in a “matrix of oppression” can stimulate, sustain, curtail or completely eradicate one’s authoring of a science identity. Additionally, an individual’s skill at authoring identities can grow over time. Over time and at new stages of one’s educational and career trajectory, an individual faced with multiple structural barriers, for e.g. due to ethnicity or gender, might likely have to conscientiously and continuously author her science identity in desirable ways.

In other cases, some low-income, ethnic minority students were unable to escape the structural effects of socioeconomic class, race and gender. For instance, Aschbacher, Li and Roth (2010) examined why some high school students amongst an ethnically and economically diverse group, initially very interested in STEM careers, persisted while others did not by focusing on identity and communities of practice. From findings, three major groups emerged: the High Achieving Persisters, the Low Achieving Persisters and the Lost Potentials. These three groups developed as a result of different experiences within science communities of practice in and out of school and in their extended families and
communities. The three groups also came from three distinct school contexts, calling into question the institutional-level influences on STEM career development.

In the Aschbacher et al. (2010) study, the group of students who eventually left the "science pipeline" were mostly low-income, ethnic minorities who were eligible for free or reduced-price lunch and were mostly from a school serving such students. The group that remained in the "science pipeline" was further differentiated as "high-achieving" and "low-achieving persisters." Similarly, the "high-" and "low-achieving persisters" represented different schools. The "high-achieving persisters" graduated from high school and proceeded immediately to college in pursuit of their careers as doctors, engineers and research scientists. They had typical student perceptions of 'school science,' such as that science was dull, boring and difficult; but they also held "altruistic interests" in science, such as to help people and to learn about the physical and biological world, and they also participated in extra-curricular science activities such as science fairs, research and internships in hospitals and zoos. They also often had family members who were science career professionals and who were able to provide science-career-related information.

The "low-achieving persisters," on the other hand, were all low-income, ethnic minority girls who aspired to be doctors and dentists. They also had "altruistic interests" in science; however, during high school, much of their time outside of school was taken up with after-school jobs; following graduation, many had to compromise to other science-related careers, such as nursing, which they could attain through community colleges or vocational or technical schools; and the girls were often first-generation college students without access to family members with science-career-related information. The three
groups of science students came from three major different family backgrounds and schools. Beyond differences in cultural, social and financial capital afforded by different families, one might wonder if the different schools promoted, more or less explicitly, different types of science identities, career options and educational pathways to those careers, for e.g. traditional 4 year colleges, community college or technical/vocational program, as well as different kinds of educational or social support. That the low-achieving persisters aspired mainly to be doctors and dentists is noteworthy as even the scope of career options within the science community differed between the high and low-achieving persisters.

In another case, Lau and Roeser (2002) found an interesting negative relationship between extracurricular science engagement and school science grades, i.e. greater extracurricular science engagement was correlated with lower school science grades. The authors attributed that unexpected finding to a statistical anomaly perhaps due to “a suppressor effect arising from a strong correlation between task values and extracurricular engagement (r=.54)” (Lau & Roeser, p. 156). An alternative hypothesis from a sociocultural perspective might be that perhaps “school science” was not sufficiently appealing to these students or compatible with their extra-curricular science identities. As such, these students might be proficient and capable, but reluctant or unable to cross the borders into the required “school science” activities or behaviors in order to earn the higher grades in school.

In another study, Brickhouse, Lowery and Schultz (2000) found that middle school girls who took up available identities that were closest to an institutionally-/school-defined
“good science student” identity, for e.g. quiet in class, consistent with home assignments and responsive to teachers’ questions, were perceived as most successful in science or as likely to accomplish their future educational and career goals by their teachers and peers; however, with respect to the girls who participated in science communities far removed from school-type applications of science or who needed to be emotionally engaged in the activity in order to participate in the science practices, for e.g. one girl was very engaged in the hobby of rock collection and another spent a great deal of time helping her father work with machines and technology based on his work involving medical instrument repairs and his hobbies with cars and motorcycles, their science identities went unnoticed and as unremarkable even though they were arguably more interested, passionate and intrinsically motivated in science. This is unfortunate as these are the characteristics that would better predict lifelong participation and innovation in science.

Brickhouse et al. (2000) critiqued the assumption underlying “school science” that sought to enculturate students into science based on the practices of research scientists as this identity is too distant and irrelevant to many students and the research scientist identity is far too narrow to be representative of all of the possible ways to interact with and do science. As such, many students, particularly low-income ethnic minority youth, begin at the margins and face incredible challenges in authoring accepted and recognizable science identities, for instance due to a lack of personal relationships and opportunities for contact with scientists, schools that lack the equipment to permit educational experiences that mimic the work of scientists and lack of access to science clubs, afterschool programs, science fairs or science-related internships that increase time doing science and the likelihood of meeting other scientists.
Brickhouse and Potter (2001) present additional evidence for the inescapable institutional effects of race, gender, ethnicity and class in developing identities around science. They presented a case study focusing on two young women of color from poor to working class backgrounds. They were both very smart students; however, one of the young women was positioned as better suited for science as compared to the other. This young woman appeared to fit the “smart science student” identity as she was always diligent in her work, disciplined in class and others looked to her test scores in order to determine if they did well enough. She, however, was marginalized in an honors class comprised of students who were all White and significantly richer than she was, was denied fulfilling and supportive relationships amongst her peers in class by being isolated socially and eventually failed critical exams, thus having to switch to business and finance studies. The other student who was very much overlooked in science and school, in general, was very successful in computer science given informal and social relationships around science and technology. For instance, she spent a tremendous amount of time online in chat rooms and in order to work around her father uninstalling the software, she figured out a way to hide the software on their home computer system. She already had an existing social identity around computers and as such expanding her science identity in the computer science classroom was a more manageable or desirable process for her. She also maintained some power in authoring her science identity as she did not wish to fully enter the masculine world of computer science, but did adapt some of its characteristics on her terms. For instance, she adapted some level of competitiveness like her male computer science peers, as well as some of their interests, but still maintained some amount of her individuality and femininity. The first young woman, on the other hand, was ascribed a
negative identity in relation to the science classroom based on race and socioeconomic status and lacked any supportive outside science communities to make up for what she was missing at school.

**Negotiating between Institutional Power and Individual Agency**

Individual agency or institutional positioning does not always win out. In some cases, students were able to negotiate these two sources of power. Brandt (2008), for instance, described "locations of possibility" in her study in which young American Indian women in undergraduate science programs were, at times, able to successfully interact with communities of science as they pursued their degrees. Some were fortunate enough to find or carve out spaces which were more hospitable to them as opposed to the more isolated and competitive university science setting and non-American Indian faculty members and peers. For instance, one student was able to work with another American Indian woman in order to work through the science texts and notes and be more prepared for their classes. Another “location of possibility” for this student was her coursework in Native American Studies in which she felt free to view education from a cultural-historical perspective, to ask questions freely and trust the information that they received. Another student did not find supportive and hospitable “locations” on the university campus; however, she often reflected on the positive experiences she had had in the past during a summer research program at another university. There she was able to develop a positive research science identity, but this was gradually eroded at her home university due to a lack of support there. In other cases, some women were unable to form meaningful relationships with faculty or study group peers. Not surprisingly, based on “locations of
possibilities” or opportunities to engage in discourses in order to develop positive and satisfying science identities, some of the women were able to persist and graduate. Others were not as successful and withdrew from college altogether.

Students carving out “locations of possibility” (Brandt, 2008) within institutional oppression is an encouraging finding; however, despite attempts at this, the ways in which some students sought to make inroads into science were still sometimes overlooked. Significant missed educational opportunities can result from overlooking the unique connections students can make to science. For instance, Barton and Yang’s (2000) critical ethnography told the story of a young man who was quite actively engaged in science in extra-curricular and out-of-school activities; however, a combination of disregard for the student’s interests and motivation in science, disconnections between the student’s in- and out-of-school activities, inequitable school policies, namely tracking, and urban poverty resulted in an excited science student’s interest being trivialized, marginalized and waned over time (Barton & Yang).

Seiler, Tobin and Sokolic (2001) also presented a case in which two cultures, a low-income, urban youth culture and a traditional science classroom culture, came together to form an unrecognizable science discourse that could not, at the time, be taken advantage of by the co-teachers in order to aid the students in moving closer towards a traditional science discourse, one that would have benefited them in the then school-sanctioned terms of achievement in science. The authors designed a Physics curriculum that centered on the design, test and redesign of model cars that would serve as the context to learn concepts related to Newton’s laws of motion. During the implementation of the curriculum, the
students engaged in science learning and practices that were hybrid combinations of and reactions to their experiences outside of school, namely as low-income, urban students. For instance, they resisted being controlled by the teacher when they were collectively called to silence for a whole-class discussion or presentation. Rather, they preferred to and continued to speak amongst themselves. Within these subversive communities, however, were conversations that involved science concepts and technical terminology that were overlooked. Additionally, the students desired to be respected and viewed favorably by their peers. As such, they were reluctant to move forward with certain aspects of the curriculum, namely testing and timing their model cars, because it created a public opportunity for failure. As a result, although many students produced the desired car, they hesitated and refused to go past the “test” component of the curriculum.

Some educators seek to respond to missed science education opportunities such as those described above. Space has been made to permit students to authentically engage in science in self-driven and self-determined ways.

**Institutional Space Made for Student Authoring of Science Identities**

Rahm (2008), for instance, described a number of cases in which, when provided sufficient latitude to bring personal meaning to school science, poor, urban students in Quebec suddenly “woke up” and became engaged in science. In Quebec, these students were similarly positioned marginally in school, in general, and science, in particular. For instance, one student, who was previously so against science that he drew a scientist crying when asked to draw a scientist, became thoroughly engaged in paleontology when given the opportunity to visit a museum, interact with fossils and learn more about various
species of dinosaurs. He personified the dinosaurs, referring to the Tyrannosaurus “as a person” and the Allosaurus and the Brachiosaurus as friends. He also willingly engaged in group work and writing, rather than seeing those activities as wastes of time as he would have before.

When students are permitted to engage in science in diverse ways and make meaning of the activities from a personal perspective they can create a hybrid or third space which can expand possibilities for themselves in science, as seen in Rahm’s (2008) and Brickhouse and Potter’s (2001) studies; however, if that hybrid self is not recognizable to or desired by the students, they are likely not to take up these new possibilities. Carlone (2004) presented such a case in which some students who were previously marginalized were able to enter the science classroom community when curriculum reforms were implemented. These girls were able to communicate to others that they were “active” learners and “lab people;” however, the new space in the science classroom was not recognizable to some students who were engaged in order to develop or maintain their “smart student” identities and, as such, they were dissatisfied and rejected this new discourse.

With practice theory (Eisenhart & Finkel, 1998 in Carlone, 2004) as a theoretical basis, Carlone (2004) argued that school girls, in addition to resisting sociohistorical patterns of gender-biases and other inequities in science and science education, can also reproduce these inequities. The reform-based “Active Physics” science curriculum broadened the scope of what constituted knowing and doing science in school to more open-ended, ambiguous, design-based, problem-solving activities. Some girls responded to
this favorably as they thought that the traditional text- and notebook-centered Physics lessons were boring; however, throughout the school, the traditional culture defined achievement in terms of grades and prioritized high academic achievement. As such, this not-so-straightforward path to achievement in science threatened some girls who preferred taking notes from the teacher and referring to the textbook for solutions. As such, using one’s agency to author identities took place in this science classroom in ways that benefited, as well as limited, the girls’ Physics learning.

Many other studies report on the largely positive effects of curricular reforms on institutional positioning of students in science by permitting space for student agency and choice in identity negotiation. For instance, Reveles and Brown (2008) examined how two teachers facilitated students’ construction of their academic identities as those of science learners. One teacher facilitated “contextual shifting,” i.e. the process of calling on different genres of action and language depending on the time and place, from that of everyday knowing to one of scientific practice. This involved the use of specific kinds of technical language and the use of meta-discourse to co-construct students’ academic identities as science learners by recalling activities of the past and linking them to the present discussion, for e.g. conducting experiments earlier on in the school year, as well as to co-construct students’ science understanding, for e.g. what is a phenomenon and are there many (Reveles & Brown). In the second case, the science teacher facilitated her students’ shift from an everyday context to the context of science in a science classroom by purposeful use of language that changed the discourse used to describe a scientific phenomenon from one drawing on the students’ already existing knowledge and ways of describing to gradual incorporation of specific technical language and ending with
providing multiple opportunities for students to utilize the new scientific discourse without scaffolding (Reveles & Brown). In both cases, the teachers paid attention to the sociocultural nature of education and the central role identity plays in the opportunity to learn. The teachers were explicit in their shifts across contexts and discourse and equitable in their co-construction of student understanding, while still eventually arriving at the specific ways of knowing and describing in science discourse.

In an earlier case, Rosebery, Warren and Conant (1992) sought to investigate the impact of a collaborative inquiry design in science instruction on language minority students’ ability to use science discourse. Collaborative inquiry is a form of authentic scientific practice in which teachers guide their students in exploring problems and defining and researching questions that are of interest to them. It is founded on the assumption that “…robust knowledge and understandings are socially constructed through talk, activity and interaction around meaningful problems, tasks and tools” (Roseberry, Warren & Conant, p. 63). In order to test this, they examined changes over time in students’ conceptual understanding in science and their use of hypotheses and experiments in explanations to two problems prior to and after engagement in collaborative inquiry. At the start of the study, the students relied heavily on personal experiences, information provided to them in the statement of a problem or anonymous people or factors, for e.g. some “thing” or “person,” to derive solutions. At the end of the study, the students increased their use of testable hypotheses and experiments in their reasoning towards a solution and instead of naming anonymous factors, they began to consider the problem as part of a larger system, for e.g. describing the connection of littering and improper waste
disposal to the water system and poisoning of animals in lakes and rivers. Overall, they grew in their ability to reason scientifically.

Summary

Overall, in participating in a science practice, there are a number of fundamental factors. First, an individual makes use of behaviors or social cues, available within the practice or other practices in which she is a member, in an attempt to be understood to be a certain type of person. These behaviors and cues can include language, content knowledge, dress, habits and shared assumptions. Second, identity formation requires the participation or acknowledgement of others partaking in the discourse or community. What she does must be recognizable to others in order for the identity to be taken up. As such, she must participate within the limits of the practice in which she wishes to negotiate an identity. These limits involve a hierarchical organization of available behaviors and cues and an individual’s use of various behaviors and cues can result in her being more or less marginalized in the practice. Third, it is through the negotiation of an individual’s sense of agency within the limits of the pre-existing structure of the practice that she can develop an identity in relation to the practice of interest. Fourth, educational institutions can be made more accommodating of individual differences, thus supporting equitable development and learning in science amongst all students. This might include instructional reforms and more equitable educational ideologies. Thus, in this study, I will examine the ways in which students developed science identities through the negotiation of their agency and the limits of the science practice and the characteristics of the science practice that supported or inhibited science identity negotiation. Furthermore, I will examine the impact of their
science identities on the science that they learn, as well as on their development of long-term STEM career plans.
CHAPTER 3: Research Design

Research Context

In this study, I sought to investigate the kinds of science identities that low-income, ethnic minority high school students developed in a science intervention that was designed to be equitable and empowering. From this study, I would be able to describe the kinds of science identities that the students developed, as well as the reasons underlying these or the outcomes of this identity negotiation, specifically on the students’ development of STEM career plans and the science that the students learn. Furthermore, I would be able to make the claim of whether or not the science intervention was equitable and empowering for the students.

The Informal Science Program: Teens for Environmental and Social Justice

The science intervention of focus was Teens for Environmental and Social Justice (TESJ), an informal science education intervention that targeted underserved public schools and low-income, ethnic minority youth, many of whom spoke English as a second language. TESJ was set within a larger, multi-year, NSF-funded research study aimed at examining long-term STEM career interest development and maintenance. The major research problems which TESJ targeted were the low levels of science proficiency amongst low-income, ethnic minority students and the underrepresentation of ethnic minority students in STEM study and careers. TESJ sought to increase the number of low-income, ethnic minority students in science by stimulating their interest in science exploration and future STEM careers. Students typically participated in the program from 9th through 12th
grade and were recruited primarily from 3 partner schools. The students were not particularly interested in science when they enrolled in the program. Rather, they were drawn to the program for assistance with college preparation and applying to college and for financial aid. Finally, the students who were recruited for the program were largely “average” academic performers based on standardized testing. TESJ sought to address the educational needs of those not already excelling in school.

The TESJ curriculum was comprised of two major components. The STEM/Career Planning aspect of the program focused on providing students with technology-rich science learning and STEM skills experiences structured around urban ecology and urban planning. The STEM career development aspect of this curriculum focused on emphasizing the significance and utility of the skills they had learned as important transferable 21st century skills. The students were also given multiple opportunities to interact with STEM career professionals in structured career roundtables and panels. The second component of the TESJ curriculum was based on social justice principles. The students worked on the urban development projects intent on addressing environmental conservation, economic development and social services within their communities. Additionally, for urban youth outreach initiatives, undergraduate students served as mentors to the high school students so that the undergraduates could share their college preparatory and current experiences with the TESJ students, further assisting them in the college planning process. Finally, the high school students received timely financial aid guidance and college application support.

TESJ incorporated many recently promoted educational reforms. For instance, TESJ was structured as an informal learning environment, targeted students’ already existing
interests, was based on a culturally-relevant science curriculum. Gloria Ladson-Billings (1995) defined culturally relevant teaching as that which promotes the academic development of young people, as well as nurtures and supports their development of cultural competence and socio-political consciousness. The fundamental social justice principles of the TESJ program focused the STEM project and class discussions on critical analyses of the students’ communities and society, in general, in terms of race, ethnicity, gender, economics and other lenses, followed by the development of feasible solutions to be implemented. Additionally, the science curriculum capitalized on the cultural experiences of the students, bringing these centrally into the academic space of the program. Furthermore, the curriculum and learning experiences incorporated the students’ experiential funds of knowledge (Basu & Barton, 2007; Moll, Amanti, Neff, & Gonzalez, 1992), emphasized the authenticity and relevance of the science that the students were learning, involved inquiry-based research problems, provided opportunities for immersive science learning experiences, incorporated state-of-the-art technology used by actual scientific research professionals and included a systematic career exploration model.

**Student Projects and Activities: STEM**

The TESJ program was structured as a youth participatory action research program in which the students were provided with opportunities to discuss environmental and social justice issues of concern to them and their local communities. Following these conversations, the students were supported in developing the research skills needed to research the environmental and social justice problems and devise action plans which they reported back to their peers and community members. Finally, the students recommended
their action plans for implementation to gatekeeping Community Development Corporations (CDCs).

Two common social problems discussed by the students were the dilapidated conditions and lack of safety of their neighborhoods. Using urban development as the research problem, subsequent curriculum activities and science skills were focused on urban planning. In the urban planning projects, the students adopted vacant parcels of land in their local city that were slated for development in the short-term with the goal of devising plans for urban development. The students visited the sites in order to conduct field survey studies and collect physical science data. The students collected data for the air and ground temperature, sound levels, traffic counts and soil lead levels. Next, the students analyzed the data in order to understand the environmental restraints of the specific plot of land, for example lead contamination, high surface temperatures or excessive urban noise levels. Specifically, the students generated 3D surface plots in Microsoft Excel and analyzed the data in relation to the sites and identified factors that contributed to peaks in the air and ground temperature and the noise levels. For instance, high temperatures were the result of urban heat island effects; high sound levels were the result of noise pollution from heavy traffic; and lead contamination was the result of historical industrial use of the land. Through these activities, the students learned fundamental mathematical and analytical skills in the context of studying environmental science and urban ecosystems.

Following the field study and graphical analysis, the students learned to use geographic information systems (GIS) technology and computational modeling tools in order to lay out their urban development plans for the sites and used the software to
further analyze the impacts of their design decisions. After the field survey of the site and graphical analysis, they would shift to making decisions about developing the parcels of land based on their new research knowledge of the site. Specifically, the students used industry-grade urban planning software, ArcGIS and Community Viz, in which they were able to modify virtual models of the parcels of land and the surrounding neighborhoods. They were able to assign various kinds of businesses, residences, recreation, surface materials, trees and foliage, signage and other aesthetics to the site.

In the urban planning software, with every design decision, the program automatically generated graphical output data for a number of variables, for e.g. commercial and residential energy use, commercial and residential water consumption, percentage of impervious surfaces, jobs generation, surface area and project site costs. Additionally, the students had data, in terms of these variables, for the site as it was at that time before development, as well as two alternative designs, one residential and one commercial. The students then argued the value of their designs based on the graphical results and the scientific understanding underlying their design decisions. For instance, a common design was to add trees for shade and temperature regulations, for sound buffering effects, thus reducing noise levels within the site, and for the site to be aesthetically pleasing. At the end of each Vacation Institute and the end-of-year Closing Symposium, the students presented their projects, including their methods, experiences and the value of the site based on scientific data and understanding. The students were expected to be able to communicate their projects and experiences competently within a scientific practice to their peers and instructors. Additionally, the students worked directly with local Community Development Corporations (CDCs) who owned the parcels of land
and recommended their final urban development plans for implementation. In this way, the students’ scientific work had authentic contributions to the communities in which they lived.

**Student Projects and Activities: Career Development**

Alongside the STEM learning goals of the program is the goal of career exploration and development for students. There is a particular focus on stimulating and sustaining students’ interests in STEM careers; however, there are substantial opportunities for students to explore their intrinsic interests. STEM is of particular significance for a number of reasons. First, as established in Chapter 1, STEM literacy and knowledge are important for informed participation in society and decision-making regarding current events. STEM literacy provides individuals with a valuable skill set that they can use in a number of STEM and non-STEM related careers, as well as in life, in general. Additionally, the STEM labor force has been rapidly growing and provides abundant job opportunities as compared to other fields and, particularly, in times of economic hardship. Furthermore, the STEM proficiency of a nation is indicative of its economic competitiveness.

Beyond these benefits, however, STEM is of particular focus in the TESJ program due to the field’s significant potential in contributing to the career development of marginalized and underserved students, namely low-income, ethnic minority students. Racial and ethnic diversity are particularly lacking in the STEM industry, also established in Chapter 1. Furthermore, STEM careers are traditionally well-paying occupations and potential pathways to economic and social stability for individuals and their families. Thus,
as a social justice goal, TESJ is committed to increasing the representation of racial and ethnic minority STEM candidates and professionals.

Low-income, ethnic minorities have been historically disenfranchised in American society. TESJ is committed to the social justice goal of career development for low-income, ethnic minority students that supports thoughtful decision-making and self-determination in one’s career choice, informed navigation of educational and other societal institutions, social mobility, empowerment and the equitable distribution of social and economic resources.

It is important to state that the TESJ program does not seek to force students to choose STEM careers, but to consider them and evaluate whether or not STEM can be a viable pathway for them. DiLisi, McMillin and Virostek (2011) found that informal science programs like TESJ can encourage and sustain science interests amongst high school students; however, the researchers found that amongst those students who had existing career interests in non-STEM fields, such as business and law, had lower levels of interest in STEM careers following the science intervention, while those who had pre-existing STEM interests or were undecided had increased in their STEM interests; therefore, it may not be possible to change students’ innate or pre-existing career interests. What is important, however, is to provide students with the opportunity to consider valuable STEM career paths that they might have overlooked, did not know existed or might not have been encouraged to consider. A central goal of the TESJ program that informed the experiences for the students was, therefore, to permit students more equitable opportunities to truly consider whether or not they are interested in STEM career pathways.
Demographics Data for 2010 – 2011 Student Enrolment

The detailed demographic composition of all students enrolled in TESJ from Fall 2010 to Summer 2011 were as follows:

Table 1: Gender Distribution

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Per cent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>38</td>
<td>61.29</td>
</tr>
<tr>
<td>Male</td>
<td>24</td>
<td>38.71</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 2: Racial/Ethnic Diversity

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Per cent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic or Latino</td>
<td>21</td>
<td>33.87</td>
</tr>
<tr>
<td>Black/Afro-Caribbean</td>
<td>16</td>
<td>25.81</td>
</tr>
<tr>
<td>Black/African American</td>
<td>10</td>
<td>16.13</td>
</tr>
<tr>
<td>African American &amp; Afro-Caribbean</td>
<td>4</td>
<td>6.45</td>
</tr>
<tr>
<td>Black &amp; Hispanic/Latino</td>
<td>3</td>
<td>4.84</td>
</tr>
<tr>
<td>African American &amp; White</td>
<td>3</td>
<td>4.84</td>
</tr>
<tr>
<td>Black, White &amp; Asian</td>
<td>2</td>
<td>3.23</td>
</tr>
<tr>
<td>Asian/Asian American</td>
<td>2</td>
<td>3.23</td>
</tr>
<tr>
<td>White &amp; Hispanic/Latino</td>
<td>1</td>
<td>1.61</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>100</td>
</tr>
</tbody>
</table>
### Table 3: Class Year

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Per cent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>16</td>
<td>31.37</td>
</tr>
<tr>
<td>Sophomore</td>
<td>12</td>
<td>23.53</td>
</tr>
<tr>
<td>Junior</td>
<td>18</td>
<td>35.29</td>
</tr>
<tr>
<td>Senior</td>
<td>16</td>
<td>31.37</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>100</td>
</tr>
</tbody>
</table>

### Participants’ Educational Context

In order to determine the wider educational context of the students, the participants’ public school district, Mar Vista, was compared to a neighboring high-achieving, affluent school district, Diego Martin, and compared to overall State statistics in order to determine a representative student profile of the TESJ high schools. The following data were obtained from the Massachusetts Department of Education (http://www.doe.mass.edu/):
<table>
<thead>
<tr>
<th>Mar Vista Public</th>
<th>Diego Martin Public</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(n = 55 371)</strong></td>
<td><strong>(n = 6 472)</strong></td>
<td><strong>(n = 957 053)</strong></td>
</tr>
<tr>
<td>First language not English:</td>
<td>First language not English:</td>
<td>First language not English:</td>
</tr>
<tr>
<td>38.8%</td>
<td>26.9%</td>
<td>15.6%</td>
</tr>
<tr>
<td>20.4%</td>
<td>7.7%</td>
<td>6.2%</td>
</tr>
<tr>
<td>Low-income: 75.6%</td>
<td>Low-income: 11.6%</td>
<td>Low-income: 32.9%</td>
</tr>
<tr>
<td>Special Education: 19.6%</td>
<td>Special Education: 16.8%</td>
<td>Special Education: 17.0%</td>
</tr>
<tr>
<td>Qualifies for free lunch: 67.3%</td>
<td>Qualifies for free lunch:</td>
<td>Qualifies for free lunch:</td>
</tr>
<tr>
<td></td>
<td>9.4%</td>
<td>27.4%</td>
</tr>
<tr>
<td>Qualifies for reduced lunch: 8.3%</td>
<td>Qualifies for reduced lunch:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.2%</td>
<td>5.6%</td>
</tr>
<tr>
<td>Dominant student ethnic profile:</td>
<td>Dominant student ethnic</td>
<td>Dominant student ethnic</td>
</tr>
<tr>
<td>African American (36.5%) and</td>
<td>White (59.3%)</td>
<td>White (69.1%)</td>
</tr>
<tr>
<td>Hispanic (39.6%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: School District and State Profiles

Table 4a: Enrolled student profile: 2009 – 2010
### Table 4b: 4 Year Graduation Rates: 2009

<table>
<thead>
<tr>
<th></th>
<th>Mar Vista Public (n = 5040)</th>
<th>Diego Martin Public (n = 472)</th>
<th>State (n = 77038)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduation rate</td>
<td>61.4%</td>
<td>90.5%</td>
<td>81.5%</td>
</tr>
<tr>
<td>Dropped out</td>
<td>19.3%</td>
<td>2.8%</td>
<td>9.3%</td>
</tr>
<tr>
<td>Permanently excluded</td>
<td>0.2%</td>
<td>0%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Earned GED</td>
<td>2.5%</td>
<td>2.5%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Still in school</td>
<td>15.3%</td>
<td>4.2%</td>
<td>6.2%</td>
</tr>
</tbody>
</table>

### Table 4c: Post-high school plans: 2008 – 2009

<table>
<thead>
<tr>
<th></th>
<th>Mar Vista Public (n = 3577)</th>
<th>Diego Martin Public (n = 432)</th>
<th>State (n = 65897)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 year college</td>
<td>49.2%</td>
<td>84.9%</td>
<td>56.6%</td>
</tr>
<tr>
<td>2 year college</td>
<td>15.7%</td>
<td>3.2%</td>
<td>23.1%</td>
</tr>
<tr>
<td>Work immediately</td>
<td>5.4%</td>
<td>1.4%</td>
<td>8.3%</td>
</tr>
</tbody>
</table>

### Table 4d: Standardized assessment performance: 2010

<table>
<thead>
<tr>
<th></th>
<th>Mar Vista Public</th>
<th>Diego Martin Public</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 10 Science</td>
<td>36% proficient</td>
<td>81% proficient</td>
<td>61% proficient</td>
</tr>
<tr>
<td></td>
<td>and above (n = 3</td>
<td>and above (n = 403)</td>
<td>and above (n = 68034)</td>
</tr>
<tr>
<td></td>
<td>487)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All grades Math</td>
<td>40% proficient</td>
<td>80% proficient</td>
<td>55% proficient</td>
</tr>
<tr>
<td></td>
<td>and above (n = 2</td>
<td>and above (n = 3171)</td>
<td>and above (n = 499717)</td>
</tr>
<tr>
<td></td>
<td>292)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All grades English</td>
<td>46% proficient</td>
<td>83% proficient</td>
<td>67% proficient</td>
</tr>
<tr>
<td></td>
<td>and above (n = 2</td>
<td>and above (n = 3159)</td>
<td>and above (n = 499025)</td>
</tr>
<tr>
<td></td>
<td>65)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Compared to the high-performing school district (Diego Martin), the home school
district of the TESJ students (Mar Vista), was quite large, was less successful overall in
science, math, English language arts and traditional high school graduation rates and
students had fewer plans to attend a four year college or university following high school
graduation.

Rationale for Research Study Design

A number of factors led me to the specific research design. First, in order to make a
claim about a social phenomenon, as a researcher, I wanted to be very present within the
setting under examination and to have plentiful data and first-hand perspectives. I wished
to have thick, detailed description of the research setting and the participants through a
qualitative study and I wished for that data to capture nuanced, unexpected, context-
dependent observations that would not be easily predicted and detected by quantitative
survey methods. Furthermore, I sought to conduct a long-term study, one that spanned a
significant period of time, in order to examine how students’ interests, statements,
behaviors, etc. changed over time, if the students followed through with their stated goals
or if their statements were consistent with their behavior. Additionally, in truly seeking to
inquire about the social phenomenon and not prove what has already been stated in the
research literature, I wished to see, first-hand, what was evident and what emerged as
important. As such, grounded theory has informed my methodology. For these reasons, I
have decided on a long-term, immersive qualitative study informed by ethnographic and
grounded theory methods.
Data Collection Methods

In undertaking an ethnographic study that examines identity development amongst science students, Brickhouse offers a number of important considerations:

Some researchers refer to changes in identity as taking place when students in classrooms learn practices that move them closer to authentic scientific practices. But is the acquisition of the practices of scientists the only way to take on a scientific identity? And how do we know that these changes effected in classrooms are changes in identities that matter? Perhaps these changes are just a “blip” in the life of a child and of no real consequence in the long run. . . . Is it really possible to study identity in classrooms [and other educational settings]? After all, most of what happens in science classrooms is so scripted that the extent to which students adopt particular practices may be more a measure of compliance to school than of developing a relationship with scientific communities. . . . [As such, methodologically,] I will argue that to make a claim that classroom instruction... [or similar interventions] has made a significant impact on the identity of a child, our data collection and analyses must be multi-contextual and /or longitudinal. Identities that matter travel across time and space – and we should work toward making our research capable of capturing this (Brickhouse in Carlone et al., 2008, p. 6).

In this study, I focused broadly on what aspects of students’ interactions were used to communicate their relationship to the science community, as well as what experiences impacted their relationship to science, i.e. their science identities. Following Brickhouse’s
(2008) methodological advice above that states in order to make a claim that an educational intervention has made an impact on the identity of a child data collected must be multi-contextual and/or longitudinal, data for the present study focused on an examination of science identity negotiation was long-term, collected over several months, and diverse, including digital video recordings, participant observations and field notes, individual interviews, and student work. Thus, a qualitative study was conducted and the data collection and analysis methods were informed by ethnography and case study. Furthermore, the study was focused on an informal science setting as opposed to a classroom such that students would have more freedom in expressing themselves and interacting with the practice and others, thus given more space to negotiate science identities.

Data spanned the time period of July 2010 to September 2011. During this time period, 3 rounds of individual interviews with 10 to 20 students in each round and 1 focus group was conducted. Field notes were recorded during 17 Saturday sessions and 3 intensive institutes (two 3-day institutes during the 2011 spring academic semester and one 8-day summer 2011 institute). Video tape recordings were taken of bi-monthly Saturday sessions, the spring and summer institutes and student presentations from February 2011 to July 2011. Finally, sample student work was collected for artifact analysis. Following data collection, interviews, focus groups and video recordings were transcribed for analysis. Ten students were selected for closer case analyses. The following summarizes the data collection methods and the frequency of data collection:
<table>
<thead>
<tr>
<th>Data</th>
<th>Number of Participants</th>
<th>Number of Time Points</th>
<th>Time of Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviews</td>
<td>10 – 20</td>
<td>3</td>
<td>Summer, 2010; Fall, 2010; Summer, 2011</td>
</tr>
<tr>
<td>Field Notes</td>
<td>62</td>
<td>31</td>
<td>Saturday sessions; two 3-day Spring Institutes; one 8-day Summer Institute</td>
</tr>
<tr>
<td>Student Work</td>
<td>10</td>
<td>4</td>
<td>January – July, 2011</td>
</tr>
<tr>
<td></td>
<td>Jul</td>
<td>Oct</td>
<td>Nov</td>
</tr>
<tr>
<td>-------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Qa</td>
<td>-</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Zs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dy</td>
<td>-</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Ua</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Hy</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Dn</td>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Ds</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Zo</td>
<td>-</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Ta</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Te</td>
<td>-</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
For the current study, ten of the sixty-two students were selected for closer analysis. These students were selected as they represented the diverse ethnic, racial, cultural, linguistic, gender and immigration backgrounds and ages in the program. This diversity is documented below in Table 8.

**Table 7: Demographic Data for Research Study Sample**

<table>
<thead>
<tr>
<th>Name</th>
<th>Gender</th>
<th>Race/Ethnicity</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qa</td>
<td>F</td>
<td>Dominican &amp; El Salvadorian</td>
<td>Freshman</td>
</tr>
<tr>
<td>Zs</td>
<td>F</td>
<td>Puerto Rican &amp; Filipino</td>
<td>Freshman</td>
</tr>
<tr>
<td>Dy</td>
<td>F</td>
<td>Latina</td>
<td>Freshman</td>
</tr>
<tr>
<td>Ua</td>
<td>F</td>
<td>Black/Haitian</td>
<td>Sophomore</td>
</tr>
<tr>
<td>Hy</td>
<td>M</td>
<td>Black/Haitian</td>
<td>Junior</td>
</tr>
<tr>
<td>Dn</td>
<td>M</td>
<td>Dominican</td>
<td>Senior</td>
</tr>
<tr>
<td>Ds</td>
<td>M</td>
<td>Black/African American</td>
<td>Freshman</td>
</tr>
<tr>
<td>Zo</td>
<td>M</td>
<td>Black/Nigerian</td>
<td>Freshman</td>
</tr>
<tr>
<td>Ta</td>
<td>F</td>
<td>Black/Haitian</td>
<td>Sophomore</td>
</tr>
<tr>
<td>Te</td>
<td>F</td>
<td>Black/Haitian</td>
<td>Junior</td>
</tr>
</tbody>
</table>
Data Analysis Methods

The research design was informed by three major methodologies: (i) immersive, long-term ethnography (Geertz, 1973 cited by Burawoy et al., 1991); (ii) grounded theory (Glaser & Strauss, 1967); and case study (R. Stake, 2000). Case study was utilized to define the levels of focus for data analysis. These were individual case analyses and cross-case analyses across all of the individual cases. Ethnography called for detailed and long-term observation of on-going activities. Grounded theory required the analysis of qualitative data and derivation of meaning based on the data itself and not as a result of the use of an *a priori* coding structure. The research question sought to examine the ways in which students negotiated science identities within the TESJ program. As such, although the data were not organized in terms of an *a priori* coding structure, the data were then analyzed in terms of the specific concept of science identity negotiation. Together, ethnography and grounded theory, along with the goals of the research question, informed a naturalistic, interpretive analysis based on what was evident in the data in relation to a specific theoretical concept – science identity negotiation. Case study was utilized to define the levels of focus for data analysis.

Determining Science Identity Negotiation:

A student was recognized as a contributing and competent member of a scientific practice within the informal TESJ program, and thus as having developed a science identity, by exhibiting: (i) an increased level of engagement and participation in the science activities; (ii) a positive affect and enjoyment of the science activities; (iii) demonstrated
competence and proficiency with the scientific tools, for example the technology, language and content knowledge; and (iv) development of long-term STEM career plans.

Within Cases:

Cases were defined at the level of individual students. For analysis of the individual cases, all ethnographic data, for e.g. digital video recordings, field notes and interview transcripts, were transcribed, categorized by case and ordered by time of data collection. Each case was coded (open coding) based on the actions and dialogues of the main student participant of that case. Data newly assigned to codes were continuously compared to data already in that coded segment, as required by the constant comparison method (Glaser & Strauss, 1967). As such, codes were developed and iteratively refined as I progressed through the data. At the end of each of case, a descriptive and analytical “story” of the main participant, based on significant codes within each data set, was written with respect to his or her participation in the science community and his or her science identity negotiation.

Across Cases:

Exploring and Identifying Cross-Cutting Factors:

Following individual case analyses, each analytical “story” was entered into Nvivo qualitative research software for additional open coding and cross-case analyses. Each case was re-coded and, again, codes were iteratively refined by new data segments continuously compared with previously coded data.
After this initial cross-case coding, resulting in the production of a master list of open codes, I organized the data for each participant’s science identity negotiation such that I could look across all the data in a uniformed and systematic way. I summarized each student’s development in terms of science identity across time. The changes in science identity over time for each student were sketched out in a simple graphical form, i.e. based on evidence in each individual case and based on the indicators of science identity negotiation which were (i) an increased level of engagement and participation in the science activities; (ii) a positive affect and enjoyment of the science activities; (iii) demonstrated competence and proficiency with the scientific tools, for example the technology, language and content knowledge; and (iv) development of long-term STEM career plans, when a student’s science identity was negotiated, it was plotted as increased as compared to an earlier time point. Conversely, if the student demonstrated a lack of science identity negotiation, this was plotted as decreased compared to an earlier time point. I also had individual case study analyses for each student, i.e. each case had a number of different codes. Thus, I was able to map the codes from each case on to the plot of the progression of the student’s science identity negotiation. So each case study was transformed into a graphical summary with the codes laid across them with respect to time. This kind of model building and use of graphical tools in qualitative and educational research has been recommended as extremely helpful and trustworthy in the data organization, analysis and sense-making processes (Briggs, 2007; Miles & Huberman, 1994).

With the data organized in this way, I was able to examine the variability amongst the science identity negotiation processes of the individual students and compare and
contrast the impact of different experiences and factors, i.e. codes, on this cross-case variability. In other words, I was able to look across the 10 cases and determine similarities and differences in terms of (i) the progression of science identity negotiation across the 10 students; and (ii) the impacts of different codes in the science identity negotiation of the students. All codes were not necessarily present across all 10 cases, but had such a significant or marked impact on the science identity negotiation or lack thereof for some students that the codes were worth further examination.

At the end, five cross-cutting themes involved in the students' development of science identities were analyzed further. These included (i) discursive and hybrid identities; (ii) peer dynamics; (iii) significant social interactions; (iv) language use; and (v) student ownership in science.

**For Explaining the Significance of Each Cross-Case Factor:**

Finally, for each of the cross-case factor identified, all of the transcripts coded under the factor of interest were exported from Nvivo to Microsoft Word. This provided all of the raw data across all ten cases relevant to each of the five cross-cutting themes. Again, ethnographic and grounded theory methods were applied to each data set. The data were organized into open codes and analyzed in a naturalistic, interpretive way.

**Trustworthiness**

Trustworthiness of the data analysis and findings was established through a number of means. First, an external judge was included for an impartial assessment of the coding structure. Three samples of data and the codes, along with their definitions, were provided.
to a doctoral student skilled in qualitative and quantitative research. The doctoral student coded the data independently and her findings were compared with mine.

A second check of validity was theoretical saturation, i.e. the point at which new data did not add new perspectives to the developing codes and theory. In other words, by completion of coding the data, all of the data fit into already existing codes and new codes were not required.

Data were also triangulated amongst time points, i.e. multiple examples of a finding were sought throughout the data. And finally, data were collected following long-term immersion in the research field (12 – 15 months) such that very detailed, thick description of observations were obtained and observations could have been repeatedly conducted over the course of the study.

**Limitations**

One limitation was the length of the study. Although the study was longitudinal (12 - 15 months), ideally a study that spanned the students’ high school and early college years should have been conducted. The students could have had many career interests at the time of the study, but whether or not they followed through with those career plans would be a more confident indicator of the development of sustained science identities.

Additionally, in a program explicitly focused on the value of science and science careers, I ran the risk of prompting the students to say positive things about STEM and about STEM with respect to themselves, i.e. they might have said what they thought I, as an instructor and researcher, wanted them to say.
Chapter 4A: Results

From the methods detailed in Chapter 3, specifically through the use of modeling and graphical tools with the qualitative data (Miles & Huberman, 1994; Briggs, 2007) and analysis informed by grounded theory (Glaser & Strauss, 1967), the following organizational plots for the data were developed for each participant:

Science Identity versus Time Plots for Cross-Case Analyses:
**DY**

- Positive affect of peers
- Positive affect in science
- STEM career plans
- Positive peer relationships
- Active participation
- Ownership & pride
- Science interest

**UA**

- Limited interest in science
- Negative peer relationships
- College aspirations
- Marginalized in science

---

- Protective peer relationships
- Positive affect of peers
- Connectedness
- Ownership & pride
- STEM career plans
- Limited interest in science
- Marginalized in science
- Math interest
- Low science self-efficacy
- Lack of positive affect in science
- College aspirations
From the plots, one can see variability in the students’ negotiation of recognizable TESJ science identities over time. The factors (codes) responsible for the trajectory of their science identities are mapped on to the above plots mostly in terms of factors that played a role at the start of the students’ time in TESJ and then at the end of the study. In cases of notable transitions during negotiation of a science identity, i.e. not at the general beginning or end at the study, the specific factors responsible are also indicated on the map.

Looking across the plots, those factors that were common in cases of consistent science identity negotiation or that supported short-term recognition of scientific behaviors were noted and investigated more rigorously, through naturalistic, interpretive analyses. Through these methods, five cross-cutting themes involved in the negotiation of student science identities have been investigated and detailed below. These cross-cutting themes are as follows: (i) discursive identities/identity development; (ii) language use in science; (iii) peer dynamics; (iv) significant social interactions; and (v) student ownership in science.

**Cross-Case Analyses of Student Science Identity Negotiation:**

As a member of the TESJ scientific practice as an instructor in the program and as the educational researcher, I determined, based on pre-existing expectations of performance, what behaviors and cues were considered “scientific,” of a science student, or of a future scientist. Some of the participants used individual agency within the pre-existing structure of TESJ in order to be identified as such or as competent, scientifically literate students within the TESJ science practice. In these students’ science identity versus time
plots, there was an increase in their science identity negotiation over time, depicted by an overall upward trajectory. These students included Qa, Zs, Dy, Te, Ds, and Zo.

Other students were identified as interested in another scientific practice, namely medicine. These students were Hg, Ua, and Ta. Yet others were identified as not interested in science at all. This was the case with Dn; but, at times, these students were seen as having some level of competence in the TESJ science practice or as engaging in the behaviors or social cues indicative of competence or skill within the practice, along with other identifiers of membership. Those students whose overall science identity negotiation dwindled over time (Hg and Ta) or peaked under certain conditions (Dn and Ua) were considered to not have developed TESJ science identities. This is because these students did not sufficiently or consistently perform the behaviors and social cues such that I could identify them as students with skill and competence within TESJ and as developing or sustaining long-term interests in science study and careers (a specific goal of TESJ).

In the sections that follow, I will focus on the similarities and differences across cases in the students’ negotiation of science identities and the cross-cutting themes responsible for these similarities and differences. I will begin by first examining the ways in which the students developed science identities by negotiating their student agency and the available behaviors and social cues within TESJ. These strategies were used largely by the students who negotiated recognizable TESJ science identities over time. Amongst those students who did not negotiate recognizable science identities, the use of these strategies was not predominant or common during the students’ time in the program or was detected only during times of short-term take-up of recognizable science behaviors or social cues.
These strategies were **discursive science identity development** and **language use in science**.

Next, I will examine the factors available within TESJ that supported the successful negotiation of student science identities over time. These cross-cutting factors were **peer dynamics, significant social interactions**, and **student ownership in science** and were detected amongst those students who negotiated recognizable science identities over time or, amongst those students who did not successfully negotiate science identities, took up recognizable science behaviors or social cues only fleetingly.

Next, I will examine the students’ reactions to being presented with a specific science practice in which they could be engaged. Here, I will discuss how the students were largely open-minded with respect to the practice, despite variable long-term visions for themselves. Finally, I will conclude the cross-case analyses by examining the STEM career development outcomes of the students as a result of TESJ. Here, I will present two main characteristics of the students’ STEM career interests. In one group, the students were driven by the sheer enjoyment of the activity or the future career. In another group, the students were exposed to role models in STEM and were strongly encouraged to pursue medical careers.

Following the discussion of the cross-cutting themes, four individual cases will be presented to exemplify the simultaneous and inexplicable effects of these cross-cutting themes responsible for the variation in science identity negotiation across students.
Discursive Identity Development in Science

Discursive identities (Brown, 2004) have been defined as an individual's way of presenting herself, through the use of behaviors and social cues, in order to signal to others significant aspects of the type of person she is. There was a notably high level of diversity amongst the identities students negotiated within the TESJ science practice. In other words, the motivations underlying students’ desires to negotiate recognizable identities within the science practice varied. For instance, Te experimented with a future STEM professional identity as an engineer, while Zo and Ds playfully engaged business mogul identities as they became proficient in the STEM technology. Other students satisfied other aspects of their identities, for e.g. Dy’s “good student” identity, while Zs, Ta, and Dn were satisfied by being engaged in a desirable social context with their peers. Collectively, however, the students participated in the TESJ science practice and negotiated science identities in order to signal various aspects of themselves that were important to them. Overall, four main messages were communicated by the students to their peers and instructors as a result of the ways in which they participated in science within the limits of TESJ. These were: (i) that they were smart and knowledgeable; (ii) that they were urban, ethnic minority youth; (iii) that they were funny and social; and (iv) that they were people-/service-oriented. These messages represented the ways in which the students used agency to participate within the TESJ structure. The messages were common across the students who did negotiate recognizable science identities; but, amongst those who did not, these messages were weakly communicated or weakly connected to the scientific activities. The ways in which the students communicated these messages are discussed below.
Smart and Knowledgeable

Participation in science was commonly used by the students to communicate to their peers and instructors that they were smart and knowledgeable in the activities at hand, as well as in activities beyond the program itself, for example, computer software hacking. One long-term project in which the students were involved was an ecological field study of an empty city lot and the design of an urban redevelopment plan for the site and the surrounding neighborhood through the use of industry-grade computer software. Proud of her accomplishments, Dominican and El Salvadorian, female freshman, Qa, voluntarily discussed her project with one instructor during the Summer Institute:

Wendesday 27th July, 2011
Qa to Mr. G: Excuse me.
[Mr. G comes over.]
Qa: Look. I did that. [Qa points to her computer screen]
Mr. G: Ok.
Qa: No pollution.
Mr. G: Wow! Got more energy. More commercial energy. That’s... [inaudible]... Looks like you got more jobs, too. Jobs and housing... (pause)... energy... (pause) ... water, barely any,... (pause) ... and energy use.
[Qa points at the screen for each one]

During the previous week, Qa demonstrated her skill with the technology by voluntarily assisting another instructor and a student in preparing to collect physical science data out in the field.

Tuesday 19th July, 2011:
Mr. T: First thing we’re gonna do is synchronize our iPads... and I want the person who has the airlinks to stand next to you.
[Darrel works with the iPad and Qa gives him the directions even before Mr. T does.]

Qa: Hit Bluetooth . . .

Mr. T: Hit Bluetooth.

Qa: Look for the number . . .

Mr. T: You connected? Now, good.

In other instances, during the Spring Institute, Latina freshman, Dy, presented the results of her group's project on behalf of the group. More noteworthy were her exchanges with one of the host university's professors, Dr. B, in a discussion of hydroponics plant system:

Thursday 21st April, 2011

Dr. B [to Dy]: Uh . . . It doesn't really give off anything. [He touches the light as he speaks. He is saying that the lights don't give off much heat.]

Dy: But, still.

Dr. B: Not really. [He puts his hand back]

Dr. B [to the class]: So, there are many questions we have to answer and one of the challenges is that the science folks who do this for a living? They aren't quite sure. They also don't really know if red and blue really are the best lights. 'cause there are some arguments that it needs to be red, blue and orange. That it needs to be red and blue when they're little plants and they switch over to more white light when they get bigger.

[Dy looks at Dr. B attentively.]

Dr. B: Do you know what plants might be eating?

Dy: Food, like water and [she points at the plant] that.

Da: The tube produces water and fuel . . .

[Dy is still pointing and talking to Dr. B, but is inaudible over Da.]

Dr. B: Those are just rocks. Everything you see here is something called a hydroponic system and so there's no soil . . . Just water and a chemical solution that plants need. Plants need basic minerals, phosphorus, nitrates, things like that. It is what you would find in the soil [Dy is still listening carefully.] The plants don't have to go digging for it. And this is what the plants are in [Dr. B holds up one of the seedlings.]

[Dy reaches out for it.]
Dr. B [to Dy]: Yup. I’m going to pass it around.
Da: It’s a little cube.
Dr. B: Yup, it looks like a cube
Dy: Cotton.
Dr. B [to Dy]: It looks like cotton, doesn’t it? But believe it or not, it’s actually rock. It is a company that makes this material. It is inert which means it doesn’t have any bacterial growth on it ever. It’s actually spun silicon. Silica rock? So, they actually break off the rock and the roots grow into this material.
[A student]: Do you still have to put it in dirt?
Dr. B: No, this is it.
[Da takes the plant.]
Dy: If you touch it, it dies, right?
Dr. B: No, you can touch this.

Through her conversation with Dr. B, Dy demonstrated her understanding, or at least her confidence in knowledge about hydroponics and plant biology. For instance, she pushed back when Dr. B told her that the lights did not give off a lot of heat, she responded quickly when asked about what plants need to grow (“Food, like water and . . .”) and she proposed that the plants were very sensitive saying, “If you touch it, it dies, right?”

Despite being much more soft-spoken than her peers, Haitian, female junior, Te, discussed their work in ways that demonstrated that they were knowledgeable and smart, as well. In the exchange below, Te was unusually outspoken in her attempts to accurately and clearly present her group’s action plans. She questioned her teammate and eventually took over in presenting on behalf of the group:

Tuesday 19th April, 2011
Ni and Te [to Sheron]: [The one in Mattapan, Neponset Park? Reservation Park?]
Sheron: So, what are you’ll going to do there?
[Se says something quietly.]
Nn: We’re trying to, we’re trying to talk about violence over there.
Te: What?!
Nn: The violence.
Te: What?!
Nn to Te [he smiles]: The violence. Aren’t we going to talk about the violence?
[Ua smiles]
Te: What was the question, Miss?
Sheron: What community are you working one?
Te: Mattapan.
Sheron: What’s wrong with it? And what are you going to change?
Te: Mattapan.
Sheron: Ok. What’s wrong with it?
Te [she flips through her papers]: Violence and security.
Se: We want to make the park a real park.
Te: We want to fix it and make the park a real park.
Sheron: A what?
Te: We want to make it a real park. There’s nothing in it! Just trees, grass…. And we want to find out what the community wants and what’s going on in the community.
Sheron: Ok…
Te: And involvement from the community. We want the community to be involved.

Communicating that one was smart and knowledgeable did not rely solely on the science projects of focus. In some cases, the students made use of the community’s resources to demonstrate their competence. For instance, Zo, a Nigerian immigrant and freshman, although mostly soft-spoken, became quite animated and active when given the opportunity to use the computers available to demonstrate his video gaming and computer hacking skill with his friends and one of his instructors, Mr. A.

March 19th, 2011:
[Ds, Zo and Oa are on Facebook on their individual computers.]
Zo: Ds, I'm going to fight you. I'm going to fight. How about you deserved it?

Zo to Ds [about what's going on on the computer screen]: This is a [inaudible]? A stupid [same inaudible word]?

Ds: Keep playing. My game is nice!

[Ds looks at Zo's computer screen as he plays]

Zo: Just for that, I'm [going to] take my time killing you.

[Zo cracks up laughing. So, do Ds and Oa.]

[Ds turns back to his game screen]


Mr. A [to Zo]: What are you playing?

Zo: Ninja Fighting Game.

Ds [to Zo]: Stop shooting in my face.

Ds [to Mr. A]: That's my character [he points to Zo's screen]

Zo [to Ds]: It's because you're so weak. You can't even, you can't even.

Mr. A [to Zo]: Is that like a Facebook game?

Zo: Yea. I hacked it.

Mr. A: Did you really?

Zo: [nods, as he continues to play]

Mr. A: How'd you do that?

Zo: There's this download called Facebook Cheat Hack... [Ds: He's lying.]

Zo to Ds: [steups] What are you talking about?! Oh my...! Imma show it to you! Imma show you on my phone! [Zo picks up his phone and starts searching].

Zo: Wait. [He puts down his phone and goes back to the computer. He continues to look over at his phone.] It will show my name and my hack code.

[Mr. A, Zo and Ds wait quietly while Ds and Zo simultaneously play on their computers.]

Mr. A: Aww, man I believe you. [Mr. A begins to move away.]

Zo [picks up his phone again]: No! You have to wait. I'll show you!

Ds: He's lying! [He looks over at Zo's phone]. You're on my Facebook!

Zo: I am? Damn!

Zo: Dude! You know how long it took me to hack that!

Zo to Mr. A: I'll call you when I find it.
Similarly, Dominican, male senior, Dn demonstrated his technology skills by assisting a peer in her TESJ STEM project, publicly acknowledging his “love” of math and confidently arguing the benefits of Macs versus PCs:

April 30th, 2011:
Ni: Come Dn . . . Alright. Dn, look. I downloaded those, but these are brushes . . .
[Dn assists Ni with a tech issue again.]
Dn to Ni: Alright, it should be here. All you have to do is just click it.
Mr. P: Are you like the math geek here?
Dn: I love math.
A girl in the background: [Says something about a Mac or PC.]
Dn: Whoa! You should just kill yourself. Windows PC’s are just pieces of craps that get viruses, after 5 years they start messing up and they suck.
Mr. P: If you get one a year, you don’t have to worry about it.
Dn: Yea, but if you buy one every year . . . you just get one of these [he gestures toward the Macs] and you’re set for the rest of your life!

In the data above, Dn confidently spoke about his knowledge of computers, saying that Macs are more superior to PCs, in addition to assisting his classmate.

**Summary: Smart and Knowledgeable**

As shown in the data above, Qa, Dy, Te, Zo, and Dn demonstrated their knowledge and skill within TESJ through the use of the resources within the practice. Qa showed how she had successfully minimized her negative environmental impact through her site design to Mr. G, as well as her skill with the educational technology, specifically the iPad; Dy engaged Dr. B in a discussion of what she thought about the heat emitted from the lights in the hydroponic system, followed by answering and asking a number of questions posed by Dr. B; Te spoke up over her peers to accurately present the planning work of group to me,
their instructor; Zo used the program’s computers to demonstrate his skills with computer hacking and gaming to his instructor, Mr. A, and his friends; and Dn assisted his classmate in editing her poster presentation through his skills with the computer software and in math.

**Urban and Ethnic Minority Youth Identities**

A second aspect of their identities that students communicated through their agentic participation in TESJ was the importance of their sense of selves as urban and ethnic minority youth. The students did not attempt to minimize or replace these aspects of their identities through their language patterns, dress, ideas, etc. For instance, all of the students spoke as ethnic minority youth with combinations of the multiple languages spoken amongst them, namely Spanish, French, and Haitian Creole, as well as variable use of Ebonics, non-standard English and youth-generated slang. Additionally, ethnic minority English accents were prevalent amongst the students.

Language use in the TESJ community will be discussed separately and in more detail; however, beyond language use, some students purposefully fore-fronted aspects of their urban and ethnic minority identities and experiences as they participated in TESJ. For instance, a staple of African American male, Ds’ wardrobe was a “doo-rag” or head scarf and he often engaged a “rapper” identity in which he would rap in student presentations or videos. He also referred to the “hood” in him and linked some characteristics of the urban community to himself and his friends. In one student-created Camtasia video, Ds narrated for his group by rapping where they went and what they observed. In another session, as the students in his small group discussed the difference between economic and social issues, Ds rapped:
March 26th, 2011:

[Ds, Zo, Bi and Hy worked in another group. They are talking about economic and social issues and the differences between the two.]

Ds [raps]: Financially, socially, physically, mentally. [He laughs]

[Mr. A and the others laugh.]

Mr. A: That's a good song. That's a good song. Ok, so you're talking about the economics. What else is there, though?

Later in the year, as Ds and Zo presented their project at the Closing Symposium, Ds referenced the “ghetto” in him, as well as his business side, in his brand for urban development. In the exchange below, Ds was explaining to one of his instructors that she will get a 2% discount at his park.

May 13th, 2011:

Ds [to his and Zo’s audience]: Yea, two per cent discount. That’s good. [He grimaces in his usual cocky way for humor]

[Zo nods.]

Ds: 2% from a thousand is a lot!

Zo: Yea [he continues to nod]

Ds: At least I didn’t let you pay the whole, full price!

Miss J.: Yea.

Ds: At least I threw in the discount. Yea, that’s the ghetto in me.

Ds [pulls Zo close and says]: Come, we have to show ‘em the business side [He and Zo smile and pose for a picture as a photographer had approached; Ds gives a thumbs up sign and smiles. Zo smiles and nods.]

[As the picture is finished being taken] Ds: Super Mega Fun Time.

Finally, when working in the computer lab conducting a Google Earth exploration of the local neighborhood of interest, Ds came across an interesting arrangement on a basketball court, typical of an inner city community. On seeing this, Ds remarked excitedly
to Zo, “Yo, they put tires on it [the basketball stand] to keep their hoop up! That’s something we would do!” (March 19th, 2011).

Another student, Zo, also signaled his Nigerian heritage by rapping in Naija (a Nigerian dialect) on one of the student-created documentaries in which they learned to work with Camtasia video software (June 18th, 2011). In another case, Dominican senior, Dn, referred to himself as “El Black Mamba” (April 30th, 2011). Additionally, with his friend, Hy, Dn dressed in stereotypical West Coast urban Latino garb, for e.g. single-buttoned plaid shirt, shorts and tennis shoes with tall, white socks and referred to themselves as “Cholos” on one occasion. Qa and Zs spoke in Spanish, referred to themselves as “Spanish people,” and asked other students and one ethnic minority instructor if they spoke Spanish. Te, Ua, and Ta spoke in French and Ta additionally spoke in Spanish.

Summary: Urban & Ethnic Minority Membership

As shown in the data above, the students negotiated identities within the science space of TESJ that signaled their urban or ethnic minority backgrounds in a number of ways, including Ds’ dress in urban garb and his presentation of self as a rapper and as from the ‘hood or the ghetto; Zo’s use of the Naija dialect in his group’s video documentary; Dn’s urban dress and self-designations as a “Cholo” and as “El Black Mamba;” Zs and Qa’s use of Spanish; Te and Ua’s use of French; and Ta’s use of both French and Spanish. Furthermore, it is noteworthy that the female participants communicated their ethnic minority identities through their bilingualism and multilingualism, while the male participants performed aspects of their urban, youth identities in more active and purposeful ways, i.e. through dress, nicknames, and artistic performance.
Funny and Social

Teenagers often wish to be socially accepted and seen positively by their peers. Many of the students in this study also participated in the science community in order to communicate to their peers and instructors that they were funny and social. In this way, the students were able to engage in science on their terms, thus preserving their social relationships amongst their peers. For instance, during the Spring Institute, although Dy was engaged in a conversation around the science of hydroponics with Dr. B, she peppered in funny comments, interpreted as attempts to still be perceived positively by her friends:

Thursday 21st April, 2011:
Dr. B: Do you know what plants might be eating?
Dy: Food, like water and [she points at the plant] that.
Da: The tube produces water and fuel [Dy is still pointing and talking to Dr. B, but is inaudible over Da]
[A boy]: Carbon!
Da: . . . and stuff like that.
Dy [points again]: The cocoa puffs on the foam!
[Some laugh.]
[Dr. B describes the summer project.]
Da: That will be so fun!
Bn: We get to build these this summer?! I'm here! [he laughs]
[Dy raises her hand high and waves.]
Dy: I'm coming, too!

....
[Dr. B describes how the water flows throughout the various systems.]

....
Dr. B: You can actually take the top off and see the water on the inside. You guys, anybody who wants to come and see the water. It's not that exciting, but it's water.
[Hr and Ta get up first to see.]
Dr. B: And there is a pump that pumps the water all the way through.
[Dy, Hg and Os go up to see it next.]
Dr. B: And it waters each plant.
Dy asks, “Why do it have bubbles?”
Dr. B: Because it’s pumping, it’s pumping the water through.

Dy was seen asking some interesting questions and being very engaged in the STEM activity; however, she made some comments, for instance by calling a part of the hydroponics system, “Cocoa Puffs,” and by imitating her friends’ interest and excitement in a somewhat over-the-top way by raising her hand high, waving and shouting out, “I’m coming, too!”

While working on her Summer Institute project, Qa and her friend, Bi, talked jokingly about their developing city block:

Wednesday 27th July, 2011:
Qa to Bi: We need a place to park! If you wanna go to Dunkin Donuts or something.
[Qa and Bi ask Zs for help regarding a lamppost.]
Qa: Wow! They got bus shelters and bench. We need a stop sign, girl! You want somebody to crash? Yo! Like I’m saying.

While working on her tablet computer, Zs, a Puerto Rican and Filipino, female freshman, remarked to her friends, “This computer is like my father! We have our ups and downs” (Wednesday 20th July, 2011). Additionally, during the Summer Institute, students were introduced to video design software, Camtasia. The students were given a few minutes to play around with the software. Zs made use of the computers, video design software and YouTube to create a funny video about “planking,” a viral video topic, that was very well received by all of the students and instructors.
Other examples included Ds’ typical self-identification as a ninja in conversations with others and in his urban development plans. In one of his earliest days in TESJ, students were asked to share an interesting thing about themselves. Ds stated that he was a ninja Saturday 20th November, 2010.

Finally, Dn also presented himself as a funny student to his peers as he played with the Lego blocks intended for a primary urban planning exercise:

Wednesday 20th April, 2011:

[Da, Zs and Dn speak leisurely in Spanish.]

[Dn fiddles with some lego blocks. They are about to begin an introductory urban planning activity using the legos.]

[Dn finds more Legos in a plastic bag.]

Zs [to Dn]: You know what we’re supposed to be doing, right? We’re supposed to use those… they each have names, so you can build up whatever we want in that space.

[Dn shushes her and continues to play.]

Zs: You was one happy kid, huh? [laughs]

Dn: I need more blocks!

[Zs then looks for a phone to take a picture of him playing.]

Before getting into the project, which he did shortly following this event, Dn took the opportunity to joke around and make his peers laugh.

Summary: Funny and Social

In the data presented above, the students were seen participating in science on their terms, thus preserving their social relationships with their friends while accomplishing the tasks of the practice and attempting to communicate themselves as members who belong in the science practice. These ways included Dy’s use of humor to offset her participation in
science and to simultaneously engage her friends; Qa’s joking with her partner while they worked on their urban planning project; Zs’ funny comments to her friends while she worked on the computer, then later her Camtasia video project on a topic that was particularly popular amongst the students that summer (i.e. planking); Dn’s humorous play with Legos to make others nearby laugh; and Ds’ self-designation as a ninja in order to make others laugh.

**People-/Service-Oriented**

Another message that the students communicated about themselves was that they were people- or service-oriented. They stated their concern for the environment, the local residents, and the country, in general, through working on various scientific projects and in the reasons underlying their STEM career interest.

Qa demonstrated her care for people earlier on by talking about the homeless, dilapidated street conditions damaging people’s cars and by saying, “I care about the people” (March 19th, 2011). Later, she demonstrated her care for the environment in her summer project from how she spoke about the plot of land to her choice of music to support the project, Katy Perry’s “Fireworks” because of the lyric, “Have you ever felt like a waste of space” (Wednesday 27th July, 2011). Her service- and people-oriented motivations culminated in a range of STEM career interests in order to help others and a shift away from her initial enterprising, business studies career interests to forensic science, psychology, and medicine.
In working on his urban development ideas targeting environmental and social justice, Ds described his plan for the community as follows:

March 19th, 2011:

Ds: Oh! I was saying that it would be cool if you could go do laundry for like twenty-five cents because you’d make more money, actually, because you’d think it’s less but you just gotta believe. More and more... because more and more people would want to go to that area to their laundry and you’d be coming in with hundreds and thousands, you know?

Ms. J: [So, you’re idea is] a service that’s needed for a cheaper cost. So people can afford it, but you would also benefit because more people would come.

Ds: I’d rather give it to the community, yo.

Ds was very business-minded; however, he was driven to design business ventures and make a profit while helping meet the needs of the local community, namely by providing affordable laundry services. Even after making a profit, Ds was willing to invest the profit in the community. Later in the session, Ds contributed the following and emphasized his community-minded goals:

March 19th, 2011:

Mr. A: If you asked a community member what they wanted. . .

Oa: A food stand.

Ms. J: For example, “What would benefit your community?” and then, “Why?”

Zs: Probably ask what they think would be best to put there and what they would get out of it.

[Ds’ hand is stretched high in the air.]

Mr. A [then says to Ds]: Ds, before your arm pops off your body.

Ds: I would walk, knock on the door and say “Hi. My name is Ds. I’m here to serve you.” And then this is what you do. “I have $10 000 to give to you. What would you put in the neighborhood?” [He pauses...] “Yea!!!”

Mr. A: I like that scenario, right? What would you do with $10 000.
Ds: They'd probably be like, “I'm gonna buy me a car.” And I'd say, “Nah, sorry. You can't do that.”

In this case, Ds described how he would raise money and ensure that it was invested in the community. When asked about what initiated his engineering career interests, Zo said, “...my dad, he was in engineering and he would build stuff and I would like the things he would build. So, I took it upon myself to go after that occupation because it's fun and you get to help your country.” His service-driven interest was an unexpected inclusion. Finally, in brainstorming initial design ideas, Dn focused on the poor planning of current housing structures in his neighborhood and wanted to better serve the community residents:

Wednesday 20th April, 2011:
Mr. Ay: So, you guys tell me what you're building here... 
Dn: Well, they don't have that much townhouses or green space. So, yea, I was thinking about adding that - townhouses and...
Mr. Ay: What are townhouses?
Dn: Well, you ever been to River...? 
[They try to describe the place he’s talking about.]
Mr. Ay: Right. A little fancier.
Mr. Ay: Yea, I like that [the placement of some of the townhouses away from the street.] Not everyone wants to live on the street.
Bw: Yea.
[Mr. Ay leans over, talks some more and points at some structures.]
....
Dn continued: Where I used to live before, townhouses, it was like project buildings, there was only one parking lot and you have to walk far to get to your house.
[Mr. Ay comments about carrying groceries from your car.]
Dn continued: And I'm not gonna use these [he holds up the stacked up blue blocks] because they already have a lot of stores.
Focusing on personal experiences of living in poorly designed housing complexes, Dn kept the comfort and convenience of the residents in mind when he planned out his community development project.

**Summary: People-/Service-Oriented**

As the data show above, the students demonstrated their care for others through the science and urban planning ideas and projects, as well as through their career goals. These included Qa’s suggestions for improving the street conditions for the people who lived in the area; Qa’s statement: “I care about the people;” and Qa’s choice of music to support her message that we should care for the environment; Ds’ plan to provide affordable and conveniently located laundry services and his offer to use his charm to encourage others to support efforts to improve the local community; Zo’s desire to help his country as motivation to be an engineer; and Dn’s suggestions about architectural improvements to make the living conditions of local residents more convenient. Furthermore it is worth noting that the students’ concern was not focused on their immediate families and friends, but on local community residents and society, in general.

**Summary: Discursive Identity Development in Science**

Overall, the students participated in the science practice or made use of available resources to communicate four major characteristics of themselves: (i) that they were smart and knowledgeable; (ii) that they were urban, ethnic minority youth; (iii) that they were funny and social; and (iv) that they were committed to helping others. These represented the ways in which the students used agency in negotiating science identities.
within TESJ. In this way, the students participated in science in ways that were satisfactory to them given the limits of the practice and in ways that successfully signaled to others that they were skilled and competent members of a scientific practice.

**Language Use**

During sessions in which the students worked on their projects, with the technology or were engaged in whole group sessions in which they were introduced to the larger STEM topics, such as urban planning, all of the students spoke in various combinations of Standard American English, non-standard English, Spanish, Haitian Creole, Ebonics and youth-generated slang, for e.g. “coding.” In order to examine the language used by the students when they perceived themselves as “doing science,” I chose to focus on the students’ presentations of their STEM projects, a focused and targeted science activity. I was interested in identifying how the students included or eliminated other discourses through language use when they perceived themselves to be centrally involved in a science activity. Four major patterns in language use were detected: (i) a largely traditional scientific discourse similar to that of research scientists; (ii) a developmental transition from non-traditional scientific discourses to a more traditional one; (iii) hybrid discourses of traditional and non-traditional scientific discourses maintained over time; and (iv) no notable or demonstrated use of a scientific discourse. Over the course of the study, the students used language patterns in distinct ways, some more purposeful than others, in negotiating a science identity within TESJ. A traditional scientific discourse held the most power in affording individuals recognition as science students, future scientists, or science people, in general. A traditional scientific discourse might be of the following form:
Statement of a question or a hypothesis; Description of an investigation conducted; presentation of evidence and results; and making a claim or argument. A non-traditional scientific discourse, on the other hand, will not be readily interpreted as scientific. These non-traditional forms can include story-telling and hip hop. A developmental transition from a non-traditional discourse to a more scientific one will afford individuals recognition as growing into competent scientists. Three of the language patterns, a traditional discourse, developmental transition from non-traditional to traditional, and hybrid discourses of traditional and non-traditional discourses, but not the language pattern that lacked any notable scientific discourses, were recognized as successfully negotiated science identities.

**Use of a Traditional Scientific Discourse**

Within the group of four students who communicated using a traditional scientific discourse, two of the students successfully negotiated science identities, i.e. Zs and Te; however, although Hg and Ta performed the behaviors and social cues of scientists, these behaviors were stand-alone indicators of science skill and proficiency within TESJ. These were not holistically supported by other behaviors and social cues that permitted recognition of a negotiated science identity within TESJ.

Zs, Te, Hg and Ta communicated largely using a traditional scientific discourse. This involved introducing and setting the context of their study, stating a research goal, detailing the research steps taken, presenting results and arguing the validity of those results through the use of evidence. Zs completed an individual project and accompanying presentation. Zs’ final presentation of her urban development project is provided below:
Thursday 28th July, 2011:

(Introduce project and context): I worked with the Madison Park project. The project was an opportunity for us, high school students, to use a program and try to see what we could put into an empty plot of land.

(State a research goal): Our goal is to make the MPR a place where people can go and relax or hang out, get some food or coffee, maybe spend a day at a little theatre.

(Detail the research steps): What did I add to the lot? I left the Tropical Foods where it was. I added more parking spaces. A nice restaurant. A small theatre. A coffee shop. And green space with fountains and benches where people can go relax and enjoy a good day.

(Initial argument): What does my plan offer? It offers the community job opportunities. Someone can get a job at the Tropical Foods or work at the small theatre or coffee shop or as a person who picks up [around] the green space or to make sure that the trash cans and recycling cans don’t get overstuffed.

(Presents results and evidence): This graph shows that my scenario has more jobs available than plan A and plan B. [Also on the graph but not read out loud: “Plan A shows 59 jobs available, Plan B shows 58 jobs available, while mine shows 75 jobs available. My plan uses up more [energy] than plan A and B's commercial use. Still this use of energy does not harm the community as you would see in the next slide. [Next slide] This graph shows that my scenario has no CO2 emissions compared to plan A and plan B. [Next slide] The total cost of my plan is less than plan A and plan B, reason being that my plan offers more green space than buildings with not as much money being used for supplies and building stuff. Thanks.

In her presentation, Zs made an initial argument, described her methods, presented evidence and findings, and closed with a final argument. This form closely fit the traditional form of scientific discourse. Another student, Hg, similarly spoke using a traditional scientific discourse; however, some steps, such as setting the context and stating a goal were overlooked, and details of steps taken had to be solicited. On the other hand, Hg did include the scientific reasoning underlying his design decisions while Zs did not. Overall, however, based on knowledge of ideal forms of scientific discourse, the quality of the
scientific discourse used by Hg was lower than that used by Zs. Hg worked with a partner, Ua. Part of Hg's end of summer presentation was as follows:

Thursday 28th July, 2011:
(Presents results and evidence):
If you look at site A and site B, carbon dioxide is really high compared to my site because when I add more trees to my site it reduces the carbon dioxide. “This graph shows us that the number of jobs is half than site A and site B, but we provide more jobs than the today scenario. [Next slide] If you look at site A, it shows, for example, that if two people are living in a house, one of them does not have a job. But compared to my site, everyone has a job which is a good thing. . . .”

(Closes with argument and presents supporting evidence):
Ok. This is the total cost of our scenario. Site A already went over the budget. “Today” is 6 million, but my site, it is not over the limit. Thank you.
[Applause]

(Details of research steps solicited):
Dr. B: Can you describe your site?
Hg: This is a small movie theatre, a coffee shop, apartment, uh, I forgot, a restaurant.
Dr. B: [What are] the stripes?
Hg: A sidewalk.
Dr. B: Where do people park?
Hg: Over here.

(Decisions based on scientific understanding):
A student: Why so many trees?
Hg: Because it reduces the sound . . . [and something about carbon dioxide.]

In his part of the presentation, Hg overlooked setting the background of the study and stating a clear goal or hypothesis and quickly jumped into the results and evidence soon after starting his presentation. Zs’ use of a traditional science discourse, on the other
hand, was more developed and detailed as compared to Hg. This is seen with Zs’ more thorough presentation of her work within a larger context which further indicated that she understood the overall purpose of the activity.

A potential contribution to the distinction between Zs and Hg might have been that Zs negotiated her science identity within TESJ over time while Hg did not. Hg did have career aspirations of becoming a medical doctor, but beyond preparation for college, he did not see himself developing in the specific skills he desired or felt that he needed to become a doctor. Thus, he might have been less engaged in the TESJ practice as compared to Zs who, on the other hand, saw TESJ as a place to meet new people, ask questions about her future STEM career interest, and learn new technology, amongst other factors.

Comparing two other students with similar distinctions, Te and Ta, a similar pattern was detected in which Ta was less motivated and engaged in the practice than Te. Although Ta did have a desire to eventually become a doctor, she did not see participation in TESJ as strongly and clearly connected to that goal. Te, on the other hand, was very motivated to learn the various technologies and to explore her STEM career interest further. In the transcripts of both girls’ urban planning presentations, Te was seen to make use of a traditional scientific discourse more proficiently than Ta.

During both the spring and summer institutes, Te worked with one or more partners. In the following, Te’s presentations at both the Spring and Summer Institutes are presented since during the summer, other group members communicated the results and evidence sections of their presentation and thus Te’s language patterns for communicating these sections were not available for analysis. During the summer, in addition to setting the
context, detailing the research steps and presenting data, Te also set her group’s present study in a larger scientific context. Ta, on the other hand, showed that she was capable of taking up a traditional science discourse, based on her Spring Institute presentation, but chose not to do so later on during the Summer Institute. This indicated differences between the two girls in their perceived importance of or ability to perform these roles as scientists as a result of differences in motivation to negotiate successful science identities.

Thursday 28th July, 2011:
Te at the Summer Institute:

(Setting context):
The site is located at 424 Dudley Street [Te recaps the history and present site context.]

(Presentation of observation data):
What we noticed when we went there? We noticed there was a lot of grass and weeds, bricks, garden, stage” and there was a bunch of holes in the ground. And also, we saw the statue of Mary. There were not enough trees and also we saw two worn down houses and we detected lead in the ground.

(Sets the present study in a larger scientific context):
Question for future research: How would the research we did help make a difference in our community?

(In Q&A, details the research steps):
The yellow is a coffee shop . . . [identifies the other buildings] . . . and this one is a shelter for homeless children.

Above, when Te spoke within her group, she set up the context of the study, presented some data and later described some of the research steps. Earlier, in the Spring Institute, Te presented evidence-based results and explained these via her understanding
of scientific phenomena. Te signaled the scientific artifacts present, namely the graphs, and even stepped in to help her partner, Ka, answer Ms. M’s questions with more scientific specificity:

Thursday 21st April, 2011:
Ms. M [to Te and Ka]: Oh! And did the trees help?
Te: Yea, because [she signals to the graph] you see? [she smiles]
Ms. M: Oh-ok. Oh! I’d have never thought of that.
Ka: So, we made sure we got that ... [inaudible].
Te: Residential energy [inaudible]... That’s why.
Ms. M: So, you use less energy, why? Because of the trees or because of [Ms. M trails off]?
Ka: The trees.
Te: It doesn’t have a lot of people and also because of the trees.
Ms. M: Oh-ok. Because it cools them in the summer?
[Te nods.]

In her Spring presentation, Te was able to present findings and make evidence-based claims, both of which are central to the scientific practice. On the other hand, Ta’s science identity did not develop over time in the program. Furthermore, Ta demonstrated that she was capable of partaking in a traditional scientific discourse, however, she chose not to take up this discourse, as well.

Thursday 28th July, 2011:
Ta at Summer Institute

(Sets the context and presents some observation data):
This is where we were at and right there, there was like no buildings and that’s where the religious people lived....
(Presents evidence-based results):
That was our result. We measure air temperature and found out that the closer it was to the concrete, it was much hotter. The blue means it was really hot and it was close to the concrete. [Next slide] And then, the sound level. There was a lot of noise close to the street. [Next slide] And then that is the surface temperature and the blue means it was really hot and it was close to the concrete. [Next slide] We found out that there was a lot of lead in the photo right there. There was a lot of lead. [Next slide] That’s our own site. That’s a lot of parking and green space and trees. We created 66 jobs, much more than the others, and our total site cost was ... I have no idea [the number is on display.]

(Sets the present study in a larger context):
Question for future research: How could we create a recreation park for youth? Survey to find out what people would like to see changed in [their] city? How could we know if a playground can be built in a certain area? It would be good to keep on collecting the same data and much more so we could see what is going on around and how can we stop it and make a better community.

(Recaps research steps):
What did we learn? We learned how to make graphs in 3D and compare them.

(In Q&A):
Ds: You say the blue means it’s hotter and the green means it’s colder? [pauses] Is it reversed?
Ta: Oh yea. My bad.

Ta presented a less detailed context of the research site and study. She additionally skipped over important details in presenting her results, such as the specific numbers related to various measures. Finally, she insufficiently addressed an error in the presentation and explanation of her findings. Earlier in the Spring Institute, Ta did a slightly better job at taking up a traditional scientific discourse. In the Spring Institute, on the other hand, Ta demonstrated that she was capable of partaking in a traditional scientific discourse.
Thursday 21st April, 2011:
Ta at Spring Institute
Sheron: Tell me about your project.
Ta: So, well, our project is about Madison Park. [She is suddenly animated and appears proud to present her work.]

(Sets the context and presents observation data):
That was the site that, where we went to [She signals.] That’s how it was. A lot of trash around. And then, it was empty.

(Sets a goal and details the research steps):
So, we made a design. We put buildings with a lot of green space to prevent air pollution.

(Initial argument and scientific reasoning):
And we think our design is better because it has less buildings and more green space to prevent pollution which causes many health problems and stuff like that.

(Evidence-based results backing argument):
And there was less cars going around [she signals the vehicle trips per day chart], so that means there was less C-O-2 [she signals the carbon dioxide auto emissions chart] going around. And one thing that we didn’t put in our design was parks and benches and stuff like that. We had everything, but those. That’s basically it.

[Ta stands back and smiles proudly.]

(Sufficient discussion and explanation of results and evidence in Q&A):
Sheron: So, that “vehicle trips per day,” what’s that about?
Ta: That one? [Yea.] Because our design doesn’t have that much houses and business, there is not a lot of cars coming around. So, that’s why that one is about.... The vehicle trips per day [Hmm-mmm]. So, there isn’t that much cars going around the place.
Sheron: So, Wait. I don’t understand.
Ta: This here, [she signals the yellow bar] is our own.
Sheron: Oh! Compared to other places?
Ta: Yea. Compared to others. [She nods.]
Sheron: Oh, I thought it was a before and after.
Ta: No.
Sheron: So, it went down? Ok.

Above, Ta made a claim and presented evidence with respect to proving that claim. Furthermore, she was able to explain the scientific explanation underlying her findings. She was thus capable of communicating using the language patterns of a traditional scientific discourse, however, later on, she chose not to engage this skill in presenting herself when doing science. As a result, her identity as a science student was negatively impacted.

Summary: Use of a Traditional Scientific Discourse

Overall, Zs and Te demonstrated proficiency in their use of a traditional scientific discourse, while Hg and Ta either were less proficient or less compelled to take up a traditional scientific discourse. Zs and Te were motivated to participate in the TESJ science practice and be identified as developing in science as they both saw the TESJ practice as meaningfully connected to their future STEM career interests. They were working on developing the knowledge and skills that would prepare them for future education and training as a forensic pathologist and an engineer, respectively. As such, they performed the behaviors and social cues in order to be recognized by their instructors and peers as doing good science. Through use of the traditional scientific discourse, Zs and Te successfully negotiated science identities that afforded them recognition as skilled and competent science students.
Hg and Ta were also somewhat proficient in the use of a traditional scientific discourse; however, use of this discourse was purposeful and agentic. Hg was a diligent and disciplined student. He did not feel that his questions about medical school were not being met, but he still was focused on doing the activities and completing the projects well. Ta, on the other hand, purposefully denied her proficiency with a traditional scientific discourse at times in which she was not compelled to negotiate a science identity. Under other conditions (which would be explored later), Ta was more driven to negotiate an identity that would allow her to be recognized as a skilled science student.

Developmental Transition from Non-Traditional to Traditional Scientific Discourses

Two students demonstrated developmental transitions from non-traditional discourses, for example that of storytelling or hip hop discourses, to a more traditional scientific discourse. Earlier on in Dn’s participation in TESJ, he presented his science project in a form that largely drew on a hip hop discourse. As a result of leadership opportunities, by the end of the summer, when Dn presented another science project on behalf of his team, he did so skillfully through the use of a traditional scientific discourse. A second student, Dy, also demonstrated growth in her proficiency with a traditional scientific discourse.

Dn did not negotiate a successful science identity over time, but did have leadership opportunities (which would be explored in detailed later) within the science community that might have boosted his science identity formation just around those activities. Two of those activities included the designing and building of a hydroponics system and then, later, presenting, on behalf of the group, the work that they had completed. Dn’s
presentation at the end of the Summer Institute (July 2011), presented later, was in sharp contrast to his Winter Institute (February 2011) presentation in which he drew from hip hop culture and ideologies, for e.g. “Go Hard in the Paint” meant as a metaphor for approaching all challenges such as learning science with seriousness and drive. In addition to talking more generally about the importance of learning science, Dn and his partner, Hy, presented their redesign project of an urban park using the GIS technology in a storytelling discourse. For instance, although observational data and initial goals for the project were stated, design decisions and the impact of the redesign were not based on scientific understanding of phenomena or empirical evidence. Rather, these were based on personal hunches and opinions.

By the end of the Summer 2011 Institute, Dn demonstrated significant growth in his proficiency with a traditional scientific discourse. Below is his presentation and handling of questions on behalf of his group. All team members were present, stood with Dn and contributed, as well. Dn, however, stood out in his level of understanding of the project at their local level, as well as the larger research context of hydroponics, and the skill at which he presented and responded to questions from the audience:

Thursday 28th July, 2011:
Dn at Summer Institute:

(Sets the context):
Dn: I wanna start off by saying what's the importance of hydroponics. Basically, it grows a variety of plants in a limited space. The water can be recycled so you don't have to keep giving it water all the time. And it's a year-round, space efficient, soil-less, so you can grow, have it even during the winter. And you don't really need soil, just these little... I forgot what it was called. And the crops can be harvested year round. So, you can grow it year round.
(Peer-teaching of hydroponics systems; shares his understanding of the scientific content):

Dn: So, this is a different kind of system. This is a drip system. “A timer controls a submersed pump. The timer turns the pump on and nutrient solution is dripped onto the base of each plant by a small drip line.” This is the NFT system. “The nutrient solution is pumped into the growing tray (usually a tube) and flows over the roots of the plants, and then drains back into the reservoir. The is usually no medium other than air.” This is the Flood Tray system. “This system consists of a tray that floods to saturate the seedlings before draining.” And the Tower system. “This system is highly efficient and allows even inexperienced growers to produce food in half the time it would take to grow the same crops in soil.” And this is the Wheel system. And the Wheel system is a system that “is compact and movable. It can grow up to 80 plants in a small space.” That’s a lot. And we came up with our own system. It’s called the Big S. Alright, yea. It’s called a Big S and “it is a vertical system designed with the ability to walk up to the plants and observe their growth while having easy access to each plant. It is energy efficient since it only uses one pump and is spatially efficient.” That’s the beginning of it. We’re not fully done because we didn’t have enough time. But from the little time that we had, this is what we came up with. And I wish we had another picture to show you. We would have brought it in if we could.

Dn: Right there is like the pipeline, where the water reservoir, it comes up to there. The black line has a pump attached to it and the water shoots up into a big, there's like a little drain thing on top and it has two feeders, so it feeds one pump... and it’s on a slope, so the water can go down and hit each plant.

(Sets up for the later argument of their design):

Dn: The variables gonna be the water distribution because we feel like one plant is going to get more than the other. And the growth of the plant because it’s not that big, so plants might be crunched up together. And the light per plant because it’s stacked up on each other. The top plants are going to have more light than the bottom ones. And we don’t know if it’s actually going to be effective. We don’t know if it’s going to work as well as we plan it.

Dn: And where can the system go? The system can go outside, in labs, in classrooms, farms and greenhouses.

(Initial argument of their project; design decisions based on scientific understanding):
Dn: Why the Big S? “In the amount of time that we had, we came up with many ideas, but this one was successful because we had the ability to build it and test. We decided to place PVC pipes in an “S,” [not on slide] some type of figure of an S, “...is space efficient, it helps distribute the water and it looks cools. The “S” also allows for different sizes of plants to grow in the system.

Ds: Did you all build that yourselves?
Dn: The Big “S,” we had help from the instructors, but we basically came up with the concept of it.
Hg: And the Tower was already built. Our goal was just to get the light to hit.
Dn: Because the light thing was one of the factors for it. We couldn’t find a way to light it, so that’s what it is.

(Argues the significance of the research field in a larger context):
Catherine: [What’s the business model underlying the project?]
Dn: The business model is like how can hydroponics be related to business. And we feel like, people say like this could be the next big thing to making money and to stop world hunger because instead of like just importing... because if you know like you can’t grow plants all year over here, so you have to import it. So, we can build like one big thing and everyone can have it.

(Demonstrates his still developing scientific understanding):
Adam: I thought you needed dirt to grow plants? I feel like students learn that in elementary school. How is it possible that this is going to work?
Ajanai: In the system, there are nutrients to put in the water.
Dn: And there’s this little thing that replaces the dirt... the, uh...
Lindsey: The substrate?
Dn: Yea. The substr___ [trails off and shakes head.]

Ds: Is this something you can build in your everyday house?
Dn: Yea, you can actually build it with like two water bottles ... and it’s like really quick because like even though these systems are really expensive, you can buy like a two litre soda and you can build it right there ... .

Dn: What we did at the farmer’s market was basically saw the different prices for the fruits and vegetables compared to regular Shaw’s to see if it was priced more. And we actually saw that one tasted better than the other... You could see a
significant difference. The [raspberries and blueberries] at the supermarket, they're bigger and they don't taste the same. The raspberries at the farmer's market, they're smaller, but they have more flavour... because they don't use any chemicals and steroids.

Mr. Ay: [Which is the best system to put in classrooms?]

Dn: I think the Flood and Drain because it's a big, tube, so you can move it around to where you want it. So, it won't take up that much space. And it's very effective, it's like the most simple system. And it has one of the best [inaudible] to me. And it's easy to handle.

Catherine: [How did you treat the aphids?]

Dn: First we used oil, but that didn't do anything... and when we went to the farmer's market, we asked what they did and one of the farmers told me that they used flowers... but we wouldn't have enough time for that. so, we went online and we saw that peppers work because it basically [burns] them...

In the above summer presentation, Dn thoroughly set up the context and importance of their hydroponics (indoor farming) project and explained the various types of hydroponics systems to his peers. The group did not conduct an investigation. Rather they designed a system. So, he also thoroughly explained the group's design and the scientific reasoning underlying the design decisions. In contrast to his Spring Institute presentation, in which he overlooked project goals and evidence-based findings, in presenting to his peers over the summer, Dn presented the group's goal and linked the steps of their design/engineering project to that goal. He thus communicated, on behalf of his group, rational and evidence-based decisions in the design process.

The other student, a Latina female, Dy, developed and sustained a science identity over time as a result of leadership opportunities, satisfying peer relationships (to be discussed later) and opportunities to enact other desirable social identities, namely a "good student" identity. From the Spring 2011 to Summer 2011 Institute, like Dn, Dy
demonstrated a developmental transition from a non-traditional to traditional scientific discourse. During the Spring Institute, Dy utilized a storytelling discourse to communicate her work. At the end of the Summer Institute, however, her proficiency in the use of a traditional science discourse was markedly increased.

Thursday 21st April, 2011:
Dy at Spring Institute:

Sheron: Tell me about your poster.

(Observation data and initial goals):
Dy: The thing is like a big green space and it has waste in it and buildings that were kind of ugly. We wanted to put townhouses and trees to make it look pretty. And we put places for businesses, but we don’t want [any] liquor stores.
Sheron: No liquor stores?
Dy: We put like a rule: No liquor stores. And we have this big green space, so that the kids could play inside in the green space, instead of playing in the street. And we put a lot of trees so that I could attract birds.

(Evidence solicited, but not provided):
Sheron: Ok. Did you see any changes? Like, those charts that you all generate?
[Dy nods.]
Dy: Yea and the money went up [there is no cost chart on display], so it’s kinda expensive, a little bit to build this. But, like, the whole thing about the people and [a bit more quietly] the happiness and everything went up, so it’s better than before. It’s way better.

By the end of the summer, Dy communicated her project in the following way:

Thursday 28th July, 2011:
Dy at Summer Institute:

[Sa begins the presentation with the history and physical description of the site.]
(Design decisions based on scientific understanding):

Dy: We could put greenhouses or put grass in the area and a basketball court or a small park with cement so that the albedo can be higher because if it’s low, it will be really hot over there. And if we take out the soil that’s contaminated and replace it with new soil, we could put apartments there.

(Detailed research steps):

Dy [continues]: We collected the data Tuesday, July 19th and on Thursday, July 21st. On Tuesday, we collected sound levels by using decibel readers. And Thursday, we collected how much lead was in the soil in different locations of it. We used Community Viz and Excel and Google Earth to graph the data. There were a few procedures during the collection of the information which was to wear shoes and with the kit, we had to put the soil into solution and combine it with another liquid. On Tuesday, Marvelous held the decibel reader and read the decibels to us. On Tuesday, Sa recorded the readings and collected the soil. And on Thursday, I put the soil into solution and then shook ‘em.

[Other group members assist in the presentation by discussing the graphical data.]

(Sums up with an argument):

Dy: Our plan is needed in this area because it’s a place where the family can go and relax with the family... It brings the community together with the garden, the pavilion, the playground and the drug store.

(Recaps skills learned in context):

Dy: We learned how to make 3-D graphs, how to test for lead, what's the EPA standard and above it and how to measure sound levels.

During the spring, Dy's discourse was of a storytelling form, i.e. largely descriptive with no clear goal or hypothesis and little presentation and use of evidence. Dy did present some of her scientific understanding underlying her decision, for e.g. in her statement, “... we put a lot of trees so that I could attract birds.” During the summer, however, Dy presented a summary argument, detailed research steps of the investigation conducted, and more of her design decisions based on scientific understanding. Over time, Dy had
improved in her ability to engage in a traditional scientific discourse in communicating science content to others.

**Summary: Developmental Transition from Non-Traditional to Traditional Science Discourses**

Overall, both Dy and Dn developed in their ability to communicate their work through the use of a traditional scientific discourse from a formerly non-traditional one. Although Dy and Dn had grown in their use of a traditional scientific discourse, they were still not thoroughly proficient, required further growth in their scientific argumentation and presentation skills, and their use still called for challenges to the science identities that they negotiated. Dy negotiated other behaviors and cues such that overall she successfully negotiated a recognizable science identity; however, Dn did not. This was largely because he clearly stated that he was not interested in science in the long-term.

**Hybrid Discourses**

Three students, Qa, Ds, and Zo, engaged in variable use of a traditional scientific discourse, along with other discourses, including storytelling, hip hop, and youth culture. All three students negotiated recognizable science identities over time. They were actively involved in the science activities and developed long-term STEM career plans and refined these through their participation in the TESJ program.

Common across all three was that over time, all three consistently and strategically inserted non-traditional discourses within the traditional scientific discourse creating hybrid discourses for communicating their scientific work. Each of these uses of hybrid
discourses was planned ahead of time. For instance, Qa planned to have a “real talk” about this plot of land and Ds and Zo branded their parks with various monikers, including, “Super Mega Fun Time,” “Super Mega Chill Time,” and “Swag-tastic Voyage.” Along with their unique ways of communicating, all three students set the context of their projects, used data as evidence, made arguments for their site designs, and demonstrated their comprehension of the scientific phenomena. In other words, the students were purposeful in their use of unique and non-traditional language styles, while at the same time demonstrated their skill and understanding in talking like scientists. For instance, Qa’s presentation below comes across as conversational, yet scientific:

Thursday 28th July, 2011:
Qa at Summer Institute:

(Sets the context and presents observational data/conversational):
Qa: And our site is Madison Park. My first impression when I came here was that this place looked awful, it needed some lawn mowing. It needed something. It was just vacant. A vacant lot. And that’s how it looked before [signals the aerial map of site]. That’s how it looked. Like, real talk, I didn’t like it. The grass was real tall. I got cut. I jumped a fence.

(Sets a goal):
Bi: The plan is, the plan I have in my head for this place is . . .
Qa: . . . marvellous houses and something that can make the community original.

(Details the research steps):
Bi: [Identifies the features.]
Qa [joins in]: A drug store, a nice restaurant and Tropical Foods supermarket.

(Presents results and evidence):
Qa: And actually, we have less, um, what do you call it? We have less pollution because of the cars. That’s ours compared to the others. I think it’s because of the trees, too. We have less energy use than the other two sites, but we have more commercial energy use than “Today.”

Qa: And obviously, we’re gonna have more jobs because they don’t even really have much there. And the total cost is so much way lower. It’s actually lower than what it is today.

(Recaps the story/experience):
[At the end, the girls play a picture slide show with Katy Perry’s Fireworks.]

Dr. B: So, tell me what you put on your site.
[Bi explains the reason for trees in relation to the uncomfortably warm weather.]

(Design decisions based on scientific understanding):
Qa [joins in]: And where the plum trees are at is actually the street. So, with more trees, you’ll have less noise and less pollution there. That’s why we have trees surrounding the place.

Qa: We have a drug store. We have 3 apartments. We have a lot of bus shelters. We have like four. And we have a nice restaurant. We left Tropical Foods there. And we have two fast food restaurants . . . and we have a lot of parking space.

In class, prior to the presentation:
Thursday 28th July, 2011:

Qa [reads her slide to Bi]: “When we first got there, this place looked like a real dump. It looked horrible.”

[Bi says something. Qa laughs.]
Bi: “. . . it’s dangerous [she points], it’s dirty [she points] . . . ”
Qa to Bi: What did you say? “This environment is serious business.”
[Bi says something.]
Qa: Nah, I want it like [she signals]. This one sounds too [trails off]. I want it like “real talk” and then show the picture. Like, “real talk. Yo!” [The girls laugh]
Shown in her conversation in preparation for her Summer Institute presentation, Qa had a specific way in which she planned to present her argument for the site design. She planned to have a “real talk” about the conditions of the site. She was additionally purposeful in her switch back and forth between traditional and non-traditional scientific discourses. Qa used a conversational form in order to set the context of the project, in setting the goal, and in detailing the research steps. She then switched to a more traditional form in presenting the results and evidence and the scientific understanding underlying her design decisions, for e.g. “... with more trees, you’ll have less noise and less pollution there. That’s why we have trees surrounding the place.”

Ds’ use of storytelling, hip hop, and science was also present quite vividly over time. There was a shift towards a more traditional scientific discourse over time, however, he maintained his individuality through periodic code-switching. Ds’ presentation of his group’s project during the Summer Institute was as follows:

Thursday 28th July, 2011:
Ds at Summer Institute:

(Sets the context and provides observational data):
Ds: And this is the St. Patrick’s site. This is the St. Patrick site before. See, you have the main entrance, the old tires. You see debris everywhere. Bricks. And the [inaudible] pipes over there. Basically, the history of this place: It was a home for the elderly that was torn down in the ’60s.

(Sets a goal):
Ds: How would this site be better used? Well, the original site, as we said, is a vacant lot. Our job was to create a new version of the site that is more eco-friendly...

(Hybrid discourse/discursive identity; insertion of hip hop ideology):
Ds: This is our park right here, “Swag-tastic Voyage.” We have the movie cinema, basketball court, garden, gazebo. . . .

(Details the steps): Ds: So, we have Methods, the data collection, the basic steps. . . . Ds: The data collection, the lead kit. We collected out lead kit... we scooped up the dirt and crushed it into a much finer substance, poured the dirt into like a capsule... Swabbed the substance with a Q-tip, rubbed it on a special card and waited for the results. . . . Ds: Data analysis. We analysed our data by putting our numbers such as temperature and site length into Microsoft Excel and turned our plotted data into graphs showing the temperatures of the site in different areas. We also used Community Viz and Google Earth.

(Presents results and evidence): Ds: This is the data we collected. Here you have the distance in feet as the x-axis [A]: The other axis is the distance in feet, as well.] Basically, what this graph shows is the air temperature of the site. As you can see, closer to the back where the cement and the old building was, the temperature, right, is higher.

(Final argument and evidence): Ds [continues]: The budget we couldn't exceed was $22 million, out of which, we only spent $3 888 815. Our site also has lead. In order to build legally, we have to remove the lead . . . which would cost an estimated $98 800. . . . Ds: [This graph shows the total site cost and this shows the number of commercial trips]. . . .

(Sets the project in a larger scientific context): Ds: We were asked a question, I forgot. And the answer: “Yes, we think it is important to collect the same data because you never know what could happen. Things tend to change over time. It could have rained and that can reverse your data causing you to not be able to have the right data to present.”

In the above presentation, Ds began with a traditional discourse, including setting a clear goal (“Our job was to create a new version of the site that is more eco-friendly”) and briefly engaged his usual hip hop speech in presenting the name of his park: “This is our
park right here, “Swag-tastic Voyage.”” He then switched back to the traditional form in
detailing the research steps, presenting the research findings and evidence, and making a
final claim. This was also in sharp contrast to his presentation during the Spring Institute
which illustrates two points. First, the Spring Institute presentation demonstrates the
growth in Ds’ proficiency in the use of a traditional scientific discourse. Second, it sets up to
demonstrate Zo’s growth in his proficiency with a traditional scientific discourse. The boys’
Spring presentation was largely of a storytelling discourse with some insertion of hip hop
and youth culture:

Thursday 21st July, 2011:
Ds [and Zo] at Spring Institute:

Ds: My name is Ds. [He saunters up to his poster, quite proudly.] Super Mega Fun
Time.
Zo: I made up the name.
Ds [points to the title while looking at the camera]: Four words.
[Ds pauses, then points to Zo.]

(Recaps the steps taken and data collected, as well as presents observation data in
limited detail):
Ds: Well, first at the spring institute, we went to Madison Park and we recorded
information such as like the sound levels of things, we did, I don’t think we did the
temperature. We didn’t do temperature. But we took pictures of the site and all that
stuff. And how loud it was around there. Then after that, we came back and started
working . . . No, after that we went to the Kroc Center and we toured that. That was
cool.

And then after that we started working on projects and that’s how I got this [he
signals the CV design]. And something I noticed when we were at Madison, I noticed
there was a lot of unused space, there was trash and all that. [Zo: Yea.] There was
garbage everywhere [Zo: nods]
Zo: It smelled bad, too.
Ds: And all that space, it was just being unoccupied and I thought that it was a waste of space . . . But also, something else I noticed, too, there was a big construction site that wasn’t really being used. But this is our place [He points].

(Limited details of the steps taken and inadequate description of their scientifically-informed design decisions):

Ds: See, we have a Supermart right here. We have some stores. And then these are some big houses right here. The mansions. The reason I put these there was because we figured, you know, a quiet section, more [pauses]. I don’t want to say rich people, but you know, more people with more money will, you know, spend a lot of money on there.

(Some scientifically-informed decisions):

Ds: I had some other buildings, but I had to re-do it. And I put some trees around there [he signals.] Trees are like sound proof. They block off the noise and provide more oxygen.

(Final argument and presentation of evidence in inadequate detail):

And basically this is a good place because . . . Alright, like the residential units [he signals the graphs], I have more space for shopping and stuff, so more people will be able to live there. And commercial jobs, it’s a higher percentage. More people would be able to live there. Way more people will be able to work there. There are more job opportunities. And up here, the carbon autoemissions impact . . . there’s not that much, ummm, pollution going around really. But, I mean, in the residential [he signals], it could be better.

(Zo’s minimal participation):

Sheron to Zo: You wanna add anything before you all leave?

Zo [shakes his head]: No. I’m good.

Ds [points at the poster again]: Super Mega Fun Time. We wanna live there.

Zo: But you have to be rich though.

During the spring, Ds presented some of the same steps, but with no clear goal to guide their design, limited presentation of findings (for e.g. “And commercial jobs, it’s a higher percentage”), as well as limited data to back claims (for e.g. “The mansions . . . more
people with more money will, you know, spend a lot of money on there.”) Furthermore, he presented some scientific reasoning for his design decisions, but these contained some inaccuracy (for e.g. “Trees are like sound proof.” While in the summer, on the other hand, Ds stated a clear goal, detailed his research steps, presented findings and evidence, and made a closing argument. Through his skillful use of a traditional scientific discourse, Ds performed the behaviors that permitted him to be recognized as a skilled member of the TESJ practice. Ds both developed his proficiency with a traditional scientific discourse and maintained his unique hybrid speech pattern that combined traditional and non-traditional scientific discourses.

With Zo, on the other hand, his proficiency in the use of a traditional scientific discourse was lower than that of Ds. This might have likely been due to Ds’ relative leadership positionality between the two, as well as Zo’s fewer opportunities to practice the use of such a discourse publicly. Additionally, had he not worked separately from Ds over the summer, he might not have been able to demonstrate his developing use of a traditional scientific discourse altogether. By the end of the summer, Zo, like Qa and Ds, communicated in a hybrid discourse around science, combining a traditional scientific discourse with a hip hop/youth discourse:

Thursday 28th July, 2011:
Zo in the Summer 2011 Closing Presentation:

(Hybrid discourse):
Zo: I’m Zo and this is Super Mega Chill Time.
[Nc then proceeds to present on the history of the site]
(Details the research steps):
Zo helps by identifying various features on the aerial map of the site.

(Further details of research steps):
Zo: This is how we made the site better . . . [he reads from the slide] “indoor basketball court, game center . . .

(Attempt at communicating scientifically-informed design decisions/insertion of youth slang):
. . . solar panels on top of the buildings, ‘cause just think, mad power . . . a park, small movie theatre, a pavilion, coffee shop and small stores.

(Details the methods; some errors present):
Zo: These are the methods we used to collect our data: The tools used to collect data were iPads, cameras, decibels, probes, pencil, paper and clip boards. First we learned how to find the surface temperature. Me, myself, I used the iPad. Mac recorded the data. And Ni used the probe to measure the temperature. Then our data analysis: When we finished collecting the data from the St. Patrick’s site, we went on Excel and input the data collected. This data is now represented by graphs and tables so it becomes easier to analyze.

(Presents results and evidence; inadequate explanation of findings):
Zo: Right there is the sound decibel and, like, this is where we recorded the traffic and stuff. And as you can see, the further we are from the field, the larger it gets. And in the middle of the field, that’s where the sound starts to decrease.

(Closing argument, but no evidence-based claims):
Zo: And, our conclusion is that our site will be a place of relaxation because we offer a pavilion, a small movie theatre and a relaxing restaurant. Because people are too stressed [nowadays] and they just want to chill.

Zo: This is our site now.
Mac: The yellow is the small restaurant. The purple is . . .
Zo: And the grass is just for people to lay down and rest.

(Inadequate presentation of evidence; hybrid scientific discourse):
Zo: This is the building cost. We’re all high schoolers, so you’ll can read that. That’s the commercial space. Commercial jobs…. We put mad trees.

(Recaps skills):
Zo: What we learned? What I learned while I was in this program was how to analyse graphs and I also learned how to collect surface and air temperature.

In beginning his presentation, Zo started with a hybrid hip hop and youth culture discourse by introducing himself as “I’m Zo,” as opposed to “My name is Zo,” and their project as “Super Mega Chill Time.” He then spoke in a rather traditional way in assisting his teammate in describing the steps they took and the changes that they had made, as well as in detailing the research steps: “These are the methods we used to collect our data. . . .” In describing the science underlying their design decisions, Zo, once again, inserted hip hop and youth culture in stating, “. . . solar panels on top of the buildings, ‘cause just think, mad power.” Weaknesses in his use of the traditional scientific discourse included his inadequate presentation of evidence, for e.g. “This is the building cost. We’re all high schoolers, so you’ll can read that,” the lack of evidence-based claims in his closing argument, as well as presenting it as a conclusion before presenting any findings, and his inadequate explanation of findings, for e.g. “And as you can see, the further we are from the field, the larger it gets. And in the middle of the field, that’s where the sound starts to decrease,” as the cause of the variation in the sound level was not explained. Overall, however, from not contributing to the presentation of the science project in the spring when he worked with Ds to presenting a sizable portion of the summer project, Zo demonstrated growth in his handle of a traditional scientific discourse, as well as his
unique way of partaking in the scientific activity, thus negotiating a non-traditional, but somewhat successfully recognized, science identity.

**Summary: Hybrid Discourses**

Overall, these three students, Qa, Ds, and Zo, communicated through the use of science discourses in hybrid and individually satisfying ways. Qa told her story of needing to take care of the site, not leaving it as “... a waste of space ...” while also demonstrating her science content knowledge. Ds and Zo also demonstrated their growing science understanding and presentation skills, while maintaining their hip hop and youth culture. Their developing communication skills in science contributed to their overall developing science identities, i.e. their recognition as science people.

**No Notable or Demonstrated Use of a Scientific Discourse**

Finally, one student, a Haitian, female sophomore did not indicate any significant use of a discourse with which to communicate in the science community. This, however, is a complex case as the student struggled with English during the program and in her high school as she was a recent immigrant from Haiti. In order to participate in the activities she often used a combination French and English and relied heavily on peer support. Besides these language issues, Ua also did not develop a science identity within the program although she had STEM career interests. She did not perceive the program as satisfactorily aligned with her mathematical and engineering interests. There was little data for Ua in communicating to her peers at a whole group level. During the closing summer
presentations, the program director encouraged her to participate in the presentation, so she read, verbatim, the caption of the graph on display at the time.

Summary: Language Use in Science

The ways in which students used the language of science allowed them to continue presenting themselves in ways that was satisfying to them, as well as in ways that would hopefully enable them to be interpreted as members of the TESJ science practice. In other words, how the students used language enabled them to be hopefully interpreted as certain kinds of science people. In using the traditional scientific discourse, Zs, Te, Hg, and Ta performed the behaviors and social cues in attempts to communicate their skill and competence. Similarly, Dy's and Dn's growth in proficiency with the traditional scientific discourse also allowed them to be interpreted as developing members of a science practice. The students who made use of hybrid discourses, combining traditional and non-traditional discourses, including storytelling, hip hop, and youth culture, communicated their skill and competence in science on their own terms, maintaining some level of control over the kind of science people they were interpreted to be. It is also noteworthy that as students experimented with the language of science, they were not penalized or scrutinized for taking up or attempting to take up the language science whether in a more or less traditional form. For instance, although Dn struggled with the word “substrate” in describing his hydroponics system, he was not ridiculed or belittled and he was applauded for his presentation. Students showed interest in their peers’ work and, although asking critical questions of each other’s work was a relatively new concept to them, there was evidence of this development at its beginning stages.
Summary: Strategies Used in Negotiation of Science Identities

Thus far, what has been presented were the two main strategies used by the high school students within TESJ in negotiating recognizable science identities. These were discursive identity development and language use in science. In discursive science identity development, the students participated in the science practice in ways that were satisfying to them as these enabled them to communicate important messages about themselves. These messages were: (i) that they were smart and knowledgeable; (ii) that they were urban and ethnic minority youth; (iii) that they were funny and social; and (iv) that they were committed to helping others. By using science to accomplish these goals, the students were able to maintain some control of who they were and how they were seen, i.e. their identities. Furthermore, these messages were communicated while partaking in a science practice. As they were recognized both on their terms and that of the science practice, they negotiated identities that permitted them to be understood as specific kinds of science people, specifically as science students or future scientists who were smart and knowledgeable, who came from urban and ethnic minority communities, who were funny and social, and who were committed to helping others.

Furthermore, the students used the language of science in different ways. This was determined by investigation of the language patterns used by the students while they were engaged in a focused science activity, presentation of their long-term science projects. Some students used science in purposeful hybrid ways, for e.g. Qa, Ds, and Zo. They maintained their unique ways of participating in the science practice, while managing to demonstrate their content knowledge understanding and skills. These students’ language
use in science was used in similar purposeful ways, as when they discursively developed identities, in order to present themselves as certain kinds of science people. Other students began in similar purposeful non-traditional ways. For e.g. recall Dn’s earlier hip hop-inspired presentation in February and Dy’s storytelling presentation in March. As they continued to develop in the practice, however, unlike Qa, Ds, and Zo, they appeared to see the traditional scientific discourse as the ideal or correct way and moved closer to that language pattern. By July, both Dn and Dy had minimized their non-traditional use of a scientific discourse and communicated in the much more straight-forward traditionally scientific way. They maintained control of their identification in other ways, for instance, continuing to communicate their messages of intelligence, service, social popularity, and urban and ethnic minority belonging. Similarly, although Zs, Te, Hg, and Ta discursively communicated specific messages about themselves through their science activities, during this public science performance, they presented in much more traditional and standard ways of speaking.

**Factors Supporting Student Science Identity Negotiation:**

In the sections that follow, I will discuss the factors that have been identified as successfully supporting students’ negotiation of recognizable science identities. Across the students who successfully negotiated recognizable science identities within the TESJ practice, a number of common factors were isolated. These included (i) peer dynamics, (ii) significant social interactions, and (iii) student ownership in science. Each of these will be explored next.
Peer Dynamics: Leadership, Kinship and Friendship

Positioning and relationships amongst community members are important factors of a social practice. These can influence entry into and mobility within the community of interest, in this case a community centered on science activities and career consideration. Within TESJ, three major characteristics of the students’ positioning and relationships in relation to their peers and instructors supported their development of science identities. These were: (i) leadership; (ii) kinship; and (iii) friendship. Those students with consistent opportunities for leadership, kinship, or friendship experiences successfully negotiated science identities. The impact of these factors have been shown to be important as even amongst those who did not eventually negotiate science identities, when permitted opportunities for leadership, kinship, or friendship, in some cases, these students took up the behaviors and social cues that afforded them recognition as participating in the TESJ practice; however, these behaviors and cues were stand-alone indicators of interest and participation in science and were not holistically supported by other indicators of a negotiated science identity.

Leadership:

Four students, Zs, Qa, Dy, and Te, were overtly positioned as student leaders in the STEM activities amongst their peers over time. As a result of this positioning, each of these girls continued successful negotiation of their science identities by becoming more active in the various STEM activities, recognizing their developing skills in STEM and with the technology and by formulating long-term career plans for themselves in science. Additionally, two other students, Dn and Ta, were positioned as leaders in specific
activities, for example in public presentations of their science projects, and, as such, took up behaviors indicative of science identities during those specific activities. During these specific activities, both Dn and Ta were active participants in the science community and communicated in the style of and with the language of scientists. Examples of each of these students’ leadership positioning and the effects on their take up of science identities are presented below.

Zs led her group projects and presentations and was often called on by her peers for assistance with the STEM technology. Reflecting on her experiences in STEM, Zs came to see herself differently. She began to see herself as skillful and knowledgeable in STEM. In her exit interview, Zs said:

July, 2011:
I don’t feel that very confident knowing that pretty much I’ve never really been that much a fan of science, but lately, I’ve noticed that science and math are the most skills that I have [Ok.] and I understand the most out of everything else. Still, talking about it, I don’t really much know because I don’t know if I’m saying the correct stuff or not. But, I still say what comes to mind. And if I’m not right, it’s better to learn something new than to not say anything at all. .

Sheron: So, what do you have planned next for yourself in terms of your education or your future career?
Zs: Well, definitely do better than my freshman year in high school. And just keep on trying harder and harder each year. Hopefully, going to college and become . . . go to medical school ‘cause I want to continue on to the forensics.

Zs began to grow in her self-efficacy, i.e. her belief that she can successfully accomplish STEM-related tasks, by saying that she was beginning to notice that she was most skilled in math and science compared to other subjects. This successfully supported her on-going plans to become a forensic pathologist.
When Qa began the program, she fit in easily with her friends; however, she was not central in the STEM activities. For instance, she might be seen speaking with and joking with her peers, but she was less turned on by the science. The following is a typical representation of Qa’s early participation in TESJ. The students were asked to work in groups and use Google Earth to survey the neighborhood to identify its assets and deficits. Qa was neither interested in the activity nor took much from it, seen by her laughing and dismissing the question at the end of the session.

March 19th, 2011:
Hy: Okay. Let’s do what we gotta do.
Da: No facebooking.
[Hy asks a few more orienting questions, as well as answers some with Qa and Da.]
[After another off-task comment, Qa gets ready to start.]
Qa [sighs]: Oh my God.
[Qa looks off towards Hy’s computer screen.]
Qa: How do [inaudible] spell barrio?

[At the end of class, I ask Qa for her reflection on today’s class.]
[Her head is down on the desk, so Da indicates to her that I asked.]
[Qa gets up and looks back. She smiles.]
[She pauses and thinks.]
Qa: Umm, ummm. [she taps Hy and looks over to him saying.] You want to help me out?
[Qa and Da laugh.]
[Da to Qa]: Give me something. Give me something to think about [and presumably to write down].
Qa: My mind, ummm, about the hobos [Da repeats “hobos” and Qa laughs] . . . about the hobos. They need a shelter . . . and about the green space, ‘cause I love sports
Da: And probably people could get easier exercise.
Qa was neither proactive in the STEM activities nor was she regarded as a critical contributor in the group work. At other times, she did not step up as a central participant in the activities nor was she expected to do so.

Saturday 30th April, 2011
[Da, Dy, Qa and Ni work in one group.]
[Mr. J instructs them how to locate their poster on the Apple computers.]
Qa: What more can you add?
Dy: What about the graphs?
Ni: We got Photoshop! We got Photoshop. . .
Dy: You can add a poster with that [Photoshop]?
Ni: Yea! You can do everything with this. We should do our poster with Photoshop.
Dy: Add the title of the park.
Ni: I like the Apple one [computer/Photoshop] better.
Qa to Dy: Do you even know what she’s doing? [laughs]

By the summer, however, Qa was regarded differently by her peers and instructors. She was called on often by Mr. T, her STEM instructor, to answer questions and to work with the more advanced technologies, such as the iPads and the GIS software. She also volunteered answers to questions and assisted the instructors, particularly around the technology. Over time, she was increasingly asked for assistance by peers. Additionally, although she continued to work with friends, she contributed more critically and valuably to the project’s development. She made many design decisions and, importantly, she assisted her friend and teammate, new to the program, with the key GIS technology. Several weeks following the Summer Institute, Qa was also invited back to campus to be one of four youth representatives in a national research conference focused on youth and motivation in STEM (September, 2011). Qa redefined her position in the STEM community as one who
was marginal and not particularly useful to an actively participating student and a peer leader. Following her experiences in TESJ, Qa summed up her self-confidence as follows:

September, 2011:
Before I went to TESJ University, I always thought that I couldn’t be somebody, well, that I couldn’t be somebody big because everyone I know, they don’t have big jobs. [They don’t have something that they could stand out with at school.] Oh, I’m a scientist, I’m a doctor. So, I never thought that I could be something. That’s the way it is with Spanish people. So, basically when I started going to TESJ University, I started meeting a whole bunch of new people and they always told me that they wanted to go to college doing one thing, and then they came out doing another thing, making more money or more professional. And that’s how I started thinking, like, I don’t think small now, I think big.

Importantly, these new feelings of confidence in her educational and life potential were accompanied by a change of perspective on science, confidence in her science skills and understanding, and long-term career plans for herself in science. She had shifted away from an extreme dislike of science and technology to being able to envision possibilities for herself in science. In the excerpts below, Qa described her change in perception of science to something that could be fun and as more than what they get to do in school science, her medical, forensic and psychology career interests, and her confidence in talking about her work in science. These were all positive changes and associated with her growing identification as a skillful science student and future scientist.

September, 2011:
Qa: I hated science and technology before TESJ. I thought engineering was about trains, but I love math. TESJ has opened up my eyes to new things. Science could actually be fun. You can be outside, do graphs that you don’t do in school. In school, [for math, you use . . .] only calculators and pencils. When you do work that is fun, it is easier to memorize. At school, you just get nagged to do things that aren’t fun.

[During the summer, a few weeks earlier]
Sheron: Do you [Qa] see yourself as a science person?

Qa: Yes.

Sheron: How did that come about?

Qa: Because I wanna study AP Chemistry. I want something to do with medicine. But, I wanna be like a forensic... like, if someone dies, I wanna be able to know like how long ago was it [Zs: Like an autopsy]... Yea. And I also wanna see like, if there's a dead body, I want to be able to just look at it and be like, “Oh, this and this.” And basically make a story out of what happened by just looking at it. I also want to study psychology, but... [laughs]. ‘cause basically I took a class at TESJ University in psychology and the program, I guess it was new. And they were talking about like little kids and when they have problems and I told the teacher that, honestly, all I think they do here is give little kids a whole bunch of medicine for no reason. They just want little kids to get an overdose which makes them even more crazy.

Finally, when asked about her confidence in talking about the work she has been doing in science, Qa said the following:

July, 2011:

Sheron: How comfortable are you talking about the science with the others?

Qa: It depends. Like here, I feel comfortable because I know what I'm talking about. But if I'm not paying attention and I know nothing, I'll feel so uncomfortable, honestly, ‘cause I'll have a big question mark in my head the whole time.

Dy was also very much a peer leader, although perhaps on a smaller scale as compared to Zs and Qa. She was seen assisting her friends and being recruited by other group members for help with the technology. She also led her group's final presentation of their project. Reflecting on the confidence and skills in science that she had developed, Dy said the following:

July, 2011:

Sheron: Ok. And this program encourages the students to do most of the talking. How comfortable or knowledgeable do you feel when you are talking about the science with the other students?
Dy: I feel very comfortable. [Says it with great confidence]

Sheron: Rating yourself from zero being absolutely not comfortable and ten being absolutely comfortable, how would you rate yourself?

Dy: Ten.

Sheron: Ok. And if one of the teachers was to pull you aside and talk science with you, how would you rate yourself?

Dy: Ten.

Sheron: Ok. And then, you were here for the career panel?

Dy: Yea.

Sheron: Ok. If one of the scientists on that panel were to pull you aside and talk to you about science or a science career, how comfortable would you feel then?

Dy: Ten.

Dy was highly confident in science. This served her well in being seen as skillful in science and in encouraging her STEM career interests. Te’s overt positioning as a student leader occurred later than the other girls. She was always diligent with her work, but as she often worked within a group of close-knit peers, this could have been easily overlooked. At the end of the summer, however, Te was also nominated to represent her peers at a national research conference hosted by TESJ’s host university along with Zs and Qa. At this conference, she discussed how she had grown in science from participation in TESJ generally and from the public forum of the conference, specifically saying.

September, 2011:

I’m still not sure [about] a future college major but [I want to do] something related to engineering. I like it even though I never did it before or built anything before. Before TESJ, the only engineering I knew about was the one to do with houses and didn’t know about what is what actually called. In TESJ, I learned about the different types of engineering ... chemical, civil, mechanical ... [I also] got to talk to some engineers and was captivated by how an engineer talked so passionately about what he does. [I was] inspired by the eagerness [with which] engineers [from career panels] talk about their jobs. ... It has been great sharing my experiences [here at the conference.] Usually I’m very nervous, shaking, sweating ... and now I’m not so much.
Te entered the program with STEM career interests, but these were solidified as a result of the various experiences she stated above, such as learning about the different fields of engineering and learning about engineering career experiences from real engineers. The public forum of the conference was the latest factor in her development.

Although Dn did not negotiate a recognizable science identity over time, when Dn presented on behalf of his group at the end of the Summer Institute, he performed in the role of a scientist and took up the appropriate discourse competently. Dn was provided with an opportunity for leadership experiences in science which resulted in a temporary boost in recognition as a science person. He presented one of two senior projects focused on hydroponics on behalf of his group. He demonstrated fluency and proficiency with the language of science, competence and significant content understanding. His summer presentation was as follows:

Thursday 28th July, 2011:

Dn at Summer Institute:

(Sets the context):
Dn: I wanna start off by saying what’s the importance of hydroponics. Basically, it grows a variety of plants in a limited space. The water can be recycled so you don’t have to keep giving it water all the time. And it’s a year-round, space efficient, soil-less, so you can grow, have it even during the winter. And you don’t really need soil, just these little . . . I forgot what it was called. And the crops can be harvested year round. So, you can grow it year round.

(Peer-teaching of hydroponics systems; shares his understanding of the scientific content):
Dn: So, this is a different kind of system. This is a drip system. “A timer controls a submersed pump. The timer turns the pump on and nutrient solution is dripped onto the base of each plant by a small drip line.” This is the NFT system. “The nutrient solution is pumped into the growing tray (usually a tube) and flows over the roots of the plants, and then drains back into the reservoir. The is usually no medium other than air.” This is the Flood Tray system. “This system consists of a tray that floods to saturate the seedlings before draining.” And the Tower system. “This system is highly efficient and allows even inexperienced growers to produce food in half the time it would take to grow the same crops in soil.” And this is the Wheel system. And the Wheel system is a system that “is compact and movable. It can grow up to 80 plants in a small space.” That’s a lot. And we came up with our own system. It’s called the Big S. Alright, yea. It’s called a Big S and “it is a vertical system designed with the ability to walk up to the plants and observe their growth while having easy access to each plant. It is energy efficient since it only uses one pump and is spatially efficient.” That’s the beginning of it. We’re not fully done because we didn’t have enough time. But from the little time that we had, this is what we came up with. And I wish we had another picture to show you. We would have brought it in if we could.

Dn: Right there is like the pipeline, where the water reservoir, it comes up to there. The black line has a pump attached to it and the water shoots up into a big, there’s like a little drain thing on top and it has two feeders, so it feeds one pump . . . and it’s on a slope, so the water can go down and hit each plant.

(Sets up for the later argument of their design):

Dn: The variables gonna be the water distribution because we feel like one plant is going to get more than the other. And the growth of the plant because it’s not that big, so plants might be crunched up together. And the light per plant because it’s stacked up on each other. The top plants are going to have more light than the bottom ones. And we don’t know if it’s actually going to be effective. We don’t know if it’s going to work as well as we plan it.

Dn: And where can the system go? The system can go outside, in labs, in classrooms, farms and greenhouses.

(Initial argument of their project; design decisions based on scientific understanding):

Dn: Why the Big S? “In the amount of time that we had, we came up with many ideas, but this one was successful because we had the ability to build it and test. We decided to place PVC pipes in an “S,” [not on slide] some type of figure of an S, . . . is
space efficient, it helps distribute the water and it looks cool. The “S” also allows for
different sizes of plants to grow in the system.”

Ds: Did you all build that yourselves?
Dn: The Big “S,” we had help from the instructors, but we basically came up with the
concept of it.
Hg: And the Tower was already built. Our goal was just to get the light to hit.
Dn: Because the light thing was one of the factors for it. We couldn’t find a way to
light it, so that’s what it is.

(Argues the significance of the research field in a larger context):
Catherine: [What’s the business model underlying the project?]
Dn: The business model is like how can hydroponics be related to business. And we
feel like, people say like this could be the next big thing to making money and to stop
world hunger because instead of like just importing . . . because if you know like you
can’t grow plants all year over here, so you have to import it. So, we can build like
one big thing and everyone can have it.

(Demonstrates his still developing scientific understanding):
Adam: I thought you needed dirt to grow plants? I feel like students learn that in
elementary school. How is it possible that this is going to work?
Ajanai: In the system, there are nutrients to put in the water.
Dn: And there’s this little thing that replaces the dirt . . . the, uh . . .
Lindsey: The substrate?
Dn: Yea. The substr___ [trails off and shakes head.]

Ds: Is this something you can build in your everyday house?
Dn: Yea, you can actually build it with like two water bottles . . . and it’s like really
quick because like even though these systems are really expensive, you can buy like
a two litre soda and you can build it right there . . .

Dn: What we did at the farmer’s market was basically saw the different prices for
the fruits and vegetables compared to regular Shaw’s to see if it was priced more.
And we actually saw that one tasted better than the other. . . . You could see a
significant difference. The [raspberries and blueberries] at the supermarket, they’re
bigger and they don’t taste the same. The raspberries at the farmer’s market, they’re
smaller, but they have more flavor ... because they don’t use any chemicals and steroids....

Mr. Ay: [Which is the best system to put in classrooms?]

Dn: I think the Flood and Drain because it’s a big tube, so you can move it around to where you want it. So, it won’t take up that much space. And it’s very effective, it’s like the most simple system. And it has one of the best [inaudible] to me. And it’s easy to handle.

Catherine: [How did you treat the aphids?]

Dn: First we used oil, but that didn’t do anything. And when we went to the farmer’s market, we asked what they did and one of the farmers told me that they used flowers ... but we wouldn’t have enough time for that. So, we went online and we saw that peppers work because it basically [burns] them.

In Dn’s presentation, he was seen as knowledgeable about the project and the related science. He also spoke in the traditional scientific discourse and handled questions from the audience well. He successfully performed the behaviors that allowed him to seen as a skillful member of the TESJ science practice.

Similarly, another female student, Ta, was temporarily positioned as a leader by her peers when nominated to be one of four groups to represent the entire STEM program at the Closing Symposium. Despite not identifying overall with the TESJ science community, in that specific honored presenter position, Ta’s participation had increased, she became a more active participant in the practice, and emoted a much more positive affect. An excerpt of her presentation is as follows:

May 13th, 2011:

Ta: So, on the first day of the Spring Institute, we went to the park. So, the next day we decide to make our own park ... and that’s what we came up with [gesture to the CV layout]. And the way we came up with that design is we wanted more green space and less houses ...

Ka: And less cars going around.
Ta: And pollution, and ... reate more green space. We use less water, less light. We created some jobs because we have businesses. And it's a safe environment.

Ms. M: Do you have buildings?

Ta: Yea, we have housing right here [she gestures]. [Ms. M: Oh! Housing right there.] [Ka: And townhouses.] And these are townhouses.

Ka: And this graph shows that we have less, um ... [Ta: C-O-2] ... 

Ms. M: When you say less C-O-2, less than what?

Ta: Less than the other places. Because the red is the residential and the green is the pedestrian mall. And we have less than the both of them.

Ms. M: Oh-ok. And why is that?

Ta and Ka: Because ... [Ta continue: First of all, we have less cars going around which also make us have less pollution.

Ms. M: Ok.

Ta: [nods].

Ms. M: What else ... are those trees or ...?

Ta and Ka: Yes, trees.

Ka: And green space all around ... .

Ms. M: Is the soil contaminated where it is?

[Ta starts saying “no” or “we don’t know”]

Ka: Yes, because it has a lot of trash.

Ms. M: Did you'll test the soil?

Ta: Actually, we didn’t get to test that. We just tested the sound and light, the temperature.

Ms. M: It was raining that day?

Ta: Yes [she laughs]

Bse: Nice job, you guys.

Ta: Thank you.

Although not portrayed clearly above, Ta was smiling throughout her presentation and enjoyed discussing her work. She was encouraged by position as a leader to take up the behaviors and cues that would deem her recognizable within the TESJ practice.
Summary: Leadership

In the data above, Te was overtly positioned as a peer leader at the research conference, along with Zs and Qa. Zs additionally led her small group projects and her friends often asked her for help when they were having challenges with the technology. Qa was called on by peers and instructors in STEM activities, as well as stepped up or offered help voluntarily. Like Zs, Dy was often called on by her peers to lead their projects or to help them even when they were in different groups. Dy was seen helping her friend who was in a different class and, at the same time, her teammate came from the separate class to call her back to help them finish the project. These leadership opportunities have been shown to be supportive of science identity negotiation. From these experiences and others, Te’s engineering career interests were cemented. Qa changed from a quiet student who barely participated and who did not contribute significantly to the development of the group science projects to one who stepped up to help both her peers and her instructors in the science activities, especially with the various technologies. She was much more outspoken and active in the STEM sessions and confident in her responses to STEM-related questions. By the fall, she said the following about herself: “I always thought that I couldn’t be somebody. . . . I don’t think small now, I think big.” Zs also discussed significant growth in her STEM self-efficacy by stating, “I’ve noticed that science and math are the most skills that I have and I understand the most out of everything else.” The positive effects of leadership experiences on supporting students’ negotiation of science identities was also demonstrated in the impact of stand-alone leadership opportunities on Dn’s and Ta’s short-term performance of science behaviors and others that permitted them to be seen as students who were active, knowledgeable participants who enjoyed the practice.
It is noteworthy that all of the students, with the exception of Dn, who were positioned as leaders and experienced growth in their science identity negotiation as a result of this leadership were girls. Four other students, one female and three males, were not positioned as leaders in the above ways in the STEM activities by their peers or instructors. Some grew in their science identity negotiation over time, namely Ds and Zo, for reasons other than leadership, for instance significant social interactions, student ownership, and the opportunity to engage in other kinds of satisfying social relationships. Lack of identification with the TESJ science practice prevented development of science identities for Ua and Hg, despite negotiating other kinds of science identities.

**Cultural Kinship:**

In an examination of discursive identities and hybrid spaces within the TESJ science community, it was discovered that some students, as a result of shared experiences such as immigration, negative stereotyping, and discrimination at school, created hybrid third spaces in which they could engage closely with others who were ethnically and culturally similar to themselves while participating in the TESJ activities. Beyond being able to engage in satisfying and protective social relationships with similar others, these students benefited from working within their close-knit peer group in a number of ways. These included: (i) that the group provided a safe and protective space for the students to partake in and experiment with the STEM activities; (ii) that group membership facilitated entry into the larger STEM community by supporting the students’ understanding of English; and (iii) with increasing confidence, the students ventured out and interacted with the larger TESJ/STEM community, sometimes stepping up as peer and student leaders.
Provision of a Safe and Protective Space

First, I will discuss the role of cultural kinship in providing a safe and protective space for taking up science. Te was successfully negotiating a science identity within the wider TESJ science community in that she had long-term career plans in engineering. She, however, was a bit soft-spoken and shy. When she worked within her smaller peer group, though, she participated much more actively and confidently while experimenting with her growing science identity. Presented below are contrasting cases of Te’s participation in the science community. In the first, Te worked with her ethnically similar friends. She was much more active, took part proactively, spoke up, asked questions and challenged her peers. Later, I will present a case in which she worked with none of her usual peer group. In that case, she was extremely soft-spoken and nervous.

Tuesday 19th April, 2011:

Te [working with her ethnically similar friends]:

Te: Is it called the Neponset Park or the Neponset River, Miss?
[Ua, Nn and Se look on attentively and answer simultaneously].
Sheron: What’s that?
Te: In Milton. [Ua says quietly: Neponset Park.] Is it Neponset Park?
Ni: Reservation Park.
[Te and Nin talk back and forth about the name of the park.]
Nn to Sheron: Actually, can I get another paper?
Ni and Te to Sheron: [The one in Mattapan, Neponset Park? Reservation Park?]
Sheron: So, what are you’ll going to do there?
[Se says something quietly.]
[Ua is writing]
Nn: We’re trying to, we’re trying to talk about violence over there.
[Ua looks up]
Te: What?!
Nn: The violence.
Te: What?!
Nn to Te [he smiles]: The violence. Aren’t we going to talk about the violence?
[Us smiles]
Te: What was the question, Miss?
Sheron: What community are you working one? [Te: Mattapan.] What’s wrong with it? And what are you going to change?
Te: Mattapan.
Sheron: Ok. What’s wrong with it?
Te [she flips through her papers]: Violence and security.
Se: We want to make the park a real park.
Te: We want to fix it and make the park a real park.
Sheron: A what?
Te: We want to make it a real park. There’s nothing in it! Just trees, grass . . . and we want to find out what the community wants and what’s going on in the community.
[Us writes and looks up periodically]
Sheron: Ok. . . .
Te: And involvement from the community. We want the community to be involved.
[Us continues to look at each of her teammates as they talk. She continues smiling.]
Nn: And we’ll have fund-raising, so we can have more money.
Te: What?
Us to Te: Fundraising to [she says the rest in French].

In the above case, Te was actively involved, understood the tasks, and was seen having fun while she worked. She was seen as competent and skillful in the practice. Te’s participation was quite different some weeks later when she was separated from her usual peer group. First, she did not want to speak at all, offering to agree with everything that was already said, saying, “All what they said.” After some time, she obliged briefly, and then retreated again. At one point, she remained quiet hoping that Ms. M would just move on
and not require her to speak further. Ms. M had to prompt her saying, “Can you say more?” in order to encourage her.

September, 2011:
Te [participating in a workshop with none of her close friends]:

Ms. M: What did you do over the summer?
Zs: [We were . . . ] sent off to different places in Boston and used different technologies to determine what they could put into the community. [We used ArcView, Excel, Camtasia . . . ArcView allowed the 3-D view of the project site.]

Qa: [I] found it challenging and confusing, especially Camtasia. Arc View [was] kind of easy. [It lets you put . . . ] everything you have in your head on to the website

Ks: [I] found it the opposite. Camtasia was easy but [there were too] many steps in the ArcView . . . like 3 different steps to put in one building.

[The group waits for Te’s reflections.]
Te: All what they said. . .

Dennis: What are your thoughts and plans after TESJ and whether or not TESJ had an impact on that?

[Several students speak. Then it is Te’s turn again.]
Te: Well, I like Math, technology, engineering and science. But I still haven’t decided what I want to be. And being in TESJ made me want to major more in one of the STEM areas.

Ms. M: More likely to major in one of those areas in college? You're a senior, so are you thinking about this in terms of your college application?

[Te is quiet.]
Ms. M: Could you say more?

Te: Well, ok. Being in TESJ basically made me want to major in one of the [STEM areas] and listening to the people talking about the majors and roundtable things helped me know more about what I want to major in, but I’m still undecided ‘cause . . .

By the time of the above event, Te had already consistently negotiated a successful science identity. She accomplished that successful negotiation while working with her cultural kinship peer group, for e.g. in her small group work, she always worked with one
or more of them and each time she presented publicly, she did so with others in her group. Thus, working within the group supported her successful identity negotiation. Had she not had those social opportunities, Te’s behavior would have been more consistently as the soft-spoken, withdrawn type shown above in the last event and she might have never successfully negotiated a recognizable science identity.

In another case of cultural kinship, Ua, who had negotiated a successful TESJ science identity, participated much more actively than usual and performed the behaviors that allowed her to be recognized as a member of the larger science community when she worked within her smaller peer group. Similarly, Ua benefited from a socially protective relationship with others from the same ethnic and cultural background and who shared similar experiences, for e.g. immigration and discrimination in school. In one case, Ua was seen volunteering answers to a particularly complex scientific problem. Although she did not know the answer, Ua joined in with her friends in volunteering guesses. This behavior was unusual for her. She was also seen to be smiling and enjoying the activity:

Thursday 21st April, 2011:

Dr. B: Just as a going away science question, you can go over and look at the plants and figure out why their shadows are green. . . .
Dn: Because of the lights! [He points at the plants and the lights.]
Dr. B: What about the lights?
A student: Because of the water?
Tne [quietly to Dr. B]: Because of the light.
Dr. B [steps over to him]: Why is the light special? Why is the light causing the shadows to look green?
Ua: Because of the color.
Tne: Because of the different colors.
Dr. B: But red and blue make purple.
Tne: And purple and...
Nn: And shadow.
Tne: And shadow!
[Dr. B leans into Nn]
Dr. B [repeats what Nn said]: Purple and green make green?
Dr. B: That's orange.
Ua [reaches out to Dr. B as she looks to him, then back at the plants as she tries another answer.]: Red and Yellow.
Ua: Blue and water make green.
Tne says something else.
Dr. B: That's right, red and blue make green.

Ua offered answers three times and even reached out to Dr. B to get his attention as she continued to struggle with the problem. Again this sort of excitement and risk-taking (as she was not sure of the answer) was unlike Ua’s usual timid and marginali behavior. She appeared interested and participated in the scientific reasoning and problem-solving activity.

**Support in Students’ Use of English**

Group membership also facilitated participation in the science activities by supporting each other’s use and understanding of English. Ua, in the following excerpt, not only was more engaged in the on-going science activity, but also persisted due to the assistance her friends provided her with French to English translations:

March 26th, 2011:

Tne [suggests]: How do we add more summer jobs for teens?
[Tha is writing and works on the phrasing of the questions.]
Tha: How can we … [inaudible] … opportunities … [inaudible]
Ua: How can we . . .

[Ua makes a suggestion, but trails off.]

[Ni and Tne talk to each other.]

[Ua taps him and asks him a question in French.]

[Ua signals with her hands as she tries to think of the words.]

Ni: Oh! Crime.

Tne: How do we help the . . . violence?

[Ua responds about violence in French. She code-switches and says violence in English.]

[Ni and Tne think about her question.]

[Ua stops Tha from writing. She taps her and speaks in French. Her question has not be formulated and stated clearly, so she is not ready for it to be written down.]

Ni: How’s the crime rate?

[Tha turns around and puts up both hands. Despite her soft voice, the two boys smile and are quiet.]

Tha: Ok, guys. [Her hands are up. She begins to formulate the question.] How can we help eliminate [inaudible] . . . less violence?

Ua repeats: Less violence?

[Ni responds in French.]

Tne [to Ni]: Prevent violence in the community.

[Te comes over.]

[Tha says something to her in French.]

[Ua speaks to Tha in French.]

[The boys are talking again.]

[Ua reaches over to pull them in. She is frustrated, but then she smiles. She winds up to try the question again.]

Tne: How can we prevent violence?

[Ua speaks in French.]

Tne: How can we prevent the violence in the community? [He taps the board with each word.]

[Ua speaks again in French, signaling her frustration as she struggles to articulate it. Tne leans his head against the board in frustration. He smiles, though.]

Ni: How’s the crime rate in the community?

[Tne and Ua continue to go back and forth in French.]
[Tha continues to write. She waves off Tne.]
Tha to Ua: Ok. Ok.
[Ua shrugs and drops her hands.]
[Ua pulls the boys back in before they go off talking again.]
Sheron: What kind of questions are you’ll thinking about?
Tne and Ni to Sheron: How can we prevent violence in the community?
Ni [stands up]: You can’t prevent violence! There’s always going to be violence!
Sheron: You could put things in place to try to prevent violence.
Ni: Oh yea.
Sheron: That’s a good question.
Ni and Tne go back talking in French.
Ua tries to come up with another question.
Tha thinks, as well.
Ua: Do we have a school in the community?
Tha is about to write it, but Ua stops her again. Tha then talks to the boys in French, trying to work on the question in English.
Ua to the boys: Do we have enough schools in the community?
Tne and Ni joke around.
Ua and Tha are frustrated.
Tha [turns back to the paper]: Ok.
Ua turns back to the paper, as well.
Ms. M stops by to help.
Ms. M: So, those look like great questions. How are you guys asking... how are you connecting the questions to the ...?
Ua [signals the first question]: [She reads out the first question.] “How do you want us to ... [inaudible]?”
Ms. M: Ok. That’s a good one to start with.
Ua continues: What are worst issues in the community?
Ms. M: Ok.
Tha goes to begin the third question.
Ua reads the third question.
Ua reads the fourth question: How can we prevent violence in the community?
Despite the frustration that Ua experienced in her attempts to contribute to the activity and her lack of personal identification with the TESJ activities, she persevered and ultimately helped her group complete their survey. Just for that activity, she took up some of the skills of a scientist – instrument development and collaboration.

**Participation in the Larger TESJ Practice**

Finally, amongst the students who benefited from cultural kinship experiences, with increasing confidence in their participation in the science practice while working amongst their sub-group of peers, some of the students eventually ventured out beyond their group and interacted with the larger TESJ/STEM community in more active and confident ways, sometimes stepping up as peer and student leaders. For instance, Hg was similarly social and more actively engaged in the various science activities amongst his cultural kinship peer group as opposed to a mixed group of peers or when working independently. Early on in the summer institute, Hg sat with three or four other students from his circle of friends each day and conversed in French. Over time, Hg was seen helping other students with the technology and speaking up on behalf of his group or in order to recruit help for his group as shown in the excerpts below:

**Wednesday 27th July, 2011:**

Qa to Cn: You know how to put a song on?

Cn shakes his head

Qa: Yes, you do! But it's for the thing, the thing that you did.

Hg comes over and does something on the computer for Qa

Hg asks Qa which song.
Qa: Firework by Katy Perry
Hg: It’s on Youtube?
The song starts playing.
Qa: I picked that song because of the lyrics.
Hg says something
He continues to work.
Qa: _____ put a song on. That’s why I put that song on. It’s like, “Do you ever feel like a little/wasted space?” It’s [she motions to the property] a waste of space!
[Jeremy runs his presentation progress by Sheron.]
Qa takes the mouse back to do something.
Hg warns: You didn’t save it.
He works again.
Qa takes the mouse again.
Hg looks on, points out at times.
Qa looks at the screen and smiles. “I’m a gangsta.”
Qa to Hg: Welcome to _____ [as she asks to put in a second song]
Qa reads some message on the computer... she then says something about iTunes [they’re encountering problems putting in the music]
Hg says something.
Qa: That’s ok... [inaudible].
Hg: You’re sure?
Qa: ... Thank You.
Hg goes back to his seat.

When Cn refused to help Qa, Hg stepped up and assisted her by coming over from the other side of the classroom.

On another occasion, when Mr. T led the class in aggregating the data collected in the field on the day before, Hg volunteers data by shouting out, something that was uncharacteristic of him:
Wednesday 20th July, 2011:

Mr. T: Ok. Qa? [What’s the data for the . . . ] 150 [feet section?]
Qa: I have her [Ua’s] data.
Mr. T: Ok.
[Qa then proceeds to call it out.]
Mr. T: Why do we only have 4 points?
Qa: Because I’m not done [calling out the data] yet.
[Qa calls it.]
Qa: And that’s it.
Mr. T: You’re supposed to have one more.
Hg: No! It’s . . . [Hg calls out the missing data].
Mr. T: Everybody copy that [data] down.

Hg shouted out the correct data voluntarily. This data was important in moving forward with the data analysis section of the STEM session. Shortly after Hg called out the data, Mr. T asked everyone to copy that data. Through this, he was seen as knowledgeable of the activity and content and as significant in moving the activity forward.

**Summary: Cultural Kinship**

The impact of cultural kinship was positive and supportive of student negotiation of a science identity either consistently over time or around specific, isolated events. For instance, Te would have likely not been able to negotiate a recognizable science identity had she not worked within her protective cultural kinship group. The only behaviors and social cues that she would been seen performing would be those of a shy, soft-spoken student and she would have likely been interpreted as lost or uninterested. Ua, similarly, would not have been able to perform the behaviors of an interested science student, even
in the short-term, had it not been for the protective nature of her peer group. Furthermore, Ua’s peer group was seen to be instrumental in supporting her use of English such that she could complete the survey instrument development and Hg was able to develop confidence within his cultural kinship group such that he was eventually able to confidently participate in some activities in larger TESJ practice.

**Friendship:**

The most basic relationship that the students sought out in TESJ was friendship and, when satisfied, this supported science community participation and identification. According to Basu and Barton (2007), urban minority youth’s interest in science activities was sustained when the activities satisfy desirable social relationships. Friendships, particularly within voluntary, after-school programs, are important relationships that need attention. Opportunities to engage with existing and developing friendships while participating in the TESJ science community successfully sustained many students’ interest in the program. For instance, Dn did not come to TESJ for the science learning experiences, but was so fulfilled socially when he attended the program that he continued attending regularly. Simply put, Dn said, “Every time I come here, I [am] happy” (February, 2011).

In addition to simply enjoying the time spent participating in a science learning community, the students also benefited from co-operative peer relationships that permitted participation in science activities and skills acquisition. For instance, Dy had completed her project in another class and left from next door to check in on her friend, Bs. When asked why she was not in her class finishing her project, she explained that she was
helping her friends and proudly showed their co-operative accomplishment. Assisting her friend sustained Dy's engagement in the science activity.

Tuesday 26th July, 2011:

Mr. T: [Why aren’t you in your class?]
Dy: I’m helping her! And, look it, all of this got accomplished because me and her worked together.
[Mr. T asks about her own project.]
Dy: Mine is done.
Mr. T: The whole thing? You’re all set?
Dy: Yea. I filled in my whole spot [she points to the screen.] Yea. All I have to add is one more thing.

Dy was happy to work with her friend and was proud of their accomplishments stating that “. . . all of this got accomplished because me and her worked together.” Ds and Zo also had a long-standing friendship within and beyond the TESJ program and through the collaborative design of the activities, they were able to socialize and have fun together as they worked. In the excerpt below, although not required to present their posters at the closing symposium, Ds and Zo had fun sharing their work in a light-hearted way. The conversation surrounding their poster was as follows:

May 13th, 2011:

Ds [to his and Zo’s audience]: Yea, two per cent discount. That’s good. [He grimaces in his usual cocky way for humor.]
[Zo nods.]
Ds: Two per cent from a thousand [dollars] is a lot!
Zo: Yea [he continues to nod]
Ds: At least I didn’t let you pay the whole, full price!
Ds: At least I threw in the discount. Yea, that’s the ghetto in me.
Ds [pulls Zo close and says]: Come, we have to show ’em the business [Ds and Zo smile and pose for a picture as a photographer had approached; Ds gives a thumbs up sign and smiles. Zo smiles and nods.]
[As the picture is finished being taken] Ds: Super Mega Fun Time.
Zo: That’s how we roll.
Ds: Now we’re going to our private jet. Excuse us, people. [Ds walks away]
Zo: Excuse [He follows Ds].

In having fun together and voluntarily prolonging their STEM project, Ds and Zo continued interacting with their project and describing it to audience members. They interacted willingly with others around the central practice of science, as well as presenting themselves as interested in their work and as enjoying their time in the program.

Summary: Friendship

Friendships supported student negotiation of science identities in a number of ways. For instance, the prospect of forming friendships encouraged the students to attend the program. Once in the program, in some cases, these relationships were sufficient to hold the students’ interests. Once regular program attendees, the hope was that the students will do and become interested in science. Additionally, friendships encouraged students to work cooperatively with each other and permitted peer-teaching opportunities around the science activities. Finally, friendships also prolonged the students’ engagement in their science activities, making science a more authentic social activity instead of decontextualized work.
Summary: Peer Dynamics

Overall, across the participants, specific kinds of relationships and interactions amongst the students and, sometimes, the instructors have been identified as important in supporting student science identity negotiation. Specifically, as have been presented and argued using the data above, leadership positioning and opportunities, protective and instrumentally supportive (i.e. the relationship helps an individual in accomplishing a specific task) relationships based on cultural kinship, and sociable and cooperative experiences of friendship have been identified, here, as supporting students in negotiating successful science identities for themselves within the TESJ program.

Significant Social Interactions

Within TESJ, the students were exposed to numerous practicing scientists, STEM professionals, and other kind of professionals throughout the year. These were in-person meetings through career panels, round table discussions and field trips, for e.g. to community development corporations (CDCs), as well as video presentations of notable speakers, for e.g. Majora Carter, a renowned social and environmental activist. The students also had ample time to interact with the TESJ development and implementation staff and instructors. These individuals, physically and virtually present, acted as unofficial mentors and role models for the students in STEM. Some students experienced support and guidance in negotiating their science identities as a result of significant social interactions with these individuals.
Three main trajectories in student negotiation of science identities as a result of these significant social interactions were uncovered. These included the transformative expansion of the identities that some students negotiated in TESJ, the gradual (less transformative) development of the science identities that some students have already begun negotiating, and maintenance of alternative science identities. Each of these will be discussed next.

**Transformative Expansion of Negotiated Student Science Identities**

First, some students experienced transformative expansion of their science identities as a result of exposure to new perspectives and conversations surrounding science, as well as growth in specific STEM career knowledge with respect to newly interesting careers. These students were exposed to pathways and possibilities that they did not think were possible or even existed prior to experiences with these individuals. These significant social interactions with the mentors and role models were both immediate and indirect.

Qa previously discussed her changed perspectives with respect to science, as well as her confidence in herself academically. This was as a result of desirable and positive peer dynamics, specifically leadership opportunities and social and collaborative opportunities around existing friendships; however, Qa also benefited from conversations with numerous adults through participation in TESJ over the year. During the year, Qa was considering a number of possible career paths for herself. One of the careers that she was considering was child psychology as she was significantly moved by the conversation she had with a
TESJ University psychology professor around children’s medical treatment in the US and her belief that children were being over-medicated.

Tuesday 19th July, 2011:

Qa: I also want to study psychology, but . . . [laughs] . . . ‘cause basically I took a class at TESJ in psychology and the program, I guess it was new. [Sheron: In TESJ?] Yea. And they was talking about like little kids and when they have problems and I told the teacher that, honestly, all I think they do here is give little kids a whole bunch of medicine for no reason. They just want little kids to get an overdose which makes them even more crazy.

Additionally, from hearing her guidance counselor’s, Mr. C’s, reflection on his career path in which he left a high-paying career in business for a more enjoyable, lower-paying career in school counseling, she realized that she could not pursue any career for financial reasons and instead of genuine enjoyment. This was an encouraging change as she also had recently come to realize that “science can be fun” (September, 2011).

Finally, with respect to the difficulty involved in studying science long-term, Qa was also significantly inspired by Dr. M, a software engineer from iRobot, when he spoke about his difficult childhood, particularly with respect to his struggles with dyslexia and the problems they caused for him in solving mathematical equations. Several weeks following the Summer Institute in which she heard Dr. M speak, she shared bits of his story that was inspiring to her with the audience at a research conference in which she served as a youth leader.
September, 2011:

Qa: Dr. M ... (pause) ... who was dyslexic [inspired me.] I have a lot of friends [who are] dyslexic. ... [Dr. M talked about how he] struggled in school, academically and socially ... [but he was ...] serious about education. ... [He] nagged his teachers. ... When I was younger, I thought I was dyslexic. I hated all the subjects. ... [Now, Dr. M ...] is very successful. ... [He] doesn’t have a TV, but he created the polling system for American Idol. He hated math, but he loved computer languages. ...

All of the interactions listed above, together with additional experiences in TESJ, facilitated Qa’s growth in self-confidence with respect to science and her consideration of science careers for herself. Another student, Ds, was also inspired by a role model in science. The students saw a video speech of social and environmental activist, Majora Carter, in which she talked about her urban development projects in South Bronx, New York, New Orleans, Louisiana, and Bogota, Colombia. Although he did not remember her name and referred to her as “the lady with the dog” (she began her speech by talking about walking her dog), Ds discussed her and her work as “the most important thing he learned in TESJ” (July, 2011). He said:

July, 2011:

To me, I would say that it doesn’t take a whole group of people to change something. It only takes one person. I remember back when we were watching that video [of Majora Carter]. ... I find that kind of amazing. ... And she just worked so hard for it. That’s like more than awesome. Spectacular.

For Ds, learning how much people can change their communities was significant. This likely was one of the major underlying motivating factors that maintained Ds’ interest in TESJ.
Continued Development of Science Identities Already Under Negotiation

Amongst a second group of students, the experiences were not as transformative. Rather, these were ongoing development of the science identities that students negotiated. This ongoing development resulted from growth in the students’ knowledge with respect to their specific STEM career interests. Through interactions with the STEM role models and mentors, the students were able to fill some holes of questioning and uncertainty. For instance, Te had long-term career interests in STEM, but was still undecided and lacked some specific knowledge. Through TESJ, specifically her conversations with STEM professionals, Te was further convinced of following through with STEM interests and expanded her understanding of engineering.

September, 2011:

Te: Well, I like math, technology, engineering and science. But I still haven’t decided what I want to be. And being in TESJ made me want to major more in one of the STEM areas.

Ms. M: More likely to major in one of those areas in college? You’re a senior, so are you thinking about this in terms of your college application?

[Te is quiet.]

Ms. M: Could you say more?

Te: Well, ok. Being in TESJ basically made me want to major in one of the [STEM areas] and listening to the people talking about the majors and roundtable things helped me know more about what I want to major in, but I’m still undecided.

Before TESJ, the only engineering I knew about was the one to do with houses and I didn’t know what it was actually called. In [TESJ] I learned about the different types of engineering … chemical, civil, mechanical … and I was captivated by how [one of the] engineer[s] talked so passionately about what he did.
Zs similarly learned additional specific career knowledge about forensic pathology from mentors and adjusted her educational plans as such. She also asked questions of the speakers on the career panel, actively seeking this knowledge about careers.

Thursday 21st July, 2011:

Zs: Based on experience or any of you can answer, how much college education do you need to become like a forensic analyst, analyst?
Dr. M: A forensic what?
Zs [and some other students]: A forensic analyst?
Dr. M: What are you going to analyze?
Zs: Like, the bodies and stuff in crime scenes.
Mr. T: Well, if you’re gonna . . . I know that the CSI’s and the shows that everyone’s watching where they do all those bodies, most of those people are called pathologists to determine cause of death . . . and pathologists are medical doctors . . . so you have to go to 4 years of college, 4 years of medical school, 1 year of internship and residency can be anywhere between 1 and 6 years, but I think pathology is about 3 or 4 years.
[Students groan.]
[Dr. M describes his experience as a forensic analyst for networks where he worked with law enforcement, investigators, intelligence folks.]
Dr. M: Forensic analysts investigate the thing after the fact.
Nh [undergraduate guest on the career panel]: For those interested in the medical field, when you get to college and you realize that you don’t want to go the pre-med track and do like history there are post-bac programs that make sure you get the science requirements for medical school.

[The following week]:

Sheron: So, what do you have planned next for yourself in terms of your education or your future career?
Zs: Well, definitely do better than my freshman year in high school. And just keep on trying harder and harder each year. Hopefully, going to college and become . . . go to medical school ‘cause I want to continue on to the forensics.

Having learned new information about the necessary step of medical school in becoming a forensic pathologist, Zs incorporated this step into her long-term science career
plans. Finally, Zo, like Te and Zs, also had long-term STEM career plans. He was interested in engineering and video game design. On learning of an MIT graduate student’s knowledge and skills in video game design, Zo uncharacteristically spoke up, proactively asking questions to learn more about this skill, for example, how to acquire computer programming skills via the internet or how to experiment with designing video games.

Thursday 21st July, 2011:

Mr. P: [Any questions for the career panel?]
Zo [raises his hand quite quickly]: Yea. How did you [Mh] get into MIT? Like what did you do?
Mh: This is going back to the advantage you have if you’re interested in Math. . . . I’m actually a biology program . . . but if you have some skills from one field and you want to apply them in another field, that’s really beneficial. . . . so when I was applying to this biology program, they saw that I could do computer programming and the math that the biologists didn’t really know and I knew some biology. . . . I’d say, really work on the quantitative stuff . . . and consider spanning more than one field like amongst math, biology, computer, physics, architecture, business. . . .
Zo: You said you made video games. How do you make them? Do you download a program or something?
Mh: So, you have to learn the very basics of how to write a computer program. That’s getting easier and easier every day. So pick a system that’s relatively easy . . . this is true of anything you want to learn . . . for anything you want to apply your knowledge to . . . then you can seek out that knowledge somewhere and figure out how to do it. In my case I wanted to write computer games . . . so I figured out how to write the program. But that’s true of like solving a very simple problem like fixing back your desktop that your little brother interfered with. But there are tutorials about programming on the internet that you can download.

The information about video game design held Zo’s interest even through the debrief conversations later that day:
Thursday 21st July, 2011:

Mr. L: So do you think that the people who make millions of dollars had the interest in what they were doing?
Sa: I think they just had better skills in what they were doing, so they stuck with it because they were really good at what they were doing.
Zo: Wait, what did that guy say about computer programming? About making your own games?
Mr. L: He said that you could go online.

Zo was immediately engaged by Mh’s knowledge of video game design and computer programming. He deemed that information important to his continued development towards becoming a video game designer himself and could use it in pursuing that STEM career plan.

**Maintenance of Alternative Science Identities**

Not all social interactions between students and science mentors and role models were significant enough to result in students being motivated to negotiate science identities in the TESJ practice. In some cases, as seen with a third group of students, despite interacting with science role models and mentors, these students maintained their already existing STEM career interests, namely medicine, and alternative science identities. Rather, growth in the students’ science identities was the result of experiences outside of the TESJ program and not the result of significant social interactions within the program. For instance, both Ta and Hg derived interests in medicine as a result of family members modeling medical careers, experiences caring for younger siblings and cousins, and the desire for significant financial earnings. When exposed to additional career perspectives, they dismissed these as not meaningful to them or as not significantly contributing to their
desired career knowledge. Reflecting on a STEM career panel that had just concluded, Ta said:

Thursday 21st July, 2011:

Much of what they talked about wasn’t interesting to me because they didn’t really talk about anything that I was interested in; but one thing I learned was that what you might want to high school might change because you might change your mind.

Ta did not see the information shared by these individuals as contributing to her own career plans nor did she consider alternative STEM perspectives. Hg, on the other hand, conducted his own research into medical school and had plans to identify more resources:

July 2010:
Every day on the computer, I try to learn more, like, I do some research to learn more about why, what I am going to do in the future. Every day I am on the computer researching some document about doctors, what to do. Every day I do that.

July 2011:
Sheron: What are your next steps or educational plans?
Hg: Go to college and go to a great med school that I know I can go far in life by going to that school.
Sheron: You have any ideas about schools?
Hg: Ummm, no. I don’t know yet. But I’m thinking maybe BC, BU.
Sheron: You wanna stay local?
Hg: I don’t wanna go . . . I don’t know. It doesn’t matter. As long as I go to college.
Sheron: What might help you?
Hg: If I, I need to find like more programs where they talk about med school.
Hg did not think that he was getting the necessary medical school information from the role models and mentors recruited for TESJ, so instead he continued to negotiate an identity with respect to the medical practice by learning more and more about doctors, medical school, and medical careers.

**Summary: Significant Social Interactions**

Mentors and role models in science were important in supporting students’ ongoing negotiation of science identities. The significant social interactions between the students and the mentors/role models supported this development through the expansion of the students’ perceived possibilities for themselves in science. These included Qa’s conversation with the psychology professor about medicating children, her conversation with Mr. C about choosing career enjoyment over money, and listening to Dr. M talk about his struggles with dyslexia during his childhood and when dealing with mathematical equations in his career and Ds learning about the significant impact that people can have in transforming their communities. Additionally, some students learned more about their specific STEM career interests. Te learned more about the specific fields of engineering and was inspired by how engineers spoke about their work, Zs learned the proper name for a forensic pathologist, more about the educational requirements of the profession, and more about what forensic pathologists actually do, and Zo learned of ways in which he can gain skills in video game design and computer programming. Some of these social interactions were structured and purposeful, set up in the form of career roundtables and panels. In other cases, these significant social interactions took place by chance or during casual conversations.
Student Ownership in Science

Student ownership, a process in which students take responsibility for their learning and make critical decisions in structuring the activities in which they are involved was present in many of the cases. By perceiving the work as their own and as something meaningful, the students would be expected to become more engaged in the activities and derive more enjoyment from them. Furthermore, by performing these behaviors, i.e. positive affect, active participation, and STEM skills development, they presented themselves such that they were interpreted as competent members of the TESJ science practice.

Demonstrating ownership over her work, Qa, in the data that follows, voluntarily called her instructor over to show him her results.

Wednesday 27th July, 2011

Qa to Mr. G: Excuse me.
[Mr. G comes over.]
Qa: Look. I did that. [Qa points to her computer screen]
Mr. G: Ok.
Qa: No pollution.
Mr. G: Wow! Got more energy. More commercial energy. That’s . . . [inaudible] . . . Looks like you got more jobs, too. Jobs and housing . . . (pause) . . . energy . . . (pause) . . . water, barely any, . . . (pause) . . . and energy use.
[Qa points at the screen for each one]

Qa valued her accomplishment, indicated by her desire to share her findings with someone. This would only benefit her skill and knowledge growth around the activity and allow her to be seen as a successful science student. Qa was also very committed to her
project and the actual city lot on which they worked. She showed this as she was very purposeful in her selection of music to accompany her presentation in order to fully communicate her message regarding the site.

Wednesday 27th July, 2011:

Qa to Cn: You know how to put a song on?
[Cn shakes his head]
Qa: Yes, you do! But it’s for the thing, the thing that you did.
[Hg comes over and helps Qa.]
[Hg asks Qa which song.]
Qa: “Fireworks” by Katy Perry
Hg: It’s on Youtube?
[The song starts playing.]
Qa: I picked that song because of the lyrics.
[Hg says something. He continues to work.]
Qa: _____ put a song on... That’s why I put that song on. It’s like, “Do you ever feel like a wasted space?” It’s [she motions to the property on the computer screen] a waste of space. . . .
Bi to Qa: I took a picture of all the trash that was there.
Qa: That will work. . . .
[Qa reads her slide to Bi]: “When we first got there, this place looked like a real dump. It looked horrible.”
[Bi says something. Qa laughs.]  
Bi: “. . . it’s dangerous [she points], it’s dirty [she points] . . . ”
Qa to Bi: What did you say? “This environment is serious business.”
[Bi says something.]
Qa: Nah, I want it like [she signals]. This one sounds too . . . I want it like “real talk” and then show the picture. Like, “real talk. Yo.” [The girls laugh]  

Qa chose specific music and planned to use pictures in order to communicate a specific “real talk” message about the site and its conditions. Ta also presented herself in a
way that communicated that she took her work seriously and was very proud of her accomplishments.

Thursday 21st April, 2011

Sheron: Tell me about your project.
Ta: So, well, our project is about Madison Park. [She is suddenly animated and appears proud to present her work.] That was the site that, where we went to [She signals.] That’s how it was... a lot of trash around. And then, it was empty. So, we made a design. We put buildings with a lot of green space to prevent air pollution. And we think our design is better because it has less buildings and more green space to prevent pollution which causes many health problems and stuff like that. And there was less cars going around [she signals the vehicle trips per day chart], so that means there was less C-O-2 [she signals the carbon dioxide auto emissions chart] going around. And one thing that we didn’t put in our design was parks and benches and stuff like that. We had everything, but those. That’s basically it.

[Ta stands back and smiles.]

Like Qa, Ta was excited to share her work with others. The girls made multiple purposeful decisions in planning and executing their work and were proud of their accomplishments. Instructors functioned as facilitators and technology supporters, i.e. they answered questions about clarifying the overall activity goals, formatively evaluated the students’ developing project both with and without requests from students, and provided instructional and technical support to the students in accomplishing various design and research tasks with the urban planning software. As such, the girls took control of the development of the respective projects, learning science skills and content along the way. This commitment to their work is important as one will only be motivated to negotiate an identity with respect to a practice that she perceives as meaningful and valuable.
Other students performed in ways that emphasized the immense pride they felt in preparing and presenting their work, as well. For instance, Dy spoke up positively about her work and defended it from others’ critiques.

Saturday 30th April, 2011

[Mr. J puts up the second poster, the exemplar.]
Mr. A: Now this one is beautiful. Absolutely beautiful.
Dy: Where’s mine? Mine is beautiful, too...
Mr. J: Any spelling errors?
Dy: Did they use Word? I used Word to check for spelling errors.

As seen above, Dy believed in the high quality of her project and felt that it deserved recognition. She showed this by shouting out, “Where’s mine? Mine is beautiful, too.” She also pointed out that she was meticulous in checking spelling errors by using Microsoft Word. Later on that morning, Dy defended her poster from critiques from other students.

The purpose of the activity in which the students were engaged at that time was to go around to their peers’ posters, examine them, and suggest improvements by making notes and affixing them to the posters using post-it notes.

Saturday 30th April, 2011

[Ds comments on Dy and her group's poster.]
Ni to Ds: Why you writing that?
Ds: Because you don’t have any graphs.
[Ni jumps up to remove the post-it. She takes it and runs away.]
Dy to Ds: Because the dude said we don’t need graphs. He said that we don’t need graphs.
Ds to Sheron: She needs a graph. Everybody . . . well, mostly everybody has a graph. You need a graph to show like what . . . [He points to their CV site layout]. Like, this over here [he points to the adjacent poster]. You [Dy] even said that you needed a graph. You probably just erased it.

Dy: We don’t need a graph!

Sa to Dy: Yes, you do. Yes, you do.

Dy: He said that we don’t need to have a graph, right?

Ds: You need a graph to explain why it’s good. There’s no graph here to explain why it’s good.

Dy: We explained it in words. Well, verbal words.

Dy strongly defended her lack of graphs against Ds and Sa. She felt strongly about the high quality of her poster at that point, believing that it needed no critiques. It is worth noting, however, that she did take personal responsibility for the final quality of the project as later on that day, she was seen asking her other teammates about adding graphs. She took the constructive criticism and aimed to improve her group’s project, rather than leaving at an incomplete stage. Like with Qa and Ta, this indicates the value at which Dy held her work which bodes well for her drive to negotiate a successful science identity in TESJ, which she did.

Ds was another student who took ownership over his work. He worked diligently in planning out and designing his site with his teammate, Zo, and although they did not fully address the results regarding the specific scientific, economic and social indicators, demonstrated that they took responsibility in their learning and were quite proud of their accomplishments as shown below:
Thursday 21st April, 2011

Ds: My name is Ds [He saunters up to his poster, quite proudly]
Sheron: I knew that would be the name [laughs]. Super Mega Fun Time. . .
Ds: Ok, well anyway. Super Mega Fun Time. . .
Ds [points to the title while looking at the camera]: Four words. . .
Ds: And all that space, it was just being unoccupied and I thought that it was a waste of space... But also, something else I noticed, too, there was a big construction site that wasn't really being used. But this is our place [He points]. . .
Ds [points at the poster again]: Super Mega Fun Time. We wanna live there.

As he and Zo designed it, they envisioned themselves living there; not an imaginary or hypothetical city, but as their own community. Ds believed in and was connected to his project. He stated, "...this is our place. . . We wanna live there." Again, in order to be driven to negotiate an identity with respect to a practice, one needs to see that practice as meaningful and worth becoming a recognized member. Other students, namely Ua, demonstrated ownership in the STEM activities, but in a relatively superficial way. For instance, in the data below, Ua wanted to make sure that the instructors was aware of her choice of color scheme for the message it communicated about green space in her and Nn's presentation.

Thursday 21st April, 2011

Mr. Ay: Tell me about your project.
Nn: The reason why we did our project was because sometimes when you build houses, you don’t put trees in them and the trees help us in life. You know?
Ua: And we share the [she signals]
Nn [interrupts]: Oh! The parking lot. We share the parking lot with the grocery store.
Mr. Ay [nods]: Hmm-mmm. Nice.
[Ua looks around]
Sheron: No questions for them?
Ka: I don't think I have a question. [Ua: Because it’s good!] Because she already told me everything about it... 
Ua: And we choose that color because it’s green and we like green space.
Sheron: Ok.

Here, Ua has taken up the message of the importance of green space. She had made certain decisions in her urban design plan and poster presentation to communicate the importance of green space and ensured that this was noticed and understood. The responsibility and independence students enacted with respect to their STEM projects supported confidence in the knowledge and skills that they gained from the activities. As the students became more knowledgeable and competent, not only will they be recognized as more central members of the science practice, but they would also grow further in their self-efficacy and confidence with respect to the science practice. This would further encourage student negotiation of science identities. For instance, Qa, on being asked how she might feel if her instructors or guests from the STEM career panel were to talk to her about her project, she responded:

July, 2011:

I feel very knowledgeable and comfortable ‘cause I’m good at talking with adults [Sheron: Ok. That’s good.] And, like, my vocabulary, it’s not that good, but it’s not that bad. It’s actually very “for my age.” And I actually know what I’m doing for Madison Park. I actually know what we’re measuring. So, I would have the knowledge to tell an adult what we’re doing.
In the above response, in saying that “... I actually know what I’m doing for Madison Park. ... So, I would have the knowledge to tell an adult what we’re doing,” Qa acknowledged her confidence in what she knew in terms of content, as well as in skill (“... what we’re measuring.”)

Similarly, Dy responded quickly and with great confidence when asked to rate herself in terms of comfort in talking to others about the science that they were doing in TESJ. Her responses were as follows:

July, 2011:

Sheron: How comfortable or knowledgeable do you feel when you are talking about the science with the other students?
Dy: I feel very comfortable. [says it with great confidence]
Sheron: Rating yourself from zero being absolutely not comfortable and ten being absolutely comfortable, how would you rate yourself?
Dy: Ten.
Sheron: Ok. And if one of the teachers was to pull you aside and talk science with you, how would you rate yourself?
Dy: Ten. ...
Sheron: Ok. If one of the scientists on that [career] panel was to pull you aside and talk to you about science or a science career, how comfortable would you feel then?
Dy: Ten.

Dy responded, without hesitation, that regardless of her audience, students, teachers, or STEM professionals, she felt extremely confident in her ability to talk about what she was doing in TESJ.
Summary: Student Ownership in Science

Student ownership was defined as a process in which students take responsibility for their learning and make critical decisions in structuring the activities in which they are involved. Furthermore, by perceiving the work as their own and as something meaningful, the students became more engaged in the practice, visibly enjoyed the activities, and developed the relevant skills and knowledge. These behaviors and cues allowed them to be interpreted as competent members of the TESJ science practice who belonged. Students demonstrated their ownership by voluntarily sharing their on-going work, by emoting high levels of pride when presenting their work publicly, by conducting their work in a diligent and meticulous manner, by becoming personally connected to their work and the products of it, i.e. the re-designed city block.

Student Reactions to the TESJ Practice

Thus far, what has been presented were the strategies students used in negotiating science identities for themselves, as well as common factors that supported student science identity negotiation. I will now present findings on how the students reacted to the opportunity to negotiate identities in science/STEM through participation in TESJ.

First, many students were open to the science practice as it was presented to them. Certain skills and content areas were distinctly represented in the TESJ science community. For instance, students were introduced to the concept of STEM and 21st century skills, as well as GIS and geospatial technology, urban planning, and green space. In their work and
discussions of their reactions to the work, many students took up and used these terms in positive ways. Some examples were as follows:

February, 2011:
Dn: Working with the GIS thing, like the maps and stuff, and gathering data and stuff. . . . Like I learned a lot like . . . I believe it was the first [session] this year when we went to the Commons and we were gathering data and taking surveys on people. Like, I found that kind of interesting.

July, 2011:
Zs: Well, finding out about the STEM was pretty interesting, as well as working on my social skills and basically preparing me for college and what’s going to be going on, like what the campus is like and what type of stuff maybe there is when I go to college.

July, 2011:
Qa: No idea what this [program] was about. . . . I find it kinda interesting. . . . I think this is engineering . . . STEM.

July, 2011:
Sheron: Ok. What is the biggest or most important thing to you that you’ve learned in TESJ?
Te: How to use the GIS program. How to create a park. Things like that.
Sheron: Why is that important to you?
Te: Because I didn’t know about it and when I came here, I learned about it and I learned how to use it.

A common descriptor used for the activities in the program was “interesting,” used by three of the four students above. What they learned in the program was considered either “interesting” or important. Additionally, the students identified specific topics as central to the practice, namely STEM and GIS.
The students entered the program with a range of background experiences and future plans with respect to STEM, but their responses were commonly positive. For instance, Dn was interested in business studies, Zs in forensic pathology, Qa was initially business studies, but became interested in a range of STEM careers, and Te was interested in engineering. Thus, it is important that the students’ openness to the STEM practice was maintained even if they did not perceive the specific skills and content targeted in TESJ as a long-term match for them personally. Most significantly, these students did not outright resist or reject engagement in STEM. For instance, Dn was interested in business studies, while Ds was interested in video game design; however, they still acknowledged the value of the program as a STEM community as shown in their responses below:

February, 2011:

Dn: [TESJ] It’s not really important to me when it comes to college because I want to go in for business and this doesn’t do much in business. But if I do want to have a career like in science, like we [saw] a lot of people today [on the career panel] for environmental science, like they gave us the key points of it.

July, 2011:

Ds: Well, me, I have my own personal thing where I want to be a video game designer...

Sheron: Can you see yourself as a future scientist? Do you see yourself developing those skills?

Ds: Hmmm. Yea, I could say I could, you know? Not as mixing potions and chemicals and stuff, but, you know, collecting data, doing surveys, going around representing different information to people telling them what’s going on in the community, you know, figuring out what people want. Yea, I could see that. I’ll say like a “survey scientist.”
Although TESJ did not provide specific business studies career knowledge for Dn, he acknowledged that it would be valuable for those interested in STEM careers. Ds had his “...own personal thing... to be a video game designer...” but still acknowledged his growth in skills regarding community development and investigations.

Finally, despite variations in the students’ predisposition to engagement in the STEM community, there was a lack of negative peer reactions from them towards their peers who were more interested in STEM.

**STEM Career Development**

Simply actively participating in the TESJ STEM activities and having fun while doing so did not afford a student a science identity. An important aspect of negotiating a science identity was students’ development of STEM career plans. This had to go beyond simply stating an interest in a STEM area. As such, in the section that follows, I will discuss the ways behaviors and social cues that students used, along with agency, in order to be identified as seriously considering STEM careers. Furthermore, a distinction was detected in the reasons underlying the students’ STEM career interest, namely their passionate or pragmatic interests in STEM careers.

**Passionate STEM Career Interests**

Students demonstrated their serious career plans in STEM fields by describing their interest in these careers as the result of an inspiring or transformative experience around a related activity, enjoyment of the activity, or a positive perception of the career. For instance, Qa was personally moved by the conversation she had with the TESJ psychology
professor about the medication of young children for psychological treatment. Additionally, she perceived forensics and medicine as fun and interesting careers from watching popular television shows such as CSI: Miami and House, respectively. Te was inspired by the ways in which engineers spoke so passionately about their careers at the career panels. Zs enjoyed an animal dissection activity in her freshman year of high school and became inspired to pursue forensics. Finally, both Zo and Ds enjoyed video gaming and computer technology. These students spoke about considering or pursuing these STEM careers because these will bring enjoyment to their lives. These students were passionately motivated to pursue their STEM career interests. It is noteworthy, as well that these students all successfully negotiated TESJ science identities.

**Pragmatic STEM Career Interests**

Another group of students also demonstrated their serious, long-term career interests in STEM fields by describing these career interests as being developed since they were young children. Three things are noteworthy about this group. First, none of these students successfully negotiated TESJ science identities. Second, all of these students were interested in medical careers. And, third, family members modeled participation in these medical careers and strongly encouraged the students to pursue these pathways. Hg, Ua, and Ta all had family members who were doctors or nurses who urged them to aspire to be medical professionals. This was the case even when Ua talked about her interest in other careers, such as fashion design. Furthermore, Hg talked about their belief in the lucrative financial earnings from becoming a doctor and Ua talked about the job stability afforded by becoming a nurse. Beyond the role models in nursing and the encouragement by family
members, Ta also described enjoying caring for younger family members as an early experience that shaped her career interest. Finally, these students did not discuss the sheer enjoyment or expectation of enjoyment in medical careers. Given the practical nature of these students’ interest in medicine, i.e. high pay and job stability, and the absence of talk about enjoying medical topics, shows, or activities, these students were considered to be pragmatically motivated to pursue their STEM career interests.

**Summary: STEM Career Development**

Overall, serious STEM career interests were demonstrated by students describing their career interests as the result of inspiring or transformative experiences around related activities, enjoyment of the activities, or a positive perception of the careers or as having held these career interests from a very young age. Two major kinds of STEM career interests were identified – passionate and pragmatic. All of the students who demonstrated passionate STEM career interests had successfully negotiated science identities in TESJ, while those who demonstrated pragmatic STEM career interests did not negotiate successful science identities; however, successful negotiation of a science identity did not mean that the student’s STEM career interest was interpreted as a well-established one that indicated a likely move toward that specific career. For instance, Dy had successfully negotiated a science identity, but had only stated her interest in medicine in an isolated class discussion in which students took turns sharing their career interests. No further mention of a career interest in medicine was made.
Results Chapter Summary:

In this study, students can negotiate successful science identities within TESJ by exhibiting: (i) an increased level of engagement and participation in the science activities; (ii) a positive affect and enjoyment of the science activities; (iii) demonstrated competence and proficiency with the scientific tools, for example the technology, language and content knowledge; and (iv) development of long-term STEM career plans. Six of the ten participants successfully negotiated science identities within TESJ, while four students did not. In order for students to successfully have negotiated science identities in the practice, the students had to consistently perform the behaviors and social cues that would permit interpretation of the students as skillful and competent members of the practice. Isolated performances of these behaviors and social cues were not sufficient in order for the students to be identified as science students or future scientists.

Two strategies have been identified as being used by students in negotiating science identities. These were discursive identity development and language use in science. The students used agency in behaving, interacting, and using the language of science in ways that allowed them to communicate specific messages about themselves and to present themselves as certain kinds of science students. Messages included that they were smart and knowledgeable, they were urban and ethnic minority youth, they were funny and social, and they were committed to helping others. The language of science was used in traditional ways and in hybrid ways, combining traditional and non-traditional forms, including story-telling, hip hop, and youth slang.
Additionally, three factors have been found to be supportive of successful science identity negotiation. These were peer dynamics, which included leadership opportunities, cultural kinship, and friendship; significant social interactions between the students and STEM role models and mentors; and student ownership over their work in science. Significant social interactions permitted expansion of the possibilities students saw for themselves in science, as well as growth in their STEM career knowledge. Student ownership encouraged the students to be responsible and committed to their work, thus perceiving the TESJ practice as meaningful and valuable enough to be driven to negotiate recognizable identities in relation to it.

Following this, I presented data in regards to the students’ reactions to being presented with a science practice in which they could be involved. First, the students mostly approached the practice and its specific topics with open-mindedness. Secondly, this open-mindedness was largely maintained despite STEM not being a long-term career match for them personally.

Lastly, the students performed specific behaviors that indicated their serious consideration of STEM career pathways. One group described their interest in various STEM careers as the result of an inspiring or transformative experience around a related activity, enjoyment of the activity, or a positive perception of the career. These students focused on the enjoyment of their potential careers or on an inspiring event. These students were passionately motivated to pursue STEM careers. Another group described their STEM career interests as being developed since they were young children, as the result of STEM role models, from being encouraged by family members, or in order to
attain stable and lucrative careers. These students were pragmatically motivated to pursue STEM careers.
Chapter 4B: Individual Case Study Analyses

Ten individual analytical “stories” of identity negotiation within the informal TESJ science practice have been determined by means of the research methods detailed in Chapter 3. In order to demonstrate how the students made use of the strategies of discursive identity development and language use in science, as well as the impact of the three factors (peer dynamics, significant social interactions, and student ownership in science) that supported successful science identity negotiation, all developed in the previous sections of Chapter 4, four of the ten individual cases will be presented in a condensed form in the upcoming sections.

The cases that follow will describe four different science identity negotiation pathways for participants in TESJ. Three of these students eventually negotiated recognizable TESJ science identities, while one student did not. How they used the strategies and factors will be described briefly.

Across all four cases, the students negotiated discursive science identities in order to communicate various messages about themselves through the use of agency within the limits of the TESJ science practice. Additionally, their use of language was important in supporting the messages they wished to communicate, as well as in maintaining autonomy in the science identities they negotiated, i.e. the students’ conformed to traditional scientific ways of speaking to different extents that reflected their interests in the TESJ practice, for e.g. training for a future career, a space to engage with technology, or a space in which they can socialize, and the identities that they had negotiated.
Qa

Qa was a 15 year old high school student of Dominican and El Salvadorian descent. At the start of her time in TESJ, Qa was friendly and outspoken; however, she was not particularly interested in science. Rather, she would often speak about her school experiences. During the program’s science activities, Qa was visibly uninterested and participated reluctantly. She was not regarded by her peers or instructors as an outstanding STEM student as they did not depend on her for any significant contribution to group projects. Finally, she did not indicate any interest in pursuing a STEM career.

By the end of the year, however, Qa was a different kind of science student. She was skilled and knowledgeable in the urban planning software and science content; she took on the roles of peer and student leader; she was a consistent active participant in the STEM activities; and she had identified a number of STEM career pathways for herself. Overall, Qa appeared to successfully merge and satisfy a number of interests through potential STEM careers. Her initial career plans involved the field of business. She was influenced by her older sister, her role model, who was financially stable and able to afford to be dressed and accessorized well through her business-related career; however, over time, Qa had shifted towards more service-oriented careers. She described becoming interested in forensics and medicine from popular television shows such as CSI: Miami and House. Her new interest in psychology was sparked by a college-level psychology course that she visited one day through a “shadow day” experience through TESJ. She felt that children were being overmedicated and was compelled to raise this point in the class. Motivated to further work in this regard, Qa now considers a career in psychology. Qa was still not in love with...
technology. She still remarked, "I do not like computers," to one of the instructors at the end of the Summer Institute; but Qa had demonstrated significant growth in the identity she negotiated within TESJ, as well as with her interests and competence in science practice and the perspective she held about STEM.

This transformation, Qa’s negotiation of a TESJ science identity, was the result of a shift in peer dynamics that permitted opportunities for leadership, significant social interactions with a psychology professor, a computer engineer, and a guidance counselor, and opportunities to take ownership of her work in science. Qa also discursively communicated messages of being smart and knowledgeable and people-/service-oriented, as well as agentically used the language of science in a hybrid way of traditional and non-traditional storytelling forms.

Zs

Zs, a Puerto Rican and Filipino, freshman female, enrolled in TESJ for two main reasons: (i) to work on her social skills and meet new people; and (ii) to learn about college and that upcoming experience. She was not aware of a STEM focus in the program prior to enrolling. The structure of the TESJ program satisfied her desire to socialize with her peers and adult mentors while providing a context in which Zs’ confidence and self-efficacy in STEM had increased. Furthermore, she learned new STEM content knowledge and skills and had opportunities to further explore her STEM career interest, forensic pathology. Significant to Zs’ science identity negotiation were leadership opportunities in which her peers often called on her for help with the science projects or expected her to lead the group; her strong peer relationships; significant social interactions, particularly with
respect to a computer engineer and her instructor, Mr. T, a former chemical engineer who shared critical information about forensic pathology with her; and opportunities for student ownership in science. Furthermore, Zs engaged in discursive identity development through science in communicating messages that she was funny and social, for instance in using the technology to create a humorous video for her peers in class. With respect to the language of science, she used a traditional scientific discourse relatively proficiently, further demonstrating her skill and competence in the TESJ science practice.

Ds

Ds was a freshman, African American male. Prior to TESJ, Ds had clearly defined STEM educational and career goals. He had planned to go to MIT for engineering and hoped to design video games or work in the mechanical engineering or computer engineering fields. He was seen thoroughly enjoying his time in TESJ and discussed his enjoyment, as well, despite being first drawn to TESJ by the financial compensation. He was quickly engaged in many aspects of the program, including the community action research components, environmental justice, and the social connectedness amongst the students. Ds employed both strategies of discursive identity development and language use in science to portray himself in specific ways within the TESJ science practice. With respect to discursive identity development, what was most interesting was his insertion of unique aspects of himself centrally into the TESJ practice such that these became commonly recognized. These unique identities included an enterprising mogul, a ninja, and a “hood” rapper. He also used the language of science in a non-traditional hybrid way that incorporated youth culture and hip hop slang. Together these strategies communicated the messages that Ds
was a smart student, from an urban, ethnic minority background, and was a funny and social kid. These were important to him as he described feeling “cool” and “smart” as he participated in TESJ. Significant social interactions, particularly learning about the work of Majora Carter, satisfying friendships, and opportunities for student ownership over his work in science were also supportive of his successful science identity negotiation.

Over the year, Ds had maintained his initial STEM career interests as he said, “I plan on going to engineering... You know, computer technician... Maybe some science. But yea, mostly engineering, building, mechanics, video game design, stuff like that.” Ds had negotiated an identity in the science practice of TESJ that was both recognizable by others and personally satisfying.

**Ta**

Ta was a Haitian female in her sophomore year of high school. She learned about TESJ from a teacher and saw it as a good program to learn about and prepare for college and to learn to work in groups. Early on in the TESJ program, Ta discussed her career aspirations of becoming a pediatrician. Ta became interested in pediatrics early on in life as a result of the role model influence of her mother as a STEM professional role model, specifically a nurse, a desire to help people, and childhood experiences with caring for young children in her family. Furthermore, medical careers were highly esteemed in her family and culture. Throughout the year, however, Ta did not perceive of the STEM and career development activities as valuable to her or as connected to her medical goals. She was, therefore, not as actively engaged in the activities as other students, such as Zs and eventually Qa.
Ta valued other aspects of the practice instead, namely social opportunities around friendship and cultural kinship. Throughout the year, Ta’s participation in the STEM activities was dependent on her ability to work and socialize with her friends. When able to work with friends and close peers, Ta became more active and central in the various activities, thus being able to demonstrate her growing STEM skills and content knowledge. Student ownership was also significant to Ta’s participation as when able to publicly present what she had accomplished, she was much more visibly happy and driven to be doing the work. She did not discuss any significant social interactions nor did she strategically use the language of science to portray herself as any specific kind of student in science.

By the end of the study, Ta had not successfully negotiated a science identity in TESJ as, despite consistently discussing a medical career interest. She had demonstrated that she was capable of doing good work or using the language of science proficiently as she had produced a good community redesign project and presented it well; however, she would later deny these capabilities, not perceiving these as important behaviors to perform. Ta had negotiated an alternative science identity, a future doctor identity, and did not perceive the behaviors and social cues of TESJ meaningful enough or connected strongly enough to her personal goals to perform them.
Chapter 5: Discussion

The research question guiding this study was, “By examining various genres of discourse, with a particular focus on language, what kinds of identities do students negotiate with respect to a specific science practice?” I was interested in investigating the ways in which students developed science identities by negotiating their student agency and the available behaviors and social cues within a science practice, namely an informal science educational setting. Additionally, I was interested in the specific factors that supported successful science identity negotiation. Finally, since simply doing the tasks of a science practice does not permit interpretation of these behaviors as indicative of serious consideration of long-term science study and STEM career interests, I was also interested in examining students’ science identity negotiation patterns in relation to their developing or sustained STEM career interests. In this chapter, I will discuss the research findings in light of these questions.

The students in the TESJ science education program interacted within the program in a number of diverse ways that incorporated and communicated important aspects of themselves and of their interests within the limits of the program. The motivations underlying the students’ authoring of these various discursive identities ranged widely and were connected to personally meaningful goals and experiences. These included experimentation with future STEM professions and communication of specific messages about themselves, including that they were committed to helping others, that they were non-traditional science people, and that they smart and knowledgeable, amongst others. They made use two major strategies, discursivity in identity negotiation and language use
in the science practice, in order to present themselves as certain kinds of science people. The students ranged in the level of purposefulness in their science identity negotiation.

Furthermore, three characteristics of the TESJ practice supported successful science identity negotiation amongst the students. These were specific kinds of peer dynamics, specifically opportunities for leadership, cultural kinship, and socializing and collaboration with friends, significant social interactions between the students and role models and mentors in science, and students' ownership over their work in science.

**Discursive Identity Development and Language Use in Science**

The strategies of discursive identity development and language use in science permitted the students to participate in science and perform available behaviors and social cues on their terms, thus maintaining some level of control over the kind of science people they were interpreted as being. The level of diversity accomplished in the students' variable and agentic participation in science was notably high. The level of diversity, in fact, was on par with patterns of discursivity uncovered by Barton and her colleagues (Barton, 1998; Barton & Tan, 2010; Barton, et al., 2008; Barton & Yang, 2000; Basu & Barton, 2007; Furman & Barton, 2006; Tan & Barton, 2008a). This is notable as Barton's science education interventions are informed by progressive educational perspectives, including identity research, and thus can be considered exemplary.

This comparison to Barton is furthermore notable since her and her colleagues' interventions typically target middle school students from underrepresented and marginalized backgrounds, while high school students are the current focus. The high level
of diversity in the identities that high school students authored with respect to the TESJ science community might be due to the informal setting of TESJ which makes non-traditional ways of interacting and identifying with science inherently more expected and acceptable; however, this level of diversity is significant as at the high school level, interest and curiosity in regards to science, when considering a cross-section of students, has already begun to steadily decrease from the middle school level (Fouad & Smith, 1996; Gibson & Chase, 2002). In high school, intrinsic interest and self-motivation in science is maintained largely from interventions (J. E. Stake & Mares, 2005), social supports and role models (Aschbacher, et al., 2010; Hill, Pettus, & Hedin, 1990) , focused STEM academic programs (Fouad, 1995), etc. Without these, many high school students’ attitudes in regards to STEM range from more indifferent to negative, especially with girls and ethnic minority students (Business-Higher Education Forum, 2011; Hill, et al., 1990; Miller, et al., 2006). Thus, it is significant that I have identified levels of diversity in discursive science identity development and language use similar to Barton’s students amongst both male and female, ethnic minority high school students.

Another notable finding in the current study was that there was little to no evidence of negative peer review as a result of student experimentation with scientific discourses and identity negotiation. This might have also been due to the informal setting of TESJ. In Brown’s (2004) study of his formal high school science class, he uncovered that there was a range in both students’ willingness and ability to take up a traditional scientific discourse. Brown argued that the students authored ways of presenting themselves and interacting within the discourse of science in order to manage the cultural conflict resulting from assimilating to school-sanctioned practices and ways of performing. Specifically, Brown
argued that the acclimation to a traditional discourse of science or “school science” was representative of assimilation into mainstream American society. For ethnic minorities, this can signify a loss of one’s ethnic identity, a significant cultural conflict. As such, in resisting cultural assimilation, the low-income ethnic minority students also resisted school practices and the science identification processes associated with these. In my current study, the informal setting of TESJ might have communicated a greatly reduced expectation of acclimation to traditional or school-like practices. As such, TESJ might have likely placed much lower stakes, risks, or consequences as a result of taking up a science identity compared to Brown’s students in the formal setting of high school. In comparison to Brown’s formal classroom, the informal TESJ setting might have permitted playful and less risky experimentation with the behaviors within the science practice.

It is noted, again however, that the TESJ program was a voluntary weekend and school vacation program while, in Brown’s (2004) study, the students were in mandatory science class. As such, the students in my current study might likely be more narrowly distributed towards the higher end of the interest and motivation spectrum, while in Brown’s study, the students were likely more widely distributed from higher to lower levels of interest and motivation in science. Still further, it is significant to recall that the students in TESJ were not particularly interested in science at the start of the program and did not enroll in the program for science learning experiences. Rather, they were seeking out assistance with the college preparation and application process. Whether it was due to the reduction of cultural conflict or enhanced motivation and interest, the informal setting of the TESJ science community appeared to be significant.
Peer Dynamics and its Impact on Science Identity Negotiation

Being able to satisfy social connectedness and desirable relationships around STEM activities has already been established as important in maintaining students’ interest and engagement in STEM (Ryan & Deci, 2000; Basu & Barton, 2007). According to Ryan and Deci, activities that permit individuals to interact with others in ways that make them feel as part of the group or the community, along with individuals’ sense of self-efficacy, and autonomy with respect to the activities, encourage intrinsic or self-driven motivation regarding participation in the activities. In other words, when intrinsically motivated, people are not driven to participate by some external goal or reward, but are motivated by enjoyment in the activities in and of themselves. Similarly, Basu and Barton argued that students are motivated to participate in science provided that the activities permit them to engage in positive, desirable, or satisfying kinds of social interactions. These motivations arise from the students’ lived cultural experiences. For instance, in Basu and Barton’s study, one student’s mother valued helping people and, so, the young man engaged in science in ways that permitted him to help his peers. Another student’s mother prioritized education amongst her children and encouraged them to remain disciplined, ignoring misbehaving others. This student was seen to work almost exclusively with a close peer, barely interacting with others; however, this benefited his disciplined and focused science learning.

My findings are consistent with the above studies, i.e. when engaged in desirable social relationships, the students in my study were more active participants in the science activities which supported science entity negotiation. Furthermore, the findings in my
study extends the above research as I have identified major, cross-cutting patterns of interactions of the high school students amongst their peers and instructors that supported student science identity negotiation, as opposed to uncovering or focusing on the reasons underlying individual differences in social relationships. In other words, the current study shows what kinds of relationships are important, instead of that relationships are important. My study thus extends Basu and Barton's (2007) findings to specify, when designing science education learning environments, exactly what kinds of social relationships are important in student science identity negotiation, namely leadership, cultural kinship, and friendship.

Furthermore, based on cursory searches of the education research literature, while social connectedness and friendship have already been established as important, the impact of leadership opportunities and cultural kinship experiences during participation in science are under-researched. Leadership research in education often focuses on educational administration, for e.g. (Robinson, Lloyd, & Rowe, 2008); however, Tan and Barton's (2008a) case study of Melanie, a sixth grade girl who moved from very marginal participation in the classroom to one of confidence and enthusiasm, might have involved leadership and kinship. For instance, Melanie’s instructor encouraged her use of narratives in explaining and answering questions in the science classroom and drew from these in further teaching. He elevated her “...narrative authority to epistemic authority, and... [created] new and different figured worlds that helped to legitimize the kinds of capital Melanie brought to bear in science class” (p. 584). This public use and modeling of Melanie’s knowledge might be seen as the instructor positioning her temporarily as a peer leader or model in science. Additionally, some of Melanie’s peers were nurturing,
encouraging and protective of her, boosting her confidence and participation in science. In my study, the relationships based on kinship provided similar benefits, although in my study the shared ethnic and cultural background was critical factor.

Given the differences in the quality of curriculum and instruction within low-income, urban schools compared to wealthier suburban schools (Apple, 2004; Kozol, 1992), low-income, ethnic minority students might not have as many opportunities to take up leadership roles in their science activities as students in wealthier districts. With respect to cultural kinship, experiences unique to low-income, ethnic minorities such as immigration for social mobility and the associated hardships and stigmas with immigration, for instance limited English language proficiency and discrimination, might present important and unique considerations for low-income, ethnic minority, urban science students. As such, these two particular social interactions, leadership and kinship, amongst low-income, ethnic minority students in science might be untapped, significant perspectives in urban science education.

**Significant Social Interactions**

Significant social interactions were important in facilitating student science identity negotiation in two major ways. First, through students’ opportunities to converse with and ask questions of STEM career professionals who participated in the TESJ program as career roundtable/panel guests, a number of students gained critical and specific STEM career knowledge. Second, through personal and virtual interactions with STEM professionals or chance conversations with role models in science and out of science, a number of students expanded the possibilities that they saw for themselves in science. These steps could have
been facilitated by the STEM professionals and other mentors serving as “ambassadors” (Abelev, 2009) to the more foreign STEM career practice, imparting important specific career knowledge and, through sharing their personal stories and STEM experiences, thus providing students with grounded and tangible understandings of what it will be like to be a scientist.

In her study, Abelev (2009) identified a number of specific processes through which “at-risk” students exhibited resilience, persisted in their educational journeys and “advanced [financially and socially] out of poverty.” Through “ambassador”-like mentors, the youth in her study all had access to middle class capital and habitus (Bourdieu, 1977), i.e. financial resources, social connections and certain taken-for-granted ways of thinking and acting, for e.g. exerting assertiveness over one's educational experiences and choices. Specifically, these mentors helped the students get access to enrolment in a higher-performing school outside of their low-performing neighborhood district, financial assistance to attend private schools or finance college and, finally, assertive representation for access to a specialized educational plan to manage road blocks, such as unplanned pregnancy. In my study, through involvement in the program, the students were all presented with the same opportunity to learn from various STEM career professionals. Some students enhanced their opportunity to learn about the science community by proactively asking questions within the whole group setting, within small round table conversations, and through one-on-one conversations. Similar to Abelev, these mentors served as bridges to a more foreign community, a professional STEM career, giving students insider perspectives and bringing them closer to learning what it takes to enter and negotiate identities within that professional practice. For instance, Zs went from a
relatively vague career plan in “forensic analysis” to knowledge of the number of post-high school years of education, including a necessary medical school phase, required to become a medical pathologist. Zo also learned about the availability of online tutorials in computer programming and video game design through proactively asking questions of a university scientist in one career panel over the summer.

Villarejo, Barlow, Kogan, Veazey and Sweeney’s (2008) study determined that undergraduate research experiences were important, transformative experiences for undergraduate students in encouraging their ultimate decision to pursue Ph.Ds. in biomedical research. These research opportunities broadened the students’ views of science and engaged them over the long-term in important ways that could not be achieved with formal classroom instruction alone. Interacting with adult mentors also provided students with more grounded and tangible understandings of science, critical in the undergraduates’ persistence in science. In the present study, the students might have benefited from being provided with similar grounded and tangible understandings of science.

**Student Ownership in Science**

Student ownership, in which students take responsibility in their learning processes and make critical decisions in structuring the activities in which they are involved, has been identified as a positively motivating factor for engaging in science amongst low-income, ethnic minority students (Barton, 1998; Furman & Barton, 2006). This student ownership was one step in students’ use of “voice,” i.e. purposeful use of a community’s tools or resources (Furman & Barton), in communicating the type of person they were and wished
to be. Barton capitalized on the dissatisfaction that a number of homeless children had with their local city environment as a starting point for scientific study. She identified this shared concern through initial conversations with the students about what were important and pressing issues in their lives. Building from there, with Barton’s guidance, the students first collected data amongst their group based on first-hand observation, then gathered more data by conducting library research and surveying the members of the community, asking questions such as, “How do you feel about where you live or work? What kind of pollution bothers you most? Do you think the gas station creates pollution? Do you create pollution?” Based on the data collected, the students then developed plans to clean up and improve their neighborhoods, including picking up trash on the street, recycling and planting vegetables and flowers. The science activities were structured around the students’ voiced concerns and driven by the students themselves. This encouraged and sustained the students’ interest in the activities, opening possibilities for long-term identity negotiation in science.

The TESJ program was structured in ways to encourage student ownership over their projects, seeing them as authentic community projects in which they, as students and community members, would have had a significant say in the development process and the resulting products would directly impact their lives. The STEM activities, as open-ended inquiry projects in which students had the freedom to design their sites however they wished emphasizing environmental conservation, economic development, social services or any combination of these, promoted student choice and self-direction in their learning. Furthermore, the scientific work was focused on local communities in which the students and their families lived or spent time as opposed to settings with which they were not
familiar or connected or communities to which they had to travel far in order to visit. In taking responsibility for their work, the students would have come to see their work in the science practice as valuable and meaningful, thus making integration into the practice similarly valuable and meaningful. Finally, encouraging student ownership over their work and, as such responsibility and independence with respect to the STEM skills and activities may also have encouraged students’ self-recognition as knowledgeable experts in their work. Self-acknowledged expert statuses also might likely have contributed to further science identity negotiation, science self-efficacy and confidence in science.

Open-Minded Reactions to the TESJ Science Practice

Another encouraging finding was the students’ open-mindedness and positive reactions towards science in the TESJ program. The students valued or at least acknowledged the importance of STEM and of taking part in the various STEM activities. Even amongst those students who did not have STEM career interests or did not perceive a match between their interests and the program’s activities, they still demonstrated remarkable open-mindedness with respect to STEM. For instance, despite Ds having computer engineering career interests, he acknowledged his valuing of and confidence in the STEM skills he acquired as a result of participation in TESJ.

Furthermore, this open-mindedness was not limited to science. Time and time again, students credited the program for teaching them to approach activities with an open mind, to be disciplined and to push themselves. The following is an example:
Sheron: What is the biggest or most important thing that you have learned or experienced in TESJ?

Dy: I've learned confidence and that you have to give everything a chance.

Encouraging students to envision broadened possibilities for themselves in self-driven ways is a significant implication for urban education.

**STEM Interest and Career Development**

Students indicated their serious consideration of several STEM careers in specific ways, namely by describing their STEM career interests as the result of inspiring or transformative experiences around related activities, enjoyment of the activities, or a positive perception of the careers or as having held these career interests from a very young age. Additionally, two distinct groups of students with serious STEM career interests were uncovered. One group focused on the enjoyment of current or future activities related to the careers or being inspired to pursue those careers. These students were intrinsically motivated (Ryan & Deci, 2000) to pursue these STEM careers as they focused on the sheer pleasure they would derive from participation. On the other hand, a second group was strongly encouraged by family members and other STEM professional role models to pursue these careers, namely medicine, and focused on the lucrative and stable nature of the career. One student in this group, Ta, in addition to her discussion of her mother as a STEM role model stated an interest to help others and experiences in caring for young ones in separate and isolated cases.

A social justice rationale underlies the STEM focus in the program design. First, STEM education is a critically important field of study for students despite future career interests as reviewed in Chapter 1. Thus, ensuring that the students have strong STEM
educational foundations is extremely important. STEM careers provided plentiful employment opportunities, as well as access to socioeconomic mobility and career advancement. This supports social justice efforts for more equitable distribution of social, financial, and cultural resources, as well as empowerment and self-determination for low-income, ethnic minority populations. With that said, the goal of the program was to enhance STEM education and increase the number of interested and proficient students in science and math, however, not at the cost at personal happiness. In other words, one goal targeted in the TESJ program was to expose students to considering STEM career pathways that they might have overlooked, did not know existed, or might not have been encouraged to consider.

The experiences in this program did permit students more equitable opportunities to truly consider whether or not they were interested in STEM careers. From these experiences, some of the students had come to see new perspectives in STEM, science in particular. They discussed coming to realize that science can be fun and interesting; that they can be satisfied in science; and that they could be successful in science. For instance, Dn grew to acknowledge the value and enjoyment of science, but his non-STEM career interest remained intact. At the start of the study, Qa was not considering STEM as a viable pathway for herself and was still somewhat undecided. She did mention a possible business career pathway. By the end of the study, Qa was contemplating a number of STEM career options. The other students solidified their pre-existing STEM career interests. These included Te’s engineering interest, Zo and Ds’ video game design and engineering interests, and Zs’ medical pathology career interest. There were, however, no changes from one STEM career to another, i.e. Hg, Ta, and Ua’s medical career interests remained intact. This
is consistent with DiLisi, et al.’s (2011) study in which those students who were undecided increased in science career interests, but STEM career interests and non-STEM career interests each remained intact. The ability for informal science interventions to enhance students’ STEM career interests is, therefore, still possible with some limitations.

Finally, despite the program’s STEM focus, there was not a high level of pressure for students to choose STEM careers or to pretend to pursue STEM careers. Rather, the program encouraged students to consider whether STEM could be a viable and satisfying pathway for them. Additionally, recall the underlying principles of the program design that acknowledged and affirmed the students’ lived experiences and made those experiences central in the various sessions in the program. The program was designed based on the principles of youth voice and empowerment and regularly discussed issues of race, ethnicity, culture and power related to being an ethnic minority in the U.S. There was, as a result, a strong valuing of the students as they are and no real pressure for them to change or adapt. The students were thus comfortable evaluating STEM honestly, for instance acknowledging its valuing and saying truthfully whether or not they wish to go forward with STEM or a different field of study altogether. As a result of the purposeful focus on the students’ lived experiences and bridging these into the academic space of TESJ, TESJ might have symbolized less of a forced cultural acclimation compared to formal school.

**Conclusion**

The findings uncovered with respect to discursive science identity formation and language use in science are consistent with existing research on identity negotiation and student engagement in science, i.e. that student engagement and participation in a science
discourse or community is based on the personally meaningful connections they make within science and this engagement and participation differs based on what aspects of themselves individuals choose to forefront or perform. The findings with respect to peer dynamics, significant social interactions around STEM and student ownership in science, however, extend the research literature. First, the findings on peer dynamics identifies what kinds of social relationships within science learning communities can promote science identity negotiation amongst low-income, ethnic minority students. The findings regarding significant social interactions and student ownership in science identify successful design features of science learning communities that also promote sustained engagement and identity negotiation in science. Finally, encouraging from this study is the high levels of diversity amongst the kinds of science identities authored by low-income, ethnic minority students as they participated in the TESJ informal science program.
Chapter 6: Implications

Importance of the Present Study Design and Findings:

Research in identity negotiation/development can make important contributions in understanding science interest and engagement amongst students. This research can help in understanding when and why individuals engage in an activity, in this case, science, and what they gain or lose from this participation. To investigate research in identity negotiation/development, studies must be long-term and should examine multiple genres of discourse or cultural tools in order to confidently determine significant changes in individuals’ identities in relation to communities and not be misled by transient behaviors. This present study was long-term (15 months) and future research would be much longer (several years) and, through the study, I examined multiple genres of discourse, including language, skills, technology use and affiliated groups. Only a handful of researchers have conducted similar long-term investigations of science identity negotiation/development (for e.g. Barton, 1998; Barton, 2008; Brandt, 2008; Brickhouse & Potter, 2001; Brickhouse, 2000; Brown, 2004; Eisenhart & Edwards, 2004; O’Neill & Barton, 2005; Rosebery, Warren & Conant, 1992; Tan & Barton, 2008a; Tan & Barton, 2008b). Similarly, few researchers have looked across the use of multiple genres of discourses in identity negotiation/development (Barton & Tan, 2010; Barton, Tan & Rivet, 2008; Furman & Barton, 2006; Brandt, 2008; Brickhouse, Lowery & Schultz, 2000; Brickhouse & Potter, 2001; Barton & Yang, 2000; Seiler, Tobin & Sokolic, 2001; Tan & Barton, 2008a; Tan & Barton, 2008b). As such, the present study contributes to a much needed area of scholarship. Furthermore, with the confidence in findings acquired from multi-faceted,
long-term and in-depth research, this study can contribute to theoretical model building around student science identity negotiation. As of now, freedom for discursivity in identity formation, leadership, cultural and social connections, student ownership over one's work in STEM, growth in specific STEM career knowledge and transformative experiences in science have been identified as important factors within this informal science learning context. This overlaps with and adds to the literature on science identity negotiation/development (H. Carlone & Johnson, 2007; Tan & Barton, 2008b), science education (Brown, et al., 2005; Kozoll & Osborne, 2004), interest and motivation (Ryan & Deci, 2000) and urban education (Carter, 2006), amongst others.

**Out-of-School Science Programs:**

The research problem driving this study was that there is a dearth of educational structures and strategies that can increase the number of interested and competent low-income, ethnic minority students in science in equitable and empowering ways. Falk and Dierking (2010) have argued the importance of out-of-school learning opportunities as one major factor underlying the achievement gap in science between low-income and ethnic minority students as compared to middle and upper middle class, White students. They based their argument on the premise of lifelong learning and the fact that Americans spend most of their lives outside of school. Low-income students in urban areas, often from ethnic minority backgrounds, lack access to informal learning facilities such as museums, zoos and Boys and Girls Clubs in which high quality, sustained science learning takes place. This underscores the importance of programs such as TESJ for addressing equity and opportunity to learn issues for low-income, ethnic minority students in science. The
informal design of the TESJ science program was successful in supporting students’ science identity negotiation processes. Furthermore, the findings from this study on an out-of-school science learning environment were consistent with the positive and important effects of out-of-school learning argued by Falk and Dierking (2010); therefore, specific program designs of the TESJ informal science learning environment should be infused into formal school science education settings.

The out-of-school science setting provided the space and freedom for the science identity negotiation processes to take place, thus supporting the development of scientific skills and literacy and STEM career interests. The TESJ program promoted engagement in science practices by tapping into students’ perception of relevance of the projects and by permitting their ownership and say over their work. The informal setting, purposefully designed to not resemble formal school practices, for instance by making student choice and voice central, minimizing lectures and keeping activities light and fun, was also important in permitting students’ playful and less risky participation in science.

In Brown’s (2004) study focused on a formal science classroom, some students were reprimanded by their peers when attempting to engage in a science discourse. This shut down further attempts at science identity negotiation. Brown argued that this was attributed to the message taken up by low-income ethnic minority students that acclimation to school or classroom culture is equivalent to acclimation to mainstream society in exchange for their ethnic minority culture, placing high stakes on the take up a traditional science identity. Informal educational settings, such as TESJ, symbolizing much
less of a forced acclimation, permit much more equitable access to and development in science and thus are important resources for underserved student populations.

**Out-of-School Science Program Design and Development:**

Given the importance of out-of-school science programs, the present research findings can also inform the design of such programs from a science identity negotiation perspective. For instance, the activities, structure and expectations of such programs should be conducive to students engaging in science in personally meaningful ways, accommodating and encouraging students' interests and individuality. Instruction should also be tailored to recognize and facilitate students' unique ways of relating to and engaging with the science community and discourse. STEM instructors for these programs should also be trained to facilitate and respond to this kind of student engagement in science. This would require understanding of the science content, as well as training in cross-cultural competence (J. P. Johnson, Lenartowicz, & Apud, 2006), i.e. one's ability to adapt, through the use of knowledge, skills and one's personal attributes, in order to effectively work or communicate with people from different cultures, in this case science students. Although this definition was derived from international business, which involves frequent cross-cultural communication and interaction, these skills and dispositions are important in the field of education. Specifically, STEM instructors should be able to recognize individual and group level differences as strengths or as based on differences in lived experiences and, although the instructors might not be able to relate to all of these experiences, they should be able to link these to the science activities of interest and the larger science community.
The program must also be long-term and immersive in nature in order for meaningful changes to take place in one’s sense of self and in understanding the type of person she communicates herself to be. Additionally, the program should be a safe space for students to try out science without fear of harsh judgment from peers or instructors. This can be encouraged, for instance, by communicating participation and learning in the program as additive to, and not subtractive from, one’s identity or understanding of herself. In other words, growth in one’s scientific skills is not meant to replace her already existing skills in multiple languages or how one looks at the world.

Additionally, specific kinds of relationships that have been identified as important in promoting interest and participation in science should be emphasized. These would include leadership opportunities, collaborative and social opportunities as students work and opportunities for students to engage with peers who are ethnically and culturally similar, not for segregation purposes, but rather in order for students to support each other in unique ways based on these shared cultural experiences.

The structure of the program should permit opportunities for students to have social interactions with key people in STEM, namely career professionals, mentors and inspirational and motivational speakers. Finally, curricular and instructional design should promote student ownership of STEM projects, thus permitting self-recognized growing expertise and identities in science.
In-School Science Education:

Research findings can also inform in-school science education. Much of the success of TESJ was due to authentic and relevant science learning experiences framed around the principles of participatory learning environments (Barab, Hay, Barnett, & Keating, 2000) and pedagogical praxis (Shaffer, 2004). As such, K-12 science education and teacher professional development should be structured around these design principles in order to best engage and reach students. Participatory learning environments are based on five guiding principles: (i) their design should engage students in doing authentic science, for instance, inquiry-based scientific activities; (ii) students should take part in science as a “knowledge-building enterprise” (Scardamalia & Bereiter, 2006) and not as seeking to memorize a readymade set of knowledge based on past scientists’ work; (iii) the activities should support collaborative group work by permitting students to work with others who have less, similar and more experience and expertise than themselves (iv) students should be engaged in work that addresses a real-world issue of relevance and importance to them; and (v) students should be active participants in a professional science community, doing the work of real scientists, and not be isolated from or only hear about the work of practicing scientists and other STEM professionals (DeBay et al., expected 2012).

In order for the learning environments to be successful in challenging the students, but also sustaining their interests, as opposed to overloading them cognitively or frustrating them, the scientific activities in which the students are engaged must be developmentally appropriate, in addition to authentic. This is accomplished by pedagogical praxis (Shaffer, 2004) and educational technology. The pedagogical praxis theoretical
perspective guides educators to design learning environments by using new technologies to bridge the gap between the work of professionals and the developmental needs of learners (DeBay, et al., expected 2012). This enables students to do the work of real scientists by being scaffolded by technology similar to, or sometimes the same as, what is used by industry experts.

Specific positive impacts on formal school include the program’s focus on enhancing students’ general scientific literacy and research skills, i.e. particularly around designing and conducting research, developing and investigating research questions, data collection and analysis, and technology use. These general scientific reasoning skills and research and analytical abilities can help formal science education, as well as other subjects, for e.g. reading comprehension and literature, and will help all-round academic development and college preparation and success. In the informal and integrative TESJ program, the students were able to see science in many different forms which expanded the opportunities they saw in science and sparked interest in exploring science long-term; however, the program’s interdisciplinary curriculum may not best meet the need for the students’ in-school science content learning needs in their local educational context, i.e. there may be insufficient science curriculum overlap.
Chapter 7: Future Research

A number of questions have been generated from the findings of this study, as well as in initially setting up the study. First, further exploration of the impact of leadership and kinship on science identity negotiation amongst low-income ethnic minority students within educational settings is desired. The potentially significant implications of these interactions amongst low-income, ethnic minority students in under-served inner-city schools have been detailed in the discussion section. Furthermore, based on a cursory examination of the research literature, both leadership opportunities and kinship experiences in science identity negotiation appear under-researched. I will ask the following research question:

- What are the specific impacts of peer interactions related to leadership and kinship on science identity negotiation amongst low-income ethnic minority students?

Given the limited impact of the TESJ program on in-school science content learning, future studies will also include the design and implementation of curriculum that better aligns with the students’ official curriculum. In these studies, I will focus more specifically on the quality of the students’ work. Furthermore, I will examine the impact of student science identity negotiation on the quality of that work in science. I will thus ask the following:

- What is the quality of the work produced across the students who did develop science identities and those who did not?
In what ways did overall science identity negotiation or the influence of specific factors supportive of science identity negotiation support science learning?

Buck et al. (2008) found that race-matching was an important factor for African American middle school girls in the impact of mentoring relationships between themselves and undergraduate female scientists; but this was not important for White and Latina middle school girls. Gender-matching, on the other hand, was not important for any of these girls. In the current study, neither race-matching nor gender-matching appeared to be significant in terms of supporting science identity growth amongst the students who had undergone growth in STEM career knowledge or transformative experiences through social interactions with significant others. In fact, there were many instances of cross-race and cross-gender interactions between students and mentors or role models which facilitated transformative experiences in science and growth in specific STEM career knowledge. As such, I would like to investigate this issue, the significance of race or gender matching in significant social interactions around science further. I will ask:

- What is the significance of race, ethnicity and gender matching between the students and STEM mentors or role models?

One interesting observation noted during the data analysis process was the long-term STEM career interests of three students, but a lack of satisfactory science identity negotiation within TESJ. This raised the question of whether or not tensions existed between the specificity of the program’s STEM curriculum and the diversity of science identities amongst students. Ryken (2006) uncovered a similar tension in a community college-industry partnership in which students were provided working opportunities in
specific industry positions, largely around pharmaceuticals, as they progressed in their coursework. The students did persist in the STEM pipeline at higher rates than comparison populations and were successful in obtaining their science degrees; however, students felt that they were learning more expansively about the STEM field of study, but that they were being trained for only a specific range of careers. In regards to an out-of-school science setting such as this, I would like to investigate whether the specificity of the students’ science career interests interfered with the possibility for some students to develop TESJ-type science identities, whether the specificity of the science targeted in TESJ circumvented the possibility for the students to expand their science identities regarding their current STEM interests or even beyond that or whether it is a matter of both or neither. I will ask:

- What tensions, if any, exist between the specificity of the STEM curriculum and the diversity in potential science identities amongst students?

A final question of interest is in regards to Gee’s (2000 - 2001) theoretical work on identities. Gee discussed different kinds of identities that individuals can have based on genetics, membership in larger institutions or organizations, use of cultural tools and association with specific communities. The resulting identities are nature-, institutional, discourse- and affinity-identity, respectively. I would be interested to know which kinds of identities based on Gee’s framework, nature-, institutional, discourse- or affinity-identity, are most important to students from underserved and marginalized groups, namely low-income and ethnic minority backgrounds. Which aspects of their identities are most important in satisfying and maintaining as recognizable as they engage in school practices, in general, will have significant implications for urban education. I will thus ask:
• Based on Gee’s (2000 - 2001) theoretical framework on identity, which aspects of low-income, ethnic minority students’ identities are most significant to them and what are the implications for the students’ engagement in school?
References


Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching, 47*(5), 564-582.


National Academies Press. (2007a). Is America falling off the flat Earth?


241


Appendix A: Summary of Findings

<table>
<thead>
<tr>
<th>Name</th>
<th>Successful Science Identity Negotiated</th>
<th>Science Language Pattern</th>
<th>Messages Communicated</th>
<th>Peer Dynamics Satisfied...</th>
<th>Significant Social Interactions Facilitated</th>
<th>Interest in or Open-Minded towards Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zs</td>
<td>Yes</td>
<td>Traditional scientific discourse</td>
<td>Smart &amp; knowledgeable Ethnic minority youth Funny &amp; Social</td>
<td>Leadership Friendship/Social Opportunities</td>
<td>STEM Career Exploration STEM Career Knowledge</td>
<td>Yes</td>
</tr>
<tr>
<td>Te</td>
<td>Yes</td>
<td>Traditional scientific discourse</td>
<td>Smart &amp; knowledgeable</td>
<td>Cultural Kinship Friendship/Social Opportunities Leadership</td>
<td>STEM Career Exploration STEM Career Knowledge</td>
<td>Yes</td>
</tr>
<tr>
<td>Hg</td>
<td>No</td>
<td>Traditional scientific discourse</td>
<td>Smart &amp; knowledgeable Ethnic minority youth Funny &amp; Social</td>
<td>Cultural Kinship Friendship/Social Opportunities</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Ta</td>
<td>No</td>
<td>Traditional scientific discourse</td>
<td>Smart &amp; knowledgeable</td>
<td>Friendship/Social Opportunities</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Dy</td>
<td>Yes</td>
<td>Storytelling discourse (Spring) traditional scientific discourse (Summer)</td>
<td>Smart &amp; knowledgeable Ethnic minority youth Funny &amp; Social</td>
<td>Friendship/Social Opportunities Leadership</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hybrid discourse of hip hop, youth and science culture (Winter Institute)</td>
<td>Smart &amp; knowledgeable Ethnic minority youth Funny &amp; Social Service-oriented</td>
<td>Friendship/Social Opportunities Leadership</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Dn</td>
<td>No</td>
<td>Hybrid discourse of a traditional scientific discourse and storytelling (Spring) mostly a traditional scientific discourse with the occasional insertion of a hybrid discourse of science, hip hop and youth culture (Summer)</td>
<td>Smart &amp; Knowledgeable Ethnic minority youth identity Funny &amp; Social Business Studies Interest Service-oriented</td>
<td>Friendship/Social Opportunities</td>
<td>Expanded potential for himself in science</td>
<td>Yes</td>
</tr>
<tr>
<td>Ds</td>
<td>Yes</td>
<td>Variable use of a traditional scientific discourse, storytelling and more conversational tones with non-Standard English</td>
<td>Smart &amp; Knowledgeable Ethnic minority youth identity Funny &amp; Social Service-oriented</td>
<td>Leadership Friendship/Social Opportunities</td>
<td>STEM Career Exploration Expanded potential for oneself in science</td>
<td>Yes</td>
</tr>
<tr>
<td>Qa</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Zo</td>
<td>Yes</td>
<td>Variable use of a traditional scientific discourse, storytelling and a more conversational tone, along with incorporation of a youth-centric identity</td>
<td>Smart &amp; Knowledgeable Ethnic minority youth identity Funny &amp; Social Business Studies Interest Service-oriented</td>
<td>Friendship/Social Opportunities</td>
<td>STEM Career Exploration STEM Career Knowledge</td>
<td>Yes</td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Ua</td>
<td>No</td>
<td>No significant uptake of a traditional scientific discourse</td>
<td>Smart &amp; Knowledgeable</td>
<td>Cultural Kinship Friendship/Social Opportunities</td>
<td>-</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Appendix B: Demographics

Figure 2: Bar Chart Representing the Gender Distribution in TESJ From July 2010 – September 2011
Figure 3: Bar Chart Representing the Racial and Ethnic Distribution in TESJ From July 2010 – September 2011
Figure 4: Bar Chart Representing the High School Class Year Distribution in TESJ

From July 2010 – September 2011
### Appendix C: Calendar of Events 2010 – 2011

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturday 2&lt;sup&gt;nd&lt;/sup&gt; September, 2010</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Saturday 16&lt;sup&gt;th&lt;/sup&gt; October, 2010</td>
<td>TESJ University Research Conference I</td>
</tr>
<tr>
<td>Saturday 30&lt;sup&gt;th&lt;/sup&gt; October, 2010</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Saturday 13&lt;sup&gt;th&lt;/sup&gt; November, 2010</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Saturday 20&lt;sup&gt;th&lt;/sup&gt; November, 2010</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Saturday 11&lt;sup&gt;th&lt;/sup&gt; December, 2010</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Saturday 29&lt;sup&gt;th&lt;/sup&gt; January, 2011</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Saturday 5&lt;sup&gt;th&lt;/sup&gt; February, 2011</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Tuesday 22&lt;sup&gt;nd&lt;/sup&gt; – Thursday 24&lt;sup&gt;th&lt;/sup&gt; February, 2011</td>
<td>TESJ Winter Institute</td>
</tr>
<tr>
<td>Saturday 19&lt;sup&gt;th&lt;/sup&gt; March, 2011</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Saturday 26&lt;sup&gt;th&lt;/sup&gt; March, 2011</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Tuesday 19&lt;sup&gt;th&lt;/sup&gt; – Thursday 21&lt;sup&gt;st&lt;/sup&gt; April, 2011</td>
<td>TESJ Spring Institute</td>
</tr>
<tr>
<td>Saturday 30&lt;sup&gt;th&lt;/sup&gt; April, 2011</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Friday 6&lt;sup&gt;th&lt;/sup&gt; June, 2011</td>
<td>TESJ End-of-Year Closing Symposium</td>
</tr>
<tr>
<td>Saturday 18&lt;sup&gt;th&lt;/sup&gt; June, 2011</td>
<td>TESJ Session</td>
</tr>
<tr>
<td>Monday 18&lt;sup&gt;th&lt;/sup&gt; – Thursday 21&lt;sup&gt;st&lt;/sup&gt; July, 2011</td>
<td>Week I TESJ Summer Institute</td>
</tr>
<tr>
<td>Monday 25&lt;sup&gt;th&lt;/sup&gt; – Thursday 28&lt;sup&gt;th&lt;/sup&gt; July, 2011</td>
<td>Week II TESJ Summer Institute</td>
</tr>
<tr>
<td>Friday 9&lt;sup&gt;th&lt;/sup&gt; – Saturday 10&lt;sup&gt;th&lt;/sup&gt; September, 2011</td>
<td>TESJ University Research Conference II</td>
</tr>
</tbody>
</table>
Appendix D: Interview Protocols

July 2010 Interview

1) What are some of your deeply-held lifelong goals for your life? With respect to education?
2) What underlies these motivations?
3) What were some big, impactful events in your life as a student?
4) How skilled do you feel as a student?
5) What are your stronger subjects? Weaker subjects?
6) Do you feel strong in science and math because it is connected to [your science-related career goal]? Or did you always like those subjects?
7) What do you think about equality or inequality amongst social groups? Can you talk a little about those issues? How did you come to think that way?
8) Has this had an impact on your thinking for your future career?
9) What do you hope to achieve as a [student’s career goal]? 
10) What careers will allow you to partake in social critique? [Define social critique and social inequality.]
11) What value does studying STEM have?
12) How do you identify yourself racially and/or ethnically?
13) Does your views about social inequality/social critique influence how you look at what is going on in your neighborhood, city or even the world?
14) Have those views influenced the career plans you’ve made for yourself?
15) How did you come to be involved in TESJ?
16) When did you join?
17) Has TESJ influenced any career planning decisions?
18) Has the environmental field study experiences influenced your school learning experiences or future plans?
19) Does TESJ have an impact on when you go back to your high school classes?
20) What would you say is an important thing that BPS students should know when they finish high school?
21) What are your plans for the summer or your upcoming school year?
22) What is your understanding of community?
October, 2010 Interview

1) What got you first interested in TESJ?
2) What do you hope to get out of TESJ or accomplish in TESJ?
3) What kept you interested? What kept you coming back?
4) What do you think about the peer interactions, like bringing these three schools together and all these teenagers together?
5) Do you interact with other people or have you maintained or strengthened friendships from your school? Have you met new people?
6) Do you feel TESJ represents a community?
7) Reflecting on your time in TESJ, what have you grown in skill with? What have you grown to be able to do well?
8) What are you thinking about career-wise now?
9) How long have you been thinking about that career?
10) What encourages you or influencing your plans?
11) Any new plans with respect to your future career or your future, in general?
12) Have you gained any new career experiences? Or information regarding [your career interest]?
13) Any new perspectives or thoughts with respect to this career path?
14) In the past, have you ever been interested in other careers that you are no longer interested in?
15) What do you think will help you get to that career?
16) What kind of experiences or what kind of knowledge do you think will help you?
17) What might get in your way, if anything at all? What might make it difficult?
18) And who might get in your way, if anyone at all?

19) What might make career planning or planning for the future easier?

20) And what might make it difficult? Does anything overwhelms you or makes you nervous?

21) How do you identify yourself racially and/or ethnically?

22) What are you hoping to do this year in TESJ?
Feb, 2011 interview

1) What impact has TESJ [had] in your educational and career planning?

2) And how about thinking about careers?

3) What changes, if any, have you undergone since you became a TESJ student?

4) When you think about your friends who either came to TESJ and stopped coming or never came at all, how do you think your educational and career planning compares to where they are now?

5) What does TESJ mean to you? Like, what sort of ideas come to mind when you think about TESJ?

6) And what are some of those things that you learned?

7) Why did you come to TESJ in the first place?

8) What changes would you make to TESJ?

9) How important is a program like this to your educational and career planning? Like when you plan for the future in general?

10) When you set goals for yourself, what keeps you motivated? What keeps you on track?

11) You know what changed that kind of mentality?

12) Ok. And what distracts you?

13) What are some important sources of support to you?

14) What do you plan to do when you graduate from high school?

15) How would your life be different if you didn’t come to TESJ?

16) How important do you think college is to [low income, ethnic minority and immigrant populations]?
17) Do you have anything to add [questions/comments] about the TESJ program?
July, 2011 Interview:

1) Since you’ve been in college bound over the summer and over the years, do you feel like you’re doing science?

2) Regardless of what you want to be when you grow up, does this make you feel like a scientist in training?

3) If you were to have a conversation with your mom about what you’ve been doing in college bound over these last couple of months and this summer, what would you tell her?

4) What are any of the research problems that you, as students, have been working to solve in college bound? Like, you’re working at MP, what is a problem you’re looking to solve? Why are you doing what you’re doing?

5) What is the biggest or most important thing to you that you have learned since you’ve been in college bound?

6) What do you have planned next for yourself in terms of your education or your career planning?

7) What will help you [based on student’s response above]?

8) And what might get in your way?

9) If you were to mentor a friend or a sibling or brother, sister, cousin or a younger student in elementary or middle school, what would you tell them about education?

10) And this program encourages the students to do most of the talking. How do you feel about talking about the science projects with your classmates? Like when you work in groups, how comfortable are you talking about the science with the other students?
11) And how about the teachers? Like if Mr. T was to pull you aside and have a conversation about Madison Park or a teacher in your school or something?

12) And the career panel? If one of the guests was to pull you aside and have a conversation with you about the Madison Park project. How would you feel? Would you feel knowledgeable or comfortable?

13) Any last comments or questions?
## Appendix E: Definitions of Science Proficiency

<table>
<thead>
<tr>
<th>Organization</th>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>PISA</td>
<td>Scientific Literacy</td>
<td>Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.</td>
</tr>
<tr>
<td>Proficiency Level 1</td>
<td>Students proficient at level 1 have such limited scientific knowledge that it can only be applied to a few, familiar situations. They can present scientific explanations that are obvious and follow explicitly from given evidence. Students performing below 335 score points – that is, below level 1 – usually do not succeed at the most basic levels of science that PISA measures. Such students will have serious difficulties in using science to benefit from further education and learning opportunities and participate in life situations related to science and technology.</td>
<td></td>
</tr>
<tr>
<td>Proficiency Level 2</td>
<td>Students proficient at level 2 have adequate scientific knowledge to provide possible explanations in familiar contexts or to draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations of the results of scientific inquiry or technological problem solving. Level 2 has been established as the baseline level, defining the level of achievement on the PISA scale at which students begin to demonstrate the science competencies that will enable them to participate actively in life situations related to science and technology.</td>
<td></td>
</tr>
<tr>
<td>Proficiency Level 3</td>
<td>Students proficient at level 3 can identify clearly described scientific issues in a range of contexts. They can select facts and tap knowledge to explain phenomena and apply simple models or inquiry strategies. Students at this level can interpret and use scientific concepts from different disciplines and can apply them directly. They can develop short statements using facts and make decisions based on scientific knowledge.</td>
<td></td>
</tr>
</tbody>
</table>
### PISA Proficiency Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 4</strong></td>
<td>Students proficient at level 4 work effectively with situations and issues that may involve explicit phenomena requiring them to make inferences about the role of science or technology. They can select and integrate explanations from different disciplines of science or technology and link those explanations directly to aspects of life situations. Students at this level can reflect on their actions and can communicate decisions using scientific knowledge and evidence.</td>
</tr>
<tr>
<td><strong>Level 5</strong></td>
<td>Students proficient at level 5 can identify the scientific components of many complex life situations, apply both scientific concepts and knowledge about science to these situations, and can compare, select and evaluate appropriate scientific evidence for responding to life situations. Students at this level can use well-developed inquiry abilities, link knowledge appropriately and bring critical insights to situations. They can construct explanations based on evidence and arguments that emerge from their critical analysis.</td>
</tr>
<tr>
<td><strong>Level 6</strong></td>
<td>Students proficient at level 6 on the science scale can consistently identify, explain and apply scientific knowledge and knowledge about science in a variety of complex life situations. They can link different information sources and explanations and use evidence from those sources to justify decisions. They clearly and consistently demonstrate advanced scientific thinking and reasoning, and they use their scientific understanding to solve unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that centre on personal, social, or global situations.</td>
</tr>
</tbody>
</table>

### NAEP Achievement Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic</td>
<td>One of the three NAEP achievement levels, denoting partial mastery of prerequisite knowledge and skills that are fundamental for proficient work at each grade assessed.</td>
</tr>
<tr>
<td>Proficient</td>
<td>One of the three NAEP achievement levels, representing solid academic performance for each grade assessed. Students reaching this level have demonstrated competency over challenging subject matter, including subject-matter knowledge, application of such knowledge to real-world situations, and analytical skills appropriate to the subject matter.</td>
</tr>
</tbody>
</table>

Performance standards set by the [National Assessment Governing Board](https://www.nagb.org) that provide a context for interpreting student performance on NAEP, based on recommendations from panels of educators and members of the public. The levels, **Basic**, **Proficient**, and **Advanced**, measure what students should know and be able to do at each grade assessed.
One of the three NAEP achievement levels, denoting superior performance at each grade assessed.

**TIMSS**

<table>
<thead>
<tr>
<th>International Benchmarks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced</td>
<td>Score of 625</td>
</tr>
<tr>
<td>High</td>
<td>Score of 550</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Score of 475</td>
</tr>
<tr>
<td>Low</td>
<td>Score of 400</td>
</tr>
</tbody>
</table>
Appendix F: Screenshots of the ArcGIS and Community Viz Urban Planning Technology
Appendix G: Graphical Output Calculated Based on the Site Design
Appendix H: Samples of Student Physical Science Data Collection and Microsoft Excel Graph Output

3D Surface Chart of Air Temperature

![3D Surface Chart of Air Temperature](image)
Data for 3d Surface Graph of Temperature

<table>
<thead>
<tr>
<th>Distance (y-axis)</th>
<th>0 m (Group 1)</th>
<th>2.5m (Group 2)</th>
<th>5.0m (Group 3)</th>
<th>7.5m (Group 4)</th>
<th>10.0m (Group 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>71</td>
<td>71</td>
<td>69</td>
<td>73</td>
<td>72</td>
</tr>
<tr>
<td>4.6</td>
<td>59</td>
<td>71</td>
<td>68</td>
<td>69</td>
<td>60</td>
</tr>
<tr>
<td>9.1</td>
<td>50</td>
<td>71</td>
<td>71</td>
<td>66</td>
<td>58</td>
</tr>
<tr>
<td>13.7</td>
<td>76</td>
<td>71</td>
<td>67</td>
<td>89</td>
<td>57</td>
</tr>
<tr>
<td>18.3</td>
<td>61</td>
<td>70</td>
<td>64</td>
<td>75</td>
<td>58</td>
</tr>
<tr>
<td>22.9</td>
<td>75</td>
<td>77</td>
<td>70</td>
<td>59</td>
<td>54</td>
</tr>
<tr>
<td>27.4</td>
<td>69</td>
<td>72</td>
<td>70</td>
<td>60</td>
<td>57</td>
</tr>
</tbody>
</table>

Temperature recorded in °F
3D Surface Chart of Sound Level
Data for 3d Surface Graph of Sound Level

<table>
<thead>
<tr>
<th>Distance (y-axis)</th>
<th>0 m (Group 1)</th>
<th>2.5m (Group 2)</th>
<th>5.0m (Group 3)</th>
<th>7.5m (Group 4)</th>
<th>10.0m (Group 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80</td>
<td>65</td>
<td>64</td>
<td>67</td>
<td>70</td>
</tr>
<tr>
<td>4.6</td>
<td>72</td>
<td>66</td>
<td>67</td>
<td>75</td>
<td>66</td>
</tr>
<tr>
<td>9.1</td>
<td>69</td>
<td>66</td>
<td>55</td>
<td>69</td>
<td>67</td>
</tr>
<tr>
<td>13.7</td>
<td>77</td>
<td>66</td>
<td>61</td>
<td>79</td>
<td>72</td>
</tr>
<tr>
<td>18.3</td>
<td>80</td>
<td>67</td>
<td>67</td>
<td>70</td>
<td>67</td>
</tr>
<tr>
<td>22.9</td>
<td>79</td>
<td>67</td>
<td>68</td>
<td>74</td>
<td>65</td>
</tr>
<tr>
<td>27.4</td>
<td>78</td>
<td>66</td>
<td>70</td>
<td>66</td>
<td>73</td>
</tr>
</tbody>
</table>

Sound level recorded in decibels