Changes in Urban Youths' Attitude Towards Science and Perception of a Mobile Science Lab Experience

Jared Fox

Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
under the Executive Committee
of the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2015

ABSTRACT

Changes in Urban Youths' Attitude Towards Science and Perception of a Mobile Science Lab Experience

Jared Fox

This dissertation examined changes in urban youth's attitude towards science as well as their perception of the informal science education setting and third space opportunity provided by the BioBus, a mobile science lab. Science education researchers have often suggested that informal science education settings provide one possible way to positively influence student attitude towards science and engage marginalized urban youth within the traditional science classroom (Banks et al., 2007; Hofstein & Rosenfeld, 1996; National Research Council, 2009; Schwarz & Stolow, 2006; Stocklmayer, Rennie, & Gilbert, 2010). However, until now, this possibility has not been explored within the setting of a mobile science lab nor examined using a theoretical framework intent on analyzing how affective outcomes may occur. The merits of this analytical stance were evaluated via observation, attitudinal survey, open-response questionnaire, and interview data collected before and after a mobile science lab experience from a combination of 239 students in Grades 6, 8, 9, 11, and 12 from four different schools within a major Northeastern metropolitan area. Findings from this study suggested that urban youth's attitude towards science changed both positively and negatively in statistically significant ways after a BioBus visit and that the experience itself was highly enjoyable. Furthermore, implications for how to construct a third space within the urban science classroom and the merits of utilizing the theoretical framework developed to analyze cultural tensions between urban youth and school science are discussed.
Key Words: Attitude towards science, third space, mobile science lab, urban science education

TABLE OF CONTENTS

LIST OF TABLES vii

LIST OF FIGURES vii

CHAPTER 1: INTRODUCTION 1

The Problem: Science Education in Urban Classrooms 2

Possible Solutions: Visualizing a New Future for Science Education in Urban Classrooms 3

Why Study Student Attitudes Towards Science? 5

A Closer Look at Informal Science, Culture, and Attitude 5

Research Questions 6

CHAPTER 2: THEORETICAL FRAMEWORK AND LITERATURE REVIEW 8

Theoretical Framework 8

Hybridity Theory and Postcolonialism 8

Origins and Interpretations of the Third Space in Science Education 10

Conceptualization of the Third Space in This Study 13

Social Capital and the Third Space 15

Forms of social capital 15

Burt's social capital and structural holes 19

Connecting urban youth, the third space, school science, and social capital 20

Literature Review 22

Defining Attitude Towards Science and Informal Science Education 22

Scientific Attitudes or Attitudes Towards Science? 23

Variables Found to Influence Students' Attitudes Towards Science............ 23

Age.. 24

Urban youth 25

Informal Science Education and Attitude Towards Science......................... 26

Defining informal science education and informal learning............. 26

Findings from informal science education research 29

Summary of Chapter 2 32

CHAPTER 3: METHODOLOGY 34

Research Design.. 34

Qualitative Research Overview 34

Case study research.. 35

A note on mixed-methods research.. 37

Sample Selection... 38

Setting 39

The BioBus experience begins...41

Daphnia experience 44

Exploring cells 48

Participants.. 52

Instrumentation 53

Survey 54

Open-response questionnaire 55

Interviews... 56

Observations 57

Data Analysis 58
ATSSA Survey 60
Likert item 15 and open-response questionnaire 61
Interviews 61
Coding of interviews 63
Observations 66
Rigor 70
Internal Validity 70
External Validity 72
Reliability 74
Ethical Considerations 75
Assumptions 75
Summary of Chapter 3 75
CHAPTER 4: FINDINGS 77
Findings—Research Question 1 77
Summary of Findings—Research Question 1 87
Findings—Research Question 2 88
Observational Findings 94
Interaction with scientists 94
Interactions with scientific tools and equipment 95
Student interaction with each other 96
Summary of Findings—Research Question 2 (Non-case Study) 97
Evaluation of this Study's Theoretical Framework 98

The BioBus as an Informal Science Education Setting 98

Voluntary 99

Learner-led 99

Unstructured...100

Open-ended 100

Non-threatening 100

Non-evaluative 101

Social..102

Informal of formal? 102

The BioBus as a Third Space 103

Physcial alignment 104

Social alignment..105

Realization of the third space..107

Case Studies of Participants 108

Penelope 109

Janis 114

Oliver 118

Yom.. 123

Sara 129

Bill..136

Derek 140

Indira 146

Summary of Participant Case Study Findings 150

Summary of Chapter 4 150

CHAPTER 5: CONCLUSION 152

Conclusion—Research Question 1 153

Summary of Conclusion—Research Question 1 157

Conclusion—Research Question 2 157

Observational Data 163

Extreme Case Study Interviews 163

Summary of Conclusion—Research Question 2 165

Discussion of Research Question 1 and 2 165

Implications of the BioBus Experience 167

Age 171

"Can This Be School?" 173

Theoretical Framework Implications 181

Limitations 186

Further Research 189

Summary of Chapter 5 191

REFERENCES 194

APPENDIX A – BioBus Student Worksheet 204

APPENDIX B – Attitude Toward Science in School Assessment (ATSSA) 206

APPENDIX C – Sample Student Interview Questions 207

APPENDIX D – Post-BioBus Likert Item 15 and Open-response Questionnaire 208

APPENDIX E – Examples of Positive Comments About a BioBus Experience From an Open-ended Response Questionnaire 209

APPENDIX F – Characteristics of Case Study Interview Participants 210

LIST OF TABLES

Table 1 – Early Categorization of Formal and Informal Learning in Science....................... 27

Table 2 – Data Collection Instruments 59

Table 3 – A priori "Lean Codes" and Theoretical Framework Components 67

Table 4 – Research Questions, Instruments, and Data Analysis Matrix............................... 69

Table 5 – ATSSA Scores Before and After a BioBus Experience by Grade 78

Table 6 – Pre- and Post-BioBus ATSSA Scores by Grade and Type of Attitude Change.... 79

Table 7 – Entire Sample Post-BioBus ATSSA Item Analysis 82

Table 8 – Extreme Cases of ATSSA Change Scores... 84

Table 9 – Post-BioBus ATSSA Item Analysis for Extreme Cases....................................... 86

Table 10 – Mean Responses to Likert Item 15 by Type of Attitude Change and Grade....... 90

Table 11 – Mean Responses to Likert Item 15 for Cases of Extreme Attitude Change........ 91

Table 12 – Positive Statements About a BioBus Experience by Attitude Change................ 92

Table 13 – Positive Statements About a BioBus Experience by Grade 93

Table 14 – Characteristics of Case Study Interview Participants....................................... 112

Table 15 – Case Study Findings and Theoretical Framework Alignment............................157

LIST OF FIGURES

Figure 1 – Original conceptualization of the third space within a science classroom........... 11

Figure 2 – Conceptualization of third space sponsorship 14

Figure 3 – Social capital brokerage flow chart 21

Figure 4 – Word cloud of informal science learning terms 28

Figure 5 – Images of the BioBus 40

Figure 6 – Graph of post-BioBus responses to Likert item 15 analyzed by grade level 89

ACKNOWLEDGMENTS

Thank you to my parents for instilling within me a love of learning and the impetus to pursue those things one is passionate for. To my wife: this work was built upon your unwavering support, motivation, care of our children, meals, sacrifice of sleep, and partnership. To my two children: your joyful distractions provided the necessary respites to clear my mind; you both are a source of endless love and motivation. To my extended family and friends: the support I received from each of you individually is too great to name, but know that this work could not have been completed without you.

Thank you to my reviewers, in particular those members of the Teachers College science education department. Dr. Emdin, your theoretical conceptions and the work that you do to push the boundaries of what science education entails have been inspirational. Dr. Rivet, your critical eye and responsiveness to my queries pushed this work to a higher level. Dr. Anderson, the value of your methodological and analytical expertise as well as the selfless giving of your time were immeasurable.

Thank you to this study's student participants, their teachers, and the BioBus staff. Without you, this research would have never occurred.

J. F.

DEDICATION

To my past, current, and future students

CHAPTER 1: INTRODUCTION

Traditional science education at the K-12 level has often proven itself incapable of engaging student interest within the classroom and encouraging the pursuit of science-related careers (Crane, 1994; Eshach, 2006; National Research Council, 2009). Nowhere is this failure more evident than in our nation's urban science classrooms where marginalized youth sit disinterested, disengaged, and alienated from the substance of what is being taught (Basu & Calabrese Barton, 2007; Crane, 1994; Emdin, 2010a; Fadigan & Hammrich, 2004; Lemke, 1990; Osborne, Simon, & Collins, 2003). Despite the bleakness of this landscape, there is hope in the form of new partnerships and lessons learned from out-of-school science experiences. Commonly known as informal science education, these experiences may provide insight into how to engage marginalized urban youth successfully within the science classroom and persuade a greater number of them to pursue careers in science and related fields (National Research Council, 2009; Rahm & Ash, 2008; Stocklmayer, Rennie, & Gilbert, 2010). The potential for informal science education to address the serious concerns raised above aligns with a stated goal of the National Science Foundation to increase the number of underrepresented and underserved youth in science-related careers (Cosmos Corporation, 1998). Moreover, achievement of this goal is one of many steps that must be taken before the commonly stated education reform goal of science for all is met. To that end, a universal and high-quality science education is critical to encourage a diversity of ideas within the field and empower a scientifically literate and globally competitive citizenry.

The purpose of this research was to utilize the setting of a mobile microscope lab to unmask how interactions between urban youth, teachers, and scientists may lead to changes in students' attitude towards science. This writing explored the current state of science education in urban classrooms, discussed past research regarding informal science education settings, and outlined how these settings may lead to increased engagement by urban youth within the science classroom.

The Problem: Science Education in Urban Classrooms

The challenges faced by urban youth within the science classroom are many. Oftentimes, the culture or "symbols, stories, rituals, tools, shared values, and norms of participation that people utilize to act, decide, communicate, analyze, and understand their day to day lives and visions for the future" (National Research Council, 2009, p. 210) and that urban youth commonly identify with are at odds with the norms of the culture of science education (Emdin, 2010a; National Research Council, 2009; Norman, Ault, Bentz, & Meskimen, 2001; Tobin, Seiler, & Walls, 1999). Aikenhead (1996) also argued that the culture of school science is the major deterrent of voluntary enrollment in science courses. Furthermore, high-poverty urban youth often lack the resources and access to quality science education instruction (Calabrese Barton, Tan, & Rivet, 2008; National Research Council, 2009). For these reasons, the culture of urban youth, who share a common affiliation and lived experience (Emdin, 2010a) is often in conflict with the values, practices, and canonical knowledge promoted by the culture of school science (Aikenhead & Jegede, 1999; Calabrese Barton et al., 2008).

Viewing science as having its own unique culture is not new. In fact, seeing school 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). More specifically, for those who wish to engage with the culture of school science, the essential and specialized scientific practice of answering questions via the collection of evidence must be mastered (National Research Council, 2009). For urban youth, the culture of school science promoted by traditional classroom practice creates a barrier and acts as a “gatekeeper” (Brown, 2004; Moje, Collazo, Carrillo, & Marx, 2001). A consequence of this cultural clash are the unequal learning opportunities that manifest when urban youth disidentify, disengage, become alienated, and as a result, “drop out” of the science classroom (Banks et al., 2007; National Research Council, 2009). The essence of this cultural rift has also been described as cultural hegemony or the “valuing and dominance of one culture over another such that the valued culture becomes the norm” (Simpson & Parsons, 2009, pp. 297-298). Indeed it is not hard to imagne how such hegemonic practices within the traditional science classroom could be at the root of the underrepresentation and general disinterest of urban youth in science and science-related careers (Emdin, 2010b). In order to bridge these cultural gaps, a new approach to learning within urban science classrooms is needed. However, many questions remain on how to accomplish this, lessons learned from research within informal science education settings and the construction of a third space may prove to be a key component of a more broad-based holistic and culturally inclusive science education tailored to bridge the gaps (Boyer & Roth, 2006, National Research Council, 2009).

Possible Solutions: Visualizing a New Future for Science Education in Urban Classrooms

It has been suggested that blending informal science with the formal science classroom is necessary to close the achievement gap between marginalized urban youth and their more mainstream peers (Banks et al., 2007; National Research Council, 2009). Furthermore, approaching science education in this manner has been advocated by a number of researchers as a means to engage all students in science regardless of background (Hofstein & Rosenfeld, 1996; National Research Council, 2009; Stocklmayer et al., 2010). From a practical standpoint, a blended approach also makes sense as students spend the majority of their time outside of the classroom and perhaps more naturally identify with scientific phenomena and principles in this context. Furthermore, extensive bureaucratic constraints often placed on the formal science education sector, e.g., time, structure, and fiscal priorities, can often be ameliorated in a situation-specific manner or circumvented entirely by use of informal science education settings (Schwarz & Stolow, 2006).

The potential for informal science education to supplement learning within the formal science classroom and meet the goals of science education reformers has not gone unnoticed. In recent years, funding for informal science education programs has increased dramatically because of its putative benefits. Between 1984 and 1994, funding for informal science education by the National Science Foundation (NSF) increased by over $30 million dollars (Cosmos Corporation, 1998) and has since eclipsed $137 million per year (U.S. Department of Education, 2007).

Despite investor recognition of the potential of informal science education to achieve reformers' goals, much research is still needed to uncover best practices that will link the lessons learned within this setting with the formal school setting (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003; Gerber, Cavallo, & Marek, 2001; Sorge, Newsom, & Hagerty, 2000) and address the aforementioned concerns associated with urban youths' science education. The need for research and discourse is furthered by findings that reveal that while most students have some positive perceptions of science, their overall attitudes towards science are negative (Bennett & Hogarth, 2009; Ebenezer & Zoller, 1993; Osborne et al., 2003). This study was intended to add to the growing body of knowledge that exists on this topic and to address the concerns above in a constructive manner.

Why Study Student Attitudes Towards Science?

Koballa (1988) stated three reasons for why it is important to study student attitudes towards science: a) attitudes are relatively stable over time, but not fixed; b) attitudes are learned and as a result can be changed; and c) attitudes are related to one's behavior which, in turn, influence an individual's actions. In keeping with this line of thought, prior attitudinal research has also demonstrated that positive attitudes towards science lead to increased enrollment in science courses (Carey & Shavelson, 1988; Osborne et al., 2003; Simpson & Oliver, 1990; Weinburgh & Steele, 2000; Wellington, 1990), positive influences on student achievement (Carey & Shavelson, 1988; Fraser, 1982; Hasan, Hill, Atwater, & Wiggins, 1995; Schibeci & Riley, 1986; Talton & Simpson, 1987; Weinburgh, 2003; Weinburgh & Steele, 2000), increased student interest in science-related careers (Carey & Shavelson, 1988; Osborne et al., 2003; Wellington, 1990), and the ability to engage students in science-related issues (Bybee & McCrae, 2011). Furthermore, measuring affective outcomes like attitude have been determined to be an appropriate and necessary research approach within informal science ecucation settings (National Reseaerch Council, 2009).

A Closer Look at Informal Science, Culture, and Attitude

In recent years, some stakeholders have argued that the informal science education setting is a place where the cultural expectations of students are less strict than those found in the formal classroom (Simpson & Parsons, 2009). Additionally, findings from critical research within informal science settings have provided the field with fruitful lessons and best practices to examine how to best engage and conciliate evident tensions between urban youth and the culture of science. To that end, it has also been theorized that the dissolution and remediation of cultural tensions between urban youth and school science can occur within an intermediary third space provided by informal science education settings (Gutiérrez, Baquedano-Lopez, & Turner, 1997; Gutiérrez, Baquendano-López, & Tejeda, 1999; Moje et al., 2001; Moje et al., 2004; Taylor, 2006). At base, the third space provides a place where opposing Discourses (Gee, 1996) between urban youth and school science can be mitigated and bridged (National Research Council, 2009; Stocklmayer et al., 2010). Similarly, this study hypothesized that if a third space could be established by informal science education settings then the differences between the cultures of urban youth and school science could be reconciled. Additionally, a novel mechanism by which the tensions between the two aforementioned cultures could be mediated was established via social capital exchange and, in turn, linked to affective outcomes. Indeed, affective measures have been been well established as a wothwhile and valid measurement within the field of informal science education research (National Research Council, 2009). Finally, the analytical lens constructed was applied to examine this study's two research questions that centered on urban youth's changes in the attitude towards science and responses to an experience aboard the BioBus, a mobile microscope lab.

Research Questions

1. How did the attitude towards science of urban youth change following a BioBus experience?
   a. What changes occurred for the entire sample?
   b. What changes occurred at each grade level?
   c. What changes occurred for extreme cases at each grade level?
2. How did urban youth respond to their BioBus experience?
   a. How did responses differ among grades?
   b. How did responses differ among positive, negative, and neutral groupings?

c. How did responses differ between positive and negative extremes?

CHAPTER 2: THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The first part of Chapter 2 presents the theoretical framework that was developed for this study from hybridity theory, the third space, and the networking structures of social capital. These three distinct, underutilized, yet interrelated bodies of work represent a new paradigm with which to examine the interactions between the cultures of urban youth and school science. Once this framework is constructed, the chapter then turns to providing a detailed overview of past research explicitly linked to the research questions, methodology, findings, conclusions, and implications of this study.

Theoretical Framework

Hybridity Theory and Postcolonialism

Hybridity theory draws from the work of the postcolonial social critic Bhabha (1994) and his examination of competing Discourses (Gee, 1996), or the way different individuals or groups read, write, and use language with each other. Postcolonialism has also been used within the field of science education research in attempts to reinterpret the historical and political idea of "colonialism"—or any form of human action that exploits, norms, represses, or dominates others (Zembylas & Avraamidou, 2008). Furthermore, hybridity helps explain how being "in-between" (Bhabha, 1994, p. 1) can be both prohibitive and productive.

When prohibitive, differences between the colonizer (those with more power) and the colonized (those with less power) lead to tensions, what Bhabha (1994) referred to as "splitting" (pp. 98-99, 131), i.e., a disruption of equipoise or the status quo occurs. In turn, this power imbalance may cause the "colonized" to feel like an outsider and result in their resistance to the dominant Discourse (Moje et al., 2004). Conversely, when the worldviews of the colonized and colonizer can be explored under an umbrella of mutual trust and respect, tensions may become productive and, as a result, a "newness enters the world" (Bhabha, 1994, p. 212). Bhabha (1994) argued that these "in between spaces provide the terrain for elaboration strategies of selfhood—singular or communal—that initiate new signs of identity and innovative sites of collaboration, and contestation in the act of defining the idea of society itself" (p. 2). At base, the hybrid space, which Bhabha also referred to as a "third space" (p. 37), is the struggle for understanding and common ground between those with differences and is essential for learning, discovery, growth, and undertaking of new meanings to occur.

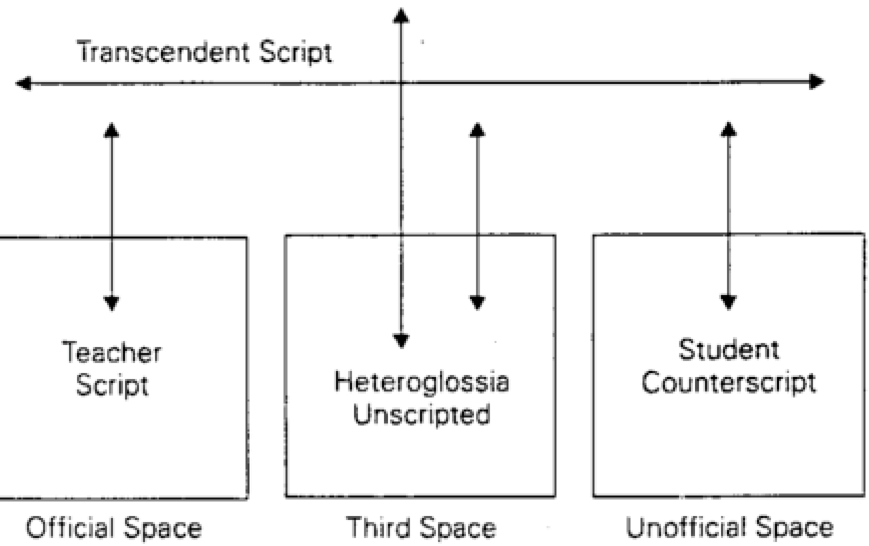
While Bhabha's work on hybridity and the third space focused more on the social elements separating cultures, Soja (1996) extended this view to include those that were physical (Moje et al., 2004). In fact, Soja (1996) argued that one should look for links between physical and social constructs and not view them as binary opposites. Soja also encouraged us to see the interconnectivity between these two aspects of our lives. Indeed, this combination of social and physical spaces has the potential to create a third space within informal science education settings.

As alluded to above, hybridity theory and the third space can and have been utilized within science education research to problematize the hegemonic overtone of Western-centric science education and allow science education researchers to "witness how dominant perspectives in the field have been implicated in the long history of colonial thinking" (Zembylas & Avraamidou, 2008, p. 981). While many studies utilizing hybridity theory and the third space as a lens have examined interactions within urban classrooms surrounding literacy and Discourses (Gutiérrez, 2008; Gutiérrez et al., 1999; Moje et al., 2001; Moje et al., 2004), others have looked at how urban youth merge science practices (Calabrese Barton et al., 2008) and utilize their funds of knowledge within the science classroom (Calabrese Barton & Tan, 2009; Moje et al., 2004).

The lens of hybridity and the third space has also been used to investigate urban youth interactions outside of the traditional classroom. This research has entailed the examination of informal science education spaces such as after-school science programs (Rahm, 2008) and university-school partnerships (Gutiérrez et al., 1997). Despite these initial attempts to utilize the third space to envision anew interactions between urban youth and the culture of school science, other avenues still must be explored to understand better what occurs within these sociophysical settings. Additionally, to the best of my knowledge, no prior studies, have attempted to measure how affective outcomes may be altered within third space environs.

Origins and Interpretations of the Third Space in Science Education

Gutiérrez, Rymes, and Larson (1995) were the first within the field of science education to conceptualize the third space (see Figure 1), doing so independently of Bhabha (1994) and Soja (1996). This first framework was organized around teacher "scripts" and student "counterscripts" and instances where the two intersected were characterized as the third space. By examining teacher scripts and student counterscripts, Gutiérrez et al. revealed that teacher scripts tended to dominate student counterscripts, stifling dialogue within the classroom. However, when teacher scripts and student counterscripts interacted authentically, "true dialogue" and the tensions that occurred could bridge social spaces within the classroom (Gutiérrez et al., 1995). The importance of this initial work should not be overlooked as it laid the foundation on which to explore a new framework. This framework has been built upon over time and used in multiple ways to examine and conceptualize the various interactions occurring within traditional and informal science settings.



Adapted from K. D. Gutiérrez, B. Rymes, & J. Larson (1995), Script, counterscript, and underlife in the classroom: James Brown versus Brown v. Board of Education," *Harvard Educational Review, 65*(3), 453. Copyright 1995 President and Fellows of Harvard College.

Figure 1. Original conceptualization of the third space within a science classroom

The next iteration of a third space framework within science education was completed by Gutiérrez et al. (1997). This group of researchers—drawing from Pearson's (1996) and Pearson and Johnson's (1978) concept of a "radical middle" or a space where "learning takes precedence over teaching; instruction is consciously local, contingent, situated, and strategic" (p. 372)—achieved a new theoretical and pedagogical paradigm by which to examine language and literacy within the science classroom. That is, by examining an afterschool university-school partnership consisting of urban elementary students, Gutiérrez et al. determined that the third space allowed for role reversals. These reversals occurred between the urban elementary students and university student volunteers and also presented opportunities for the co-construction of communal knowledge (Gutiérrez et al., 1997). Thus, the stage was set to examine more closely and utilize the lens of the third space outside of urban youth classrooms and within informal science education settings.

Since the foundational work of Gutiérrez et al. (1995) and Gutiérrez et al. (1997), the third space has been referred to as “an interstitial space” (Turnbull, 1997), and an area “that merges the ‘first space’ of people’s home, community, and peer networks with the ‘second space’ of the Discourses they encounter in more formalized institutions such as work, school, or church” (Moje et al., 2004, p. 41). Additionally, it is “a transformative space where the potential for an expanded form of learning and the development of new knowledge are heightened” (Gutiérrez, 2008, p. 152), and a place where an intersection of “knowledge, practices, and languages” (Glasson, Mhango, Phiri, & Lanier, 2010, p.128) is actualized. This conceptualization has even been likened to Vygotsky’s (1978) zone of proximal development (Gutiérrez, 2008; Gutiérrez et al., 1999) in terms of being capable of allowing those within this space to reach previously unreachable understandings. Moreover, the transformative potential of the third space to help science educators develop “culturally inclusive pedagogies” (Taylor, 2006, p. 206) that allow urban youth to rethink who they are and what they are capable of within the science classroom (Gutiérrez, 2008), provide authorship and connectivity to one another, and aid their success in school (Emdin, 2009) has not gone unnoticed.

In recognition of this potentiality, Moje et al. (2004) attempted to categorize the third space during their ethnographic study of urban middle school students’ funds of knowledge. This work determined that the third space occurs in three different forms: as a bridge builder between home and academic Discourses; as a “navigational space” that unites different discourse communities; and as a space of cultural, social, and epistemological change (Moje et al., 2004). Moje et al. also utilized these three categorizations of the third space to frame their study and determine the importance of utilizing urban youths' funds of knowledge to improve literacy practices within the science classroom.

Conceptualization of the Third Space in This Study

This research drew heavily from the classifications of the third space created by Moje et al. (2004) to examine the interactions of urban youth within the setting of a mobile microscope laboratory (i.e., the BioBus). In addition, a novel interpretation was utilized to view these interactions via the conceptualization of the third space as a sponsor to the culture of school science that traditionally implies a teacher-centered, positivist approach to science education (Emdin, 2010b). In addition to this latter categorization, the third space was also viewed as a place where individuals and groups with different values, worldviews, and lived experiences were able to interact free of judgment and stereotypes. From this premise, I also suggested that the nonthreatening sociophysical environment provided by the third space of an informal science education setting may allow urban youth the metaphysical space necessary to re-envision preconceived notions of the culture of school science.

By drawing from the framework outlined above and visualized in Figure 2, I proposed that the first space of urban youth culture can be symbiotically connected to the second space of the culture of school science via the third space of an informal science education experience. By doing so, I also suggested that the third space is capable of resolving and releasing tensions between the cultures of urban youth and school science. The cultural reconciliations that occur within this third space may also have affective outcomes, which, in turn, may change student attitudes towards science and empower urban youth to rethink their relation to science and science-related careers. Conversely, unabated or unresolved tension would only serve to continue the marginalization and disenfranchisement of urban youth from the culture of school science.

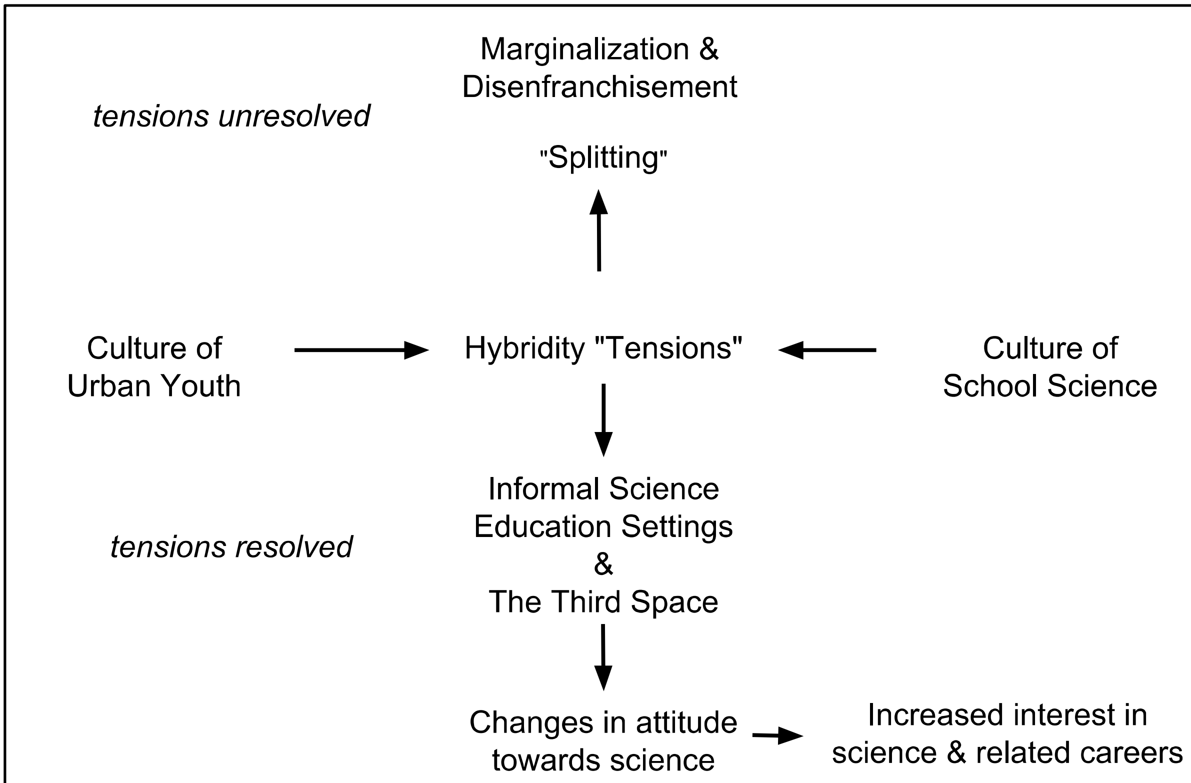


Figure 2. Conceptualized roles informal science education settings and the third space play in mitigating tensions between the cultures of urban youth and school science as well as the outcomes of resolved and unresolved tensions.

Figure 2. Conceptualization of third space sponsorship

As my review of the third space has shown, interpretations of what it is and how it can be defined as vary. With that said, I have demonstrated that it is possible to conceptualize the third space as a place where dissimilar groups and cultures are able to interact and potentially resolve cultural tensions (see Figure 2). To that end, the third space construct was utilized in this study to provide a way in which to view interactions between urban youth and the culture of school science within informal science education settings. More specifically, the third space was seen as a means to examine changes in urban youths' attitude towards science and reveal their perception of a mobile science laboratory experience aboard the BioBus. Additionally, a mechanism for how attitudinal changes and shifting perceptions occurred was also constructed. This mechanism, which details what social capital is and how it is transferred between disparate groups; potentially influencing affective measures like a student's attitude towards science along the way, is outlined below.

Social Capital, the Third Space, and Attitudes Towards Science

According to Bourdieu, (1986), social capital is "the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition," (p. 51) and is dependent on the network size of an individual or group as well as the amount of capital those connections have on their own. More succinctly, Coleman (1988) saw social capital as being "productive, making possible the achievement of certain ends that in its absence would not be possible" (p. S98). Generally speaking, the more social capital an individual possesses, the better off he or she will be due to the connections available from the people that individual knows and the networks at his or her disposal. Applying this social capital construct to the interaction of urban youth within the third space and informal science education settings, I developed a lens to analyze how the acquistion of social capital within these environs could be used as a means by which to explain how measured changes in attitudes towards science occurred. Indeed the interplay of these connections will be further detailed below.

Forms of social capital. Coleman's (1988) examination of social capital resulted in the classification of three distinct forms. These forms are: a) obligations, expectations, and trustworthiness of structures; b) information channels; and c) norms and effective sanctions. Each is briefly discussed below.

Obligations, expectations, and trustworthiness—the first form of social capital listed above—play out as a series of credits and debits that are dependent on the reliability and social position of each individual (Coleman, 1988). Practically speaking, if someone does something for another person, an in-kind reciprocation is generally expected. Coleman's second form of social capital, information channels, can be thought of as the way in which knowledge is acquired. Pursuant to this rubric, the more information we acquire and the more easily it can be acquired, the better our chances are of increasing our social capital. In contrast, an individual with fewer information channels has greater difficulty accessing and acquiring social capital. Furthermore, Coleman also pointed out that an individual does not necessarily need to be in direct contact with all sources of information, and may instead depend upon indirect networks for access to social capital.

The third and final categorization of social capital outlined by Coleman (1988), norms and effective sanctions, is also referred to as "closure." In fact, following his analysis of high school dropout rates in public, private, and religious schools, Coleman concluded that closure was the source of social capital. Coleman's analysis revealed that religious schools had lower incidences of high school dropouts due to what he referred to as the creation of an "intergenerational closed" community, or a group of individuals with a shared set of values and willingness to enforce them through norming expectations. Coleman went on to suggest that the normative expectations of religious schools are in many ways stricter than those found within public or private schools.

Another example provided by Coleman (1988) of closure as the source of social capital was the close-knit communal and familial ties and religious affiliation found among Jewish diamond jewelers. In this example, Coleman proposed that closure serves as the insurance necessary to facilitate transactions within the diamond market. The strength of these ties makes transactions and trades occur with ease because trust among dealers is taken for granted. Finally, Coleman pointed out that in the absence of such close-knit relationships among diamond dealers, transactions would not take place without elaborate and expensive bonding and insurance devices that would ensure satisfactory levels of reciprocal trust.

Despite the benefits social capital provides, there can also be negative consequences of its acquisition via closure. Two of these negative impacts, the exclusion of outsiders and downward leveling norms (Coleman, 1988), are likely barriers for urban youth within the science classroom. The exclusion of outsiders arises when the close-knit ties between members of a group leads to nonmembers being barred from joining said group (Coleman, 1988). This same outsider status can be applied to many urban youth when they are confronted with social practices and epistemologies in science class that do not value their culture, worldviews, or funds of knowledge (Emdin, 2010b). For example, if urban youth do not see their culture valued, as is often the case within their science classroom, it is not hard to imagine how they may remain outsiders to the culture of school science; then, an untenable cycle begins wherein they are unable to access the network of social capital it possesses. Conversely, one could argue that urban youth do have their own form of social capital thanks to the strong ties and closure among those within this group. That being said, the social capital within urban youth culture may not be deemed appropriate or valued within the formal science classroom. As a result, even when urban youth have closure among themselves, they still may struggle to gain social capital from the culture of school science in school. Or, in terms of Coleman's interpretation, they lack the information channels necessary for social capital acquisition.

With regard to the downward leveling norms, the second negative impact of social capital acquisition through closure that is made manifest by a study of the urban youth experience within the science classroom, a number of points must be made. First, downward leveling norms are “situations in which group solidarity is cemented by a common experience of adversity and opposition to mainstream society. . . . [In this context] individual success stories undermine group cohesion because the latter is precisely grounded on the alleged impossibility of such occurrences” (Portes, 1998, p. 17). Paradoxically, this outlook has the unfortunate ability to perpetuate an ongoing cycle of impoverishment among those existing outside of mainstream culture and desiring inclusion on enlightened terms. “The result [of this almost Sisyphean redux] is downward leveling norms that operate to keep members of a downtrodden group in place and force the more ambitious to escape from it” (p. 17). Indeed, it is not hard to envision outsider status and downward leveling norms playing out within urban science classrooms across the nation. In fact, I have seen this phenomenon occur on more than one occasion in the urban science classroom when more successful students are mocked for their success on a test or for something as simple as answering a question correctly. To wit, occurrences like these happening within the researcher’s own classrooms have not gone unnoticed by science education researchers who have proposed that some urban youth view engaging with the culture of school science as “acting white” (Fordham & Ogbu, 1986). As a result, urban youth may be hesitant to leave the relative safety of their known culture for fear of being ridiculed and reviled by their peers for lack of authenticity.

In this way, the coupling of outsider status and downward leveling norms may exacerbate the struggles urban youths face when attempting to access the social capital held within the culture of school science. Furthermore, the inability of some urban youth to access the social capital held within the culture of school science may eventually lead to disinterest, alienation, poor attitudes towards science, and, ultimately, a dearth of individuals from urban cultures in science-related careers. An alternative to this bleak picture exists, and this researcher argues that if more student-centric conditions are created for urban youth, giving them an opportunity to connect to the culture of school science, they may be able to shed their outsider status, and the ill effects of downward leveling norms will be reversed in part or whole. Indeed, my framework posits that the utilization of the third space, facilitated by informal science education learning experiences, is one possible means to influence affective outcomes like a student's attitue towards science. Below, a mechanism for how this facilitation may take place is presented.

Burt's social capital and structural holes. While we have seen above how Coleman (1988) viewed the source of social capital stemming from closure within tight-knit groups, an alternative and contrasting viewpoint to social capital acquisition was offered by Burt (2000), who argued social capital is instead acquired by brokerage across structural holes. According to Burt, people existing on opposite sides of a structural hole

> are focused on their own activities such that they do not attend to the activities of people in the other group. Holes are buffers, like an insulator in an electric circuit. People on either side of a structural hole circulate in different flows of information. Structural holes are the opportunity to broker the flow of information between people, and . . . bring together people from opposite sides of the hole. (p. 208)

Utilizing this description we can envision how the cultures of urban youth and school science exist on opposite sides of a structural hole within their own array of networks, Discourses, funds of knowledge, and lived experiences.

Burt (2001) argued that the linking of disparate groups through a structural hole is the source of social capital and can lead to an expanded and broader knowledge base. He stated, "brokerage across structural holes is social capital . . . networks that span structural holes are associated with creativity and learning" (p. 236). In keeping with this conceptual model, Burt identified three mechanisms responsible for the brokerage of social capital: clique networks, entrepreneurial networks, and hierarchical networks in a study of the business world. In brief, he concluded that clique networks are made of interconnected relationships that create tight-knit social support networks at the expense of the acquisition of social capital. Clique networks can also be seen as being synonymous to the concept of closure presented by Coleman (1988). Entrepreneurial networks are large, sparse, and rich with opportunities to broker connections across structural holes. In entrepreneurial networks, social capital is fluid and acquired with relative ease. Finally, hierarchical networks transmit social capital via a central contact akin to a sponsor. Or, in terms of the business world, this could be viewed as a subordinate worker gaining access to a previously inaccessible network through their boss (Coleman, 1988).

Connecting urban youth, the third space, school science, and social capital. Before continuing, revisiting the overarching framework of this study is necessary to further align the cultures of urban youth and school science with the interplay of the third space and transmission of social capital. When this is accomplished, I will have fully constructed the lens through which the interactions of urban youth with the culture of school science were viewed during an informal science education experience aboard a mobile microscope laboratory and how a student's attitude towards science may be altered.

If one accepts that urban youth are more likely to engage with one another than with the culture of school science, they can then be characterized as belonging to a clique network. According to Burt (2001), a clique network is insular and oftentimes conferred outsider status. Furthermore, a clique network is similar to the concept of closure outlined by Coleman (1988) above. For the purpose of this theoretical framework, however, the similarity between a clique network and Coleman's concept of closure end there. The former will not be viewed as the source of social capital, but as a hindrance to its acquisition. In this way, I am intentionally drawing from the two negative aspects of closure, namely the exclusion of outsiders and downward leveling norms, as outlined above. As a result, this theoretical framework is juxtaposed with Burt's (2000, 2001) view that structural holes are the ultimate source and means of social capital acquisition.

For the purposes of this study, I suggest that many urban youth, as members of a clique network, voluntarily forgo the social capital held by the entrepreneurial network of school science in favor of their own dense and tightly bound groups. As a result, urban youth require a "sponsor" anytime they "try to broker a connection into a group not likely to accept [them] as a legitimate member" (Burt, 2001, p. 407). That is, sponsorship of urban youth to the culture of school science must be facilitated via a hierarchical network. Or, in terms of this study, it was hypothesized that sponsorship to the culture of school science could occur if urban youth were presented with an opportunity to interact within the third space of an informal science education setting.

Additionally, this study utilized third space sponsorship to suggest a mechanism for the way in which urban youth connect to and acquire social capital from the entrepreneurial network represented by the culture of school science. In other words, the third space allows for cultural tensions between urban youth and school science to be mediated (see Figure 2) and social capital to be brokered by connecting disparate groups through a structural hole made by the third space (see Figure 3). Furthermore, I posited that if social capital could be brokered then student attitudes towards the culture of school science could be changed. With this study's framework fully conceptualized, the researcher now has a multidimensional lens through which to view changes in urban youth's attitude towards science and their perception of the informal science education experience aboard the mobile science laboratory BioBus.

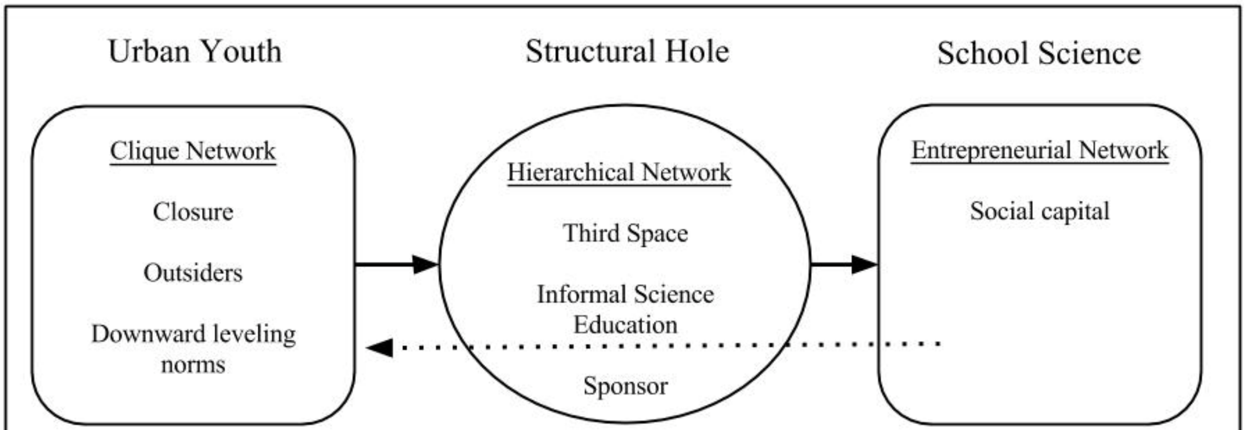


Figure 3: Flow diagram representing a model for how urban youth may access (solid arrows) and acquire (dashed arrow) the social capital held by school science via the structural hole created by third space sponsorship within informal science education settings.

Figure 2. Social capital brokerage flow chart

Literature Review

The second part of Chapter 2 will review prior work related to this study's research questions. The following is an in-depth analysis of findings from studies focused on urban youth, informal science education, and attitude towards science. In addition, working definitions of attitudes towards science and informal science education are presented.

Defining Attitude Towards Science and Informal Science Education Outcome

Defining attitude is a common practice of "attitude research" (Blalock et al., 2008; Gardner, 1975; Germann, 1988; Koballa, 1988; Noll, 1935; Shrigley, Koballa, & Simpson, 1988; Walczak & Walczak, 2009). As a result, it is important to review the various ways in which attitude has been defined in the past in order to determine how it was utilized in this study. Attitudes in general have a cognitive, emotional, and action-tendency component (Oppenheim, 1992) and can be thought of as "systems of cognitions, feelings, and inclinations towards action that have developed through informal and formal experiences" (Bybee & McCrae, 2011, p. 12).

Furthermore, attitudes have also been categorized as being ephemeral, learned and not inherited, derived from social interactions, and organized around beliefs (Shrigley et al., 1988). Finally, and perhaps more simply, attitude is a predisposed response to act favorably or unfavorably towards an object (Fishbein & Azjen, 1975). To that end, the National Research Council (2009) has deemed attitude and other affective outcomes as appropriate measures for research occurring within informal science education settings.

Scientific Attitudes or Attitudes Towards Science?

Gardner (1975) was among the first to make the distinction between scientific attitudes and attitudes towards science. Scientific attitudes can be thought of as "habits of thinking" (Noll, 1935) or the ability to think like a scientist (Koballa, 1988). Furthermore, they encompass "a particular approach a person assumes for solving problems, for assessing ideas and information, and for making decisions" (Germann, 1988, p. 690). That is, possession of a scientific attitude implies that an individual can think critically and suspend judgment (Koballa, 1988).

On the other hand, attitude towards science is the "emotional reactions of students towards science . . . a learned predisposition to evaluate in certain ways, objects, people, actions, situations or propositions involved in learning science" (Gardner, 1975, p. 2). More simply, one's attitude towards science can be boiled down to whether or not an individual likes or dislikes science itself (Bybee & McCrae, 2011; George, 2000; Oliver & Simpson, 1988).

Attitude Towards Science Findings Related to this Study

With clear distinctions now having been made between a scientific attitude and attitude towards science, the literature review turns to presenting prior work directly related to and drawn upon by the researcher to craft this study. Of note here is that the research discussed was selected critically and by no means represents an exhaustive list of all variables found to have influenced students' attitude towards science. With that being said, the review here includes all works directly related to the overarching purpose of this study and its associated research questions.

Age. A number of studies have found that as students become older, their attitudes towards science become less positive (Atwater, Wiggins, & Gardner, 1995; Barmby, Kind, & Jones, 2008; Bennett & Hogarth, 2009; Breakwell & Beardsell, 1992; Finson & Enochs, 1987; Francis & Greer, 1999; George, 2000; Greenfield, 1996; Haladyna & Shaughnessy, 1982; Hasan et al., 1995). This decline in student attitudes towards science is of particular concern to this study because of the finding that negative attitudes are a source of lower motivation and achievement for urban 7th and 8th graders (Atwater et al., 1995).

The steady decline of student attitudes towards science typically begins in middle school and continues throughout high school (Bennett & Hogarth, 2009; George, 2000). As a result, George (2000) has called for "special efforts to be made by . . . schools to help students view science with more positive feelings" (p. 223). Similarly, Bennett and Hogarth (2009) found in their study of 280 students aged 11, 14, and 16 years, using the Attitudes to School Science and Science instrument, that attitudes towards science become significantly more negative between 11 and 14 years of age. To that end, this study focused specifically on this age range.

While downward-trending student attitudes towards science do not bode well for goals of increasing the number of students who pursue science-related careers, one can take some solace in the finding that the decision to enter science is made at an early age, often before middle school (Maltese & Tai, 2010). This is not to say that this pursues a better understanding of the underlying reasons for why declining student attitude towards science occurs as age increases, but rather it is a way to highlight the complexity of the relationship between student attitude towards science and its role in influencing decisions to pursue science-related careers.

Urban youth. Given science reformers' efforts to increase the number of underrepresented and underprivileged groups within science-related careers, the lack of studies on the attitude towards science of urban youth is surprising. With that said, the studies that do exist reveal similar attitudinal findings as those presented above, with some notable exceptions. Atwater et al. (1995), in an examination of an urban southeastern and mainly African American middle school, found that 25% of the students they studied had very positive attitudes towards science and that those with positive attitudes had similar feelings towards their science teacher, science curriculum, and science classroom culture, but neutral feelings towards their classrooms' physical environment and their school in general. This same study also found that students with negative attitudes towards science had negative feelings towards all of the aforementioned variables examined (Atwater et al., 1995). Finally, this study revealed that family attitudes towards science may not necessarily influence urban student attitudes towards science (Atwater et al., 1995).

Science curriculum reform programs and their impact on urban students' attitude towards science have also been studied. Weinburgh (2003) examined the impact of a four-year science reform program on low-income African American urban students in Grade 5. Findings revealed that only a small positive impact on changes in attitude towards science resulted from this particular curricular reform (Weinburgh, 2003). Similarly, Freedman (1997) found that hands-on laboratory experiences in a 9th grade physical science curriculum in an urban school of students from diverse backgrounds had only a slight positive impact on students' attitude towards science. Catsambis (1995) in a study of African American students found that high achievement in science was not necessary for this particular population of students to have a positive attitude towards science. Interestingly, this “attitude-achievement paradox” (p. 389) suggested that a favorable attitude towards science of students from nondominant backgrounds may be aided by the nonthreatening assessment and low-stakes nature of informal science education settings. This possibility and other findings from research in informal science settings and students’ attitude toward science are discussed below.

Informal Science Education and Attitude Towards Science

Before reviewing past research from the field of informal science education, it is important to first define what these settings are and what learning looks like within them. This importance is furthered due to the fact that this study took place within the BioBus mobile microscope lab; a relatively novel science education setting.

Defining informal science education and informal learning. Informal science education is generally thought of as science programs and experiences that occur outside of the formal science classroom (Rennie, Feher, Dierking, & Falk, 2003; Wellington, 1990). There is also general agreement that the out-of-school experiences often associated with this type of learning span a wide range of settings to include designed environments like museums, aquariums, zoos, science centers, everyday learning environments that are created from the Internet and media, and after-school programs (Allen et al., 2008; National Research Council, 2009; Simpson & Parsons, 2009; Stocklmayer et al., 2010).

Early categorizations of informal science learning (see Table 1) created distinct binaries between informal learning and learning within the formal school setting. They tended to focus more on the context of the setting and not the nature of learning (Eshach, 2006; Hofstein & Rosenfeld, 1996; Stocklmayer et al., 2010).

Table 1

Early Categorization of Formal and Informal Learning in Science

Informal Learning	Formal Learning
Voluntary	Compulsory
Haphazard, unstructured, unsequenced	Structured and sequenced
Nonassessed, noncertificated	Assessed, certificated
Open-ended	More closed
Learner-led, learner-centered	Teacher-led, teacher-centered
Outside of formal settings	Classroom and institution based
Unplanned	Planned
Many unintended outcomes (outcomes more difficult to measure)	Fewer unintended outcomes
Social aspect central, e.g., social interactions, between visitors	Social aspect less central
Low "currency"	High "currency"
Unidirected, nonlegislated for	Legislated and directed (controlled)

Adapted from J. Wellington (1990), Formal and informal learning in science: The role of the interactive science centres, *Physics Education, 25*, 248. Copyright 1990 IOP Publishing.

However, more recently, nuanced, broad, and somewhat contentious definitions have been utilized to define informal learning,

> what makes a learning environment informal is the subject of much debate, informal environments are generally defined as including learner choice, low consequence assessment, and structures that build on the learners' motivations, culture, and competence. Furthermore, it is generally accepted that informal environments provide a safe, nonthreatening, open-ended environment for engaging with science. (National Research Council, 2009, p. 47).

This much is also clear when analyzing the words and phrases used to describe informal learning from seven often-cited works (Cosmos Corporation, 1998; Crane, 1994; Eshach, 2006; National

Research Council, 2009; Ramey-Gassert & Walberg, 1994; Stocklmayer et al., 2010; Wellington, 1990) within the domain of informal science education research. An interesting exercise can be done, using Wordle, the online word cloud generator (see Figure 4), to refine and focus the field's understanding of informal learning.

To create Figure 4, all of the words and phrases utilized to characterize informal learning within each article cited above were placed into the Wordle online application. In turn, Wordle counted the number of times each word and phrase occurred, giving more weight to those that appeared the greatest, with the end result being the word cloud seen in Figure 4. This nonscientific method should not be thought of as a means to replace a rigorous meta-analysis of how various researchers have defined informal science learning, but instead as a quick and simple way to clarify how informal science learning is defined within the field of informal science education research.

Figure 4: Word cloud of terms used most frequently to describe informal science learning. Image generated using http://wordle.net.

Figure 4. Word cloud of informal science learning terms

A glance at the word cloud constructed reveals that the most prominent word associated with informal science learning is *voluntary*, although other phrases like *intrinsic motivation*, *learner-led, nonevaluative, nonthreatening,* (has) *personal meaning, unstructured, free-choice*, and *open-ended* also draw the viewer's attention. In this way, a clearer definition of what informal learning entails has emerged. However, all informal science education settings and the experiences they offer likely fall on a continuum of these descriptors. To that end, I will return to and provide justification for why the setting of this study, a mobile science lab, was characterized as an informal learning environment in Chapter 4.

Findings from informal science education research. Now that this review has defined what informal science education is and what learning looks like within these settings, I turn to presenting past findings within this domain that are directly related to this study.

Despite the limited research on the impact of informal science education on student attitudes towards science, some notable studies (Finson & Enochs, 1987; George & Kaplan, 1998; Gibson & Chase, 2002; Haladnya, Olsen, & Shaughnessy, 1982; Jarvis & Pell, 2002a, 2005; Osborne et al., 2003; Zacharia & Calabrese Barton, 2004) that have examined the relationship between these two variables do exist. The settings of studies examining changes in student attitude towards science within informal science education ranged from visits to science centers and museums (Finson & Enochs, 1987; Jarvis & Pell, 2002b, 2005) to extracurricular participation in science clubs and activities (George & Kaplan, 1998; Osborne et al., 2003; Zacharia & Calabrese Barton, 2004). Furthermore, two separate meta-analyses have revealed how informal science education programs can have positive (Haladnya et al., 1982) and mixed impacts on student attitudes towards science (Schibeci, 1984).

Positive impacts on student attitude towards science was revealed by Finson and Enochs (1987) in their examination of Kansas public and private school students in Grades 6-8 before and after a field trip to a science-technology museum. Utilizing a science attitude survey instrument, the researchers discovered that students who visited the science-technology museum had more positive attitudes towards science and technology than those who did not attend the museum (Finson & Enochs, 1987). Furthermore, no significant difference was found between males and females of high and low socioeconomic status. It should also be noted that teachers who prepared their students for the museum visit and debriefed with them afterwards demonstrated higher attitudinal changes than students whose teachers did no prior- or post-trip activities (Finson & Enochs, 1987). With that said, Finson and Enochs were unable to confirm that positive changes in students' attitude towards science and technology were the result of visiting the museum. This limitation may have been because of the difficulties associated with measuring one-time interventions like field trips or because their study was lacking a qualitative component that would have provided a thicker and richer description of the reasons for student attitudinal change.

Sorge et al. (2000) studied the impact of the Space Science Education Program (SSEP) as a part of the University of New Mexico's science outreach to Hispanic middle school students. The final evaluation of this program determined significant positive changes in attitude towards science for the boys and girls enrolled in SSEP (Sorge et al., 2000). Interestingly, this study also revealed the difficulty that these students had identifying themselves as scientists, leading Sorge et al. to posit that this occurrence may have been due to a lack of science role models and negative media stereotyping.

Gibson and Chase (2002) examined the long-term impact of a two-week Summer Science Exploration Program on the attitude towards science of public middle school students. Using a mixed-methods approach, they determined that students who had participated in the summer program developed and maintained a more positive attitude towards science than their nonprogram participant peers (Gibson & Chase, 2002). Gibson and Chase argued that these findings should be of note because most middle school students typically develop negative attitudes towards science as they age. However, we should also consider that studies entailing summer science programs may result in the self-selection of participants who most likely already have positive attitudes towards science.

Finally, two studies at the Challenger Centre, a science museum in the United Kingdom where students command and direct a space mission (Jarvis & Pell, 2002, 2005), measured the effect that this type of informal science education experience had on students' attitude towards science. In the earlier of the two studies, Jarvis and Pell (2002) developed an attitudinal instrument that was administered to 655 elementary students. This study found that the Challenger experience inspired 24% of all students, and in particular girls, to want to become scientists (Jarvis & Pell, 2002). It was also found that any initial interest by girls to become a scientist was short-lived; moreover, "A sizeable number of pupils were relatively unaffected by the experience and there was a significant negative effect on a small group of anxious girls" (p. 979).

This initial quantitative study was revisited and refashioned by Jarvis and Pell (2005) into a mixed-methods study of 300 children aged 10-11 from four different schools. In this follow-up study, aspects of the quantitative results found previously by Jarvis and Pell (2002) were reinforced via 70 teacher and student interviews. Findings from this qualitative examination showed that a small percentage (20%) of students experienced a short-lived interest in becoming a scientist immediately following the Challenger experience. Furthermore, of all students demonstrating positive changes in their attitude towards science, the majority were boys—a reversal from Jarvis and Pell (2002). In this instance, boys showed a marked increase (although not significantly so) in their attitude towards science, whereas girls' attitude was virtually unchanged (Jarvis & Pell, 2005). Despite these somewhat conflicting findings from Jarvis and Pell (2002, 2005), this series of studies and others mentioned above revealed that informal science education experiences can have positive impacts on students' attitude towards science, even following short duration events. Furthermore, these results, coupled with the relatively sparse findings on the impact of informal science education experiences on the attitude towards science of urban youth, give impetus to and warrant further investigation into understanding the interplay between these two domains.

Summary of Chapter 2

This chapter presented this study's theoretical framework and literature review. The theoretical framework constructed provided a means by which interactions between the culture of urban youth and school science were viewed within the informal science education setting of the mobile microscope lab BioBus during this research. Additionally, an overview for how tensions between urban youth and school science could be resolved and, in turn, lead to changes in students' attitude towards science was examined (see Figure 2). Finally, a mechanism detailing how attitudinal changes might occur via social capital brokerage was crafted (see Figure 3).

In the literature review part of this chapter, working definitions of attitude towards science, informal science education, and informal learning were provided. Furthermore, all prior research directly related to the overarching purpose and research questions associated with this study were discussed. To that end, the examination of the work completed by researchers on students' attitude towards science, urban youth, and informal science education settings helped inform the methodologies of this study, which are outlined in the forthcoming chapter.

CHAPTER 3: METHODOLOGY

The purpose of this study was to investigate changes in urban youths' attitude towards science after a mobile microscope laboratory BioBus experience. Additionally, this research assessed student perceptions of the BioBus experience itself and, subsequently, was able to assess the applicability of the theoretical framework utilized herein. That is, it was determined whether or not and in what instances the BioBus experience could be viewed as a third space sponsor capable of mediating tensions between the cultures of urban youth and school science via the transfer of social capital.

In the following sections of this chapter, the design of the study is described in detail, beginning with an examination of the methodological approach chosen to examine the research questions guiding this study. Following this discussion, the sample of participants is described. Next, the data collection techniques and approaches to analyzing data are outlined. Finally, issues of rigor, ethics, bias, and limitations are addressed.

Research Design

For this study, a qualitative research approach, including observations, interviews, and an open-response questionnaire, was utilized in conjunction with a quantitative survey. This mixed-methods data collection process allowed me to analyze deeply the interactions of urban youth within the mobile microscope lab BioBus.

Qualitative Research Overview

A qualitative approach asks the researcher to be the primary data collection instrument and to use inductive analysis to process, make meaning, and understand the phenomenon under study (Merriam, 2009). Qualitative research is further characterized as a study that takes place within the field, collects data from multiple sources, makes use of a theoretical framework, creates interpretations of what is observed, and provides a holistic account of a phenomenon (Creswell, 2007).

In part, the qualitative aspects of this study were chosen due to the recognition among science education attitudinal researchers to move away from traditionally quantitative and positivist approaches (Krogh & Thomsen, 2005). To that end, Schibeci (1984), following a review of 200 attitudinal studies, stated, "It is disappointing that the set of conclusions which can be drawn from such a large body of literature is so limited" (p. 46).

Finally, a qualitative approach was deemed appropriate due to the more holistic interpretation of reality that this methodological stance allows. Myriad variables (e.g., age, gender, family and peer influence, etc.) are responsible for influencing a student's attitude towards science. As a result, it is exceedingly difficult for any one quantitative instrument to capture the interplay among and between each variable in its entirety (Petty, Wegener, & Fabrigar, 1997). To that end, the more in-depth discovery and research process called for by qualitative case study research may help overcome these limitations.

Case study research. Of the qualitative methodologies available, a case study was deemed as being the most appropriate as I, like Rahm (2008), looked to examine the interarctions between the cultures of urban youth and school science within a third space setting. With that having been said, according to Merriam (2009), "A *case study* is an in-depth description and analysis of a bounded system" (p. 40, emphasis in original), that has the potential to uncover new relationships, meanings, and explanations for the objects of study. Research utilizing a case study approach is characterized by detailed and in-depth data collection from multiple sources (e.g., field observations, interviews, and audio- and videotaping) that are then used to generate a case description with emergent themes (Creswell, 2007). In this way, a case study provides a specific, heuristic, and “thick” description that is concrete and highly contextualized (Merriam, 2009). Furthermore, the holistic approach offered by a case study (Feagin, Orum, & Sjoberg, 1991) provides an opportunity to capture and analyze more fully the interplay between influential attitudinal variables within informal science education environs and their effect on a student’s attitude towards science.

A case study was also deemed appropriate for this study after reviewing Yin’s (2003) suggestions for case study research. That is, this case study’s design utilized open-ended questions, involved participants whose behavior cannot be manipulated, included my desire to examine contextual conditions related to the studied phenomenon, and determine unclear boundaries between the phenomenon and context of study. Furthermore, a desire to understand cultural systems of action holistically (Feagin et al., 1991) or the sociocultural relationship between the cultures of urban youth and school science is another reason a case study was appropriate for this study. Finally, and perhaps most powerfully, a case study’s data analysis should be approached from multiple perspectives, giving voice to the powerless and voiceless (Tellis, 1997). Given the context of this study, it has been often cited that urban youth lack a voice in the traditional science classroom (Basu & Calabrese Barton, 2007; Crane, 1994; Emdin, 2010a; Fadigan & Hammrich, 2004; Lemke, 1990; Osborne et al., 2003).

Case studies have also been categorized as being explanatory, exploratory, descriptive, single, holistic, and multiple (Yin, 2003), as well as intrinsic, instrumental, and collective (Stake, 1995). The research questions investigated and the theoretical underpinnings of this study required that a variety of the categorizations listed above be utilized to fully describe the case study that was completed. To begin, this research was *explanatory* as I attempted "to explain the presumed causal links in real-life interventions" (Yin, 2003, p. 547). To elaborate, the causal question of this work entailed the extent to which a mobile science lab experience changed urban youths' attitude towards science.

This study was also *descriptive* in the sense that it detailed the response of urban youth to their BioBus experience. Additionally, it was descriptive because it utilized a theoretical frame to examine a phenomenon within the real-life context in which it occurred (Tellis, 1997; Yin, 2003). Furthermore, this case study could be categorized as being *instrumental.* According to Stake (1995), a case study is *instrumental* when the case itself is of secondary interest and findings are instead used to shed light on a particular situation or help refine a theory. Indeed, one of the secondary purposes of this study was to examine critically the theoretical framework utilized and measure the applicability of its usage outside of the setting in which this research occurred. Finally, this study was a *single* case as it examined urban youth within one type of mobile science lab, i.e., the BioBus mobile microscope laboratory.

A note on mixed-methods research. While case study research is a qualitative methodology, it is not uncommon for quantitative survey data to be incorporated into this type of research.

> Unique in comparison to other qualitative approaches, within case study research, investigators can collect and integrate quantitative survey data, which facilitates reaching a holistic understanding of the phenomenon being studied. In case study, data from these multiple sources are then converged in the analysis process rather than handled individually. Each data source is one piece of the "puzzle," with each piece contributing to the researcher's understanding of the whole phenomenon. This convergence adds strength to the findings as the various strands of data are braided together to promote a greater understanding of the case. (Baxter & Jack, 2008, p. 554)

That said, I purposefully chose to implement a quantitative survey in this study to further triangulate findings across data collection instruments and complement the thick and rich description expected of qualitative methodologies. As a result, this work can also be viewed as belonging to mixed-methods research or " . . . the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (Johnson & Onwuegbuzie, 2004, p. 17).

According to Johnson and Onwuegbuzie (2004), the mixing of research methodologies allows investigators to capitalize on the strengths and minimize the weaknesses that would be present if quantitative and qualitative approaches were used separately. Moreover, Greene, Caracelli, and Graham (1989) cited five rationales for conducting mixed-methods research: triangulation (multiple data points), complementarity (reinforcement of findings within each method utilized), initiation (revelation of contradictions), development (using findings in one method to inform those found in another), and expansion (widening the breadth of research). That said, this study was informed by and put to use all five aforementioned rationales in its search for a greater understanding of the experience that urban youth had within the mobile science lab BioBus. More specifically, the multiple sources of qualitative data collected from this study were complemented by the incorporation of this study's quantitative survey data. By doing so, not only were the often cited external validity issues of qualitative methodologies addressed (Johnson & Onwuegbuzie, 2004; Merriam, 2009), but the fundamental principle of mixed research—the reinforcement of strengths and minimizing of weaknesses—was put into practice (Johnson & Turner, 2003).

Sample Selection

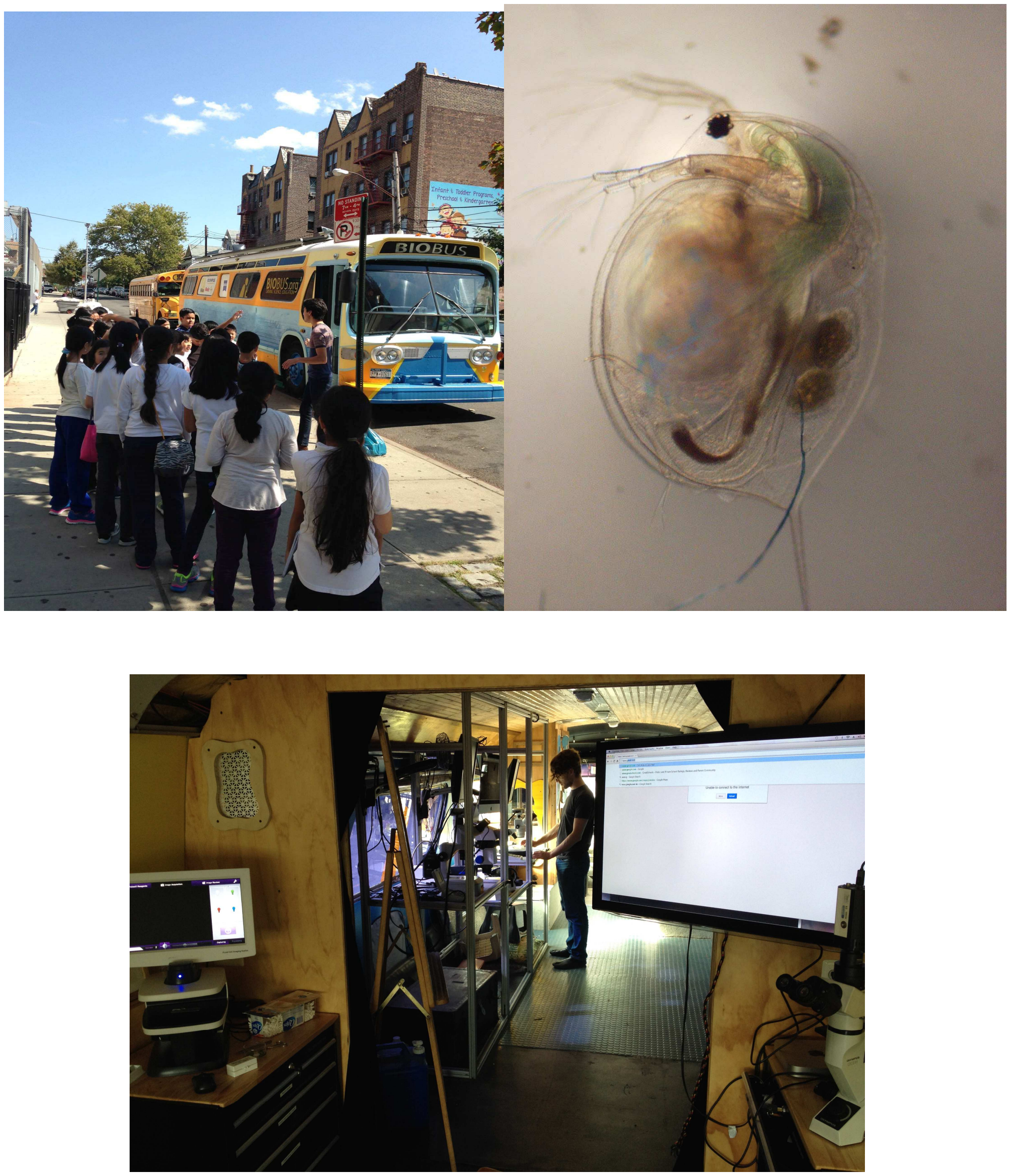
This case study was anchored and bound to the experience had by urban youth from four different science classes at four different schools within a major Northeast metropolitan area aboard the mobile microscope laboratory BioBus. By cementing this study to the experiences of one specific group of students (i.e., urban youth) within one science education setting (i.e., the mobile microscope laboratory BioBus), this researcher was able to classify this project a single case study (Yin, 2003). Furthermore, because this case study was delimited to the events that occurred aboard the BioBus within a specific time and place (Creswell, 2007), I was able to ensure its feasibility (Baxter & Jack, 2008).

Setting

Parked on the curb outside of each school that it visits, the BioBus (see Figure 5) cheerily awaits. A relic from another era, this one-time San Francisco transit bus, built in 1974 and still adorned with its original VW-bug style headlights, has had its exterior coated in bright yellow, orange, and powder blue paint; evoking images not too dissimilar from the magic school bus popularized by the children's book and animation series with same name.

Perched on top of the BioBus's roof and running from front to back are 9-solar panels and a small green roof. The bus, a working model of alternative energy sources, runs off of a waste-to-vegetable oil diesel engine that is stowed neatly below its rear liftgate.

Inside the bus, seats gutted, are two activity areas separated by a heavy maroon curtain. Directly behind the driver's seat, a wooden cabinet stands. Inside the closed doors are a number of batteries that are used to run the microscopes, cameras, and visual displays that are used by its visitors. On one side of the cabinet, the batteries' LCD lights can be seen blinking green through a large window that is framed by a yellow wooden cut-out of a *Daphnia*. Across from the battery compartment, standing guard at the top of the entrance stairs, sits a rather stout pellet-burning stove that is used to heat the bus on cooler days.



Students being welcomed to the BioBus at their school (top left) a photograph taken of a pregnant *Daphnia* using a stereomicroscope on the BioBus (top right) the two activity areas inside of the BioBus (bottom).

Figure 5. Images of the BioBus

Following the driver-side wall back towards the rear of the bus are three microscope stations (see Figure 5). Each microscope is framed within a metal scaffold and sits on top of a rectangular-shaped platform that allows it to be raised and lowered depending upon the height of expected visitors. Resting upon each platform is a research-grade stereomicroscope, each costing upwards of $35,000, with the unique ability to magnify a specimen from the macroscopic/organismal to cellular level (10X - 100X) quickly and crisply. Attached to each microscope, is a $10,000 HD-resolution color camera capable of transmitting live images of a specimen to a large digital monitor secured at the top of the scaffolding. Across from the microscopes is an empty, but windowed wall where students stand when first entering this part of the bus and welcomed by staff-scientist Dr. Wren.

At the back station of the bus, blue-topped vinyl benches wrap around the side and back walls in a U-shaped formation. Directly in front of and to the side of the curtain that separates the bus in half are two microscopes resting on rectangular tool chests (see Figure 5). A student seated on the rear bench of the bus that looks towards the left side of the curtain would see a $20,000 three color digital video fluorescence microscope with the ability to visualize DNA and cell organelles. That same student, when adjusting their gaze to their right, would see a $15,000 digital video phase contrast compound microscope that allows live-specimens to be viewed at the organelle level without staining. Attached to this set-up a similar camera as those found in the front of the bus transmits images to a large TV-monitor mounted directly above it. In between these two microscopes rests a small wooden stool that is used by Dr. Leslie when visitors are on board.

The BioBus experience begins. As students approached the bus they were greeted by Dr. Wren outside on the sidewalk. The din of a typical urban landscape; house sparrows chirping, cars passing by, helicopters and planes flying overhead, horns honking, and sirens wailing, were heard cycling through in the background. In many instances, community members from within the neighborhood stand or walk by in close proximity to the class assembled.

Soon after gathering outside the bus and when weather and temperatures were permitting, Dr. Wren facilitated a short conversation about the BioBus. During this time each class typically arranged itself in a haphazardly formed circle around Dr. Wren as he explained his reasoning for the BioBus's construction. The typical explanation that was given was twofold. First, students were told it was built to give them a "chance to go inside a real research lab" and utilize the same microscopes used by scientists to, "explore the world around us and try to figure out the answers to the questions we have." Students were also commonly told that the microscopes they would be using that day costed upwards of $30,000; garnering responses that ranged from silently raised eyebrows and smiles to hushed whispers and more emotive giggles.

Following the presentation of the bus's first purpose, students were then told the bus was also created to provide them with examples of alternative energy sources. At this point, students were asked to direct their attention to the roof of the bus and make observations. These observations typically came quickly and in rapid-succession and included questions ranging from what happens when the panels get wet to how the panels actually make electricity. Following a short discussion on the bus's solar panels and the mentioning that they provided the power source for the microscopes and other equipment they would be interacting with while inside the bus, students were asked to move towards the back. During this transition, students typically broke out into free-flowing conversation that, in some instances, took some time to settle down. When all class members were gathered at the rear of the bus, their attention was directed by Dr. Wren towards the small green roof overhanging the bus's rectangular window framed by two yellow tail fins. At this point, students and Dr. Wren entered a discussion about what a green roof is and why it might be beneficial. During these conversations, students participated at will, both answering and asking questions. On one occasion, Dr. Wren asked students to consider if they would rather be on the sidewalk or grass in the park during a hot summer day to draw attention to a green roofs heat-reflective properties.

At the conclusion of the green roof discussion, classes were split into two equally sized groups which ranged during researcher observations from from 9 - 14 students. Immediately following this, both groups clomped their way up the BioBus staircase, collected a clipboard and worksheet (see Appendix A) from the driver's seat and made their way to their group's assigned activity station (front or back). As students shuffled towards their seats in the back of the bus and assembled along the passenger side wall in the front, a general sense of excitement and wonder could be heard as students reacted to the environment they had just entered. Student responses ranged from quick emotive bursts, "Yo, yo, yo, yo, yo" to declarations like, "This is the coolest bus I've ever been in," and "Oh, snap this is so awesome." Other comments consisted of observations, "Oh, this bus is pretty big," and questions "Yo, where the seats at? and "Eww, what is that?"

When weather did not allow introductory discussions to take place outside, time was taken by Dr. Wren to introduce the aforementioned goals and detail the alternative energy sources of the BioBus at the front station of the bus. However, in these instances, despite the bus's solar panels and green roof being mentioned, the discussion focused on its pellet-burning stove. To begin, Dr. Wren held aloft one of the compacted-sawdust pellets that served as the fuel source for the stove. When this was done, the overlapping line of students along the wall of the bus often broke and soon resembled a football huddle with their attention directed towards the pellet-holding Dr. Wren. At this time, pellets were passed out to each student who, in turn, smelled, rolled, and brought each closer to their eyes for further inspection. During this time, laughter was often heard as students verbally shared their observations, "It looks like cat food," and asked sensory-based questions like, "Can we eat it?"

As students continued to observe their pellets, Dr. Wren explained how they were made of compacted sawdust and served as an example of how a waste product could be reused as a resource. In turn, this statement often led into a conversation on the differences between renewable and non-renewable energy sources. Dr. Wren often made comparisons between the way heat was being generated from the stove on the bus to how it was generated by oil in students' apartment buildings. Before transitioning into the microscope activity, Dr. Wren encouraged students to be a part of the solution to discover new ways to harness energy from renewable sources like solar panels and biofuels and in one instance was prompted to do so after a student asked, "Can oil be made in factories?"

***Daphnia* experience.** As Dr. Wren wrapped up his introductory discussion he transitioned to explaining the next activity students would participate in; exploring *Dapnia* with microscopes. Dr. Wren often began by mentioning that the animal that students would be working with that day could be found living in a puddle within a local park, to which in one instance I noted a student excitedly exclaimed, "Green lake park?" At this point, Dr. Wren held up a small vial that was illuminated by a flashlight over his head; inside was some water and one or two *Daphnia* swimming around. In some instances audible "oohs" and "ahs" could be heard as students crept closer to Dr. Wren and, in many instances, formed a circle around him and the vial he was holding aloft. Next, Dr. Wren turned students' attention to their worksheet and encouraged them to make observations and draw *Daphnia's* actual size in the space provided. Most, if not all students, followed this suggestion as the vial was passed around the recently formed circle. As student sketched the speck-sized *Daphnia,* groups conversed with each other and Dr. Wren, making observations about what they saw, “It’s small, like a grain,” and asking probing questions like, “How did you find this?”

As students finished their drawings, Dr. Wren guided groups of 3 to 5 towards one of the scaffolded microscope stations. As groups assembled, Dr. Wren shifted from one to the next, flipping on the visual display and pointing out the focus and zoom knobs to students as he went. As soon as video displays were turned on, images much larger than the small creature that students had just drawn could be seen (see Figure 5). At this time, across all observations, student discussions became much more animated and in some cases elicited gasps of surprise. Moreover, I noted that throughout the time students were using microscopes, conversations were free flowing and unstructured. As students took turns manipulating the controls of the microscope, their comments were reactionary, “Oh, wow,” “Right there, awesome, that looks awesome,” and “Eww!” observational, “I see the eyes,” and “It looks like it ate a bug,” inferential, “It looks like its trying to hatch,” and questioning, “What is that?” “Is that the heart?” and “Why do the eyes have the little circles?”

While student groups continued viewing *Daphnia* under the microscope, Dr. Wren encouraged them to adjust the zoom and focus knobs of each, move the specimen slide around the stage, and record observations and questions on their worksheet. Dr. Wren also challenged students to focus and zoom in on various body parts and then label them on their handout. However, when students attempted to do this, *Daphnia’s* body parts were not always easily recognizable and as a result debates and discussions often broke out within and across student groups. In one group, members challenged each other when trying to confirm whether or not they were looking at the *Daphnia’s* transparent heart. In these instances, students often shared the observation that the body part that they were viewing was beating while they pounded a closed fist against their chest.

After an initial 3 or 4 minutes of high levels of excitement during which students were often heard laughing and seen smiling and pointing at screens, student groups somewhat settled into the microscope activity. Throughout the next 10 or so minutes students continually labeled body parts, recorded observations and wrote down questions on their worksheets. Sometimes I noted students revising their labels as new observational evidence was discussed and common body part understandings made were agreed upon. I also noted, that in many, if not all cases, student conversations remained focused on the *Daphnia* activity at hand and did not drift off topic.

Every once in awhile, if an interesting observation like *Daphnia* excreting waste or carrying embryos was noted, Dr. Wren encouraged all students to focus their attention on a nearby group's display monitor. During these moments, I recorded that student groupings were able to shift fluidly from one microscope station to the next, contracting and expanding in size as observations, questions, and conversations developed. Additionally, I also noted that sometimes students chose not join to the larger group and remained engrossed in their own microscope station's display. In one instance, when the entire group had assembled to view a *Daphnia* that a student believed to be pregnant, a conversation that focused on what evidence the student had used to make this particular claim ensued. Immediately following this discussion, another student declared to the group assembled that the *Dapnia* they were viewing was a girl. Following this declaration, Dr. Wren informed the group that *Daphnia* and a lot of animals similar to it actually reproduced asexually. Interestingly, this revelation was met by a short pause in conversation that was eventually broken when a student stated, "I'm scared." However, I sensed that this statement did not reflect true fear as it was mentioned in a flippant and playful manner.

As students transitioned back to their assigned microscope stations, they were often often overheard encouraging each other to take turns adjusting their microscope's focus and zoom knobs. In one particular example, a student that was the first in their group to use the microscope instructed another classmate on how to move the *Daphnia* slide around on the stage and adjust the level of magnification. Some students even began explaining to their classmates at other microscope stations about what body part they were viewing; providing evidence for their conclusion along the way.

As the 12 to 15 minutes of time during which students were actively using microscopes came to an end, Dr. Wren asked each to return to the wall directly across from the stations. After transitioning, and letting out what during some observations amounted to a collective groan, students were asked to focus on one of the three digital displays. Next, Dr. Ben adjusted the microscopes zoom to the cellular level, focusing in on the *Daphnia's* eye, shell, or heart. During this time, I often noticed students slowly move towards the visual display and, in some instances, a circle formed around Dr. Wren and the microscope station. As students continued to gaze at the monitor, Dr. Wren explained that the second half of the BioBus experience would entail the viewing of cells.

At this point, students transitioned from the front of the bus to the back. This swap entailed having all students from the back of the bus form a line that sometimes stretched from the driver's seat at the front of the bus to the curtain through which they had just passed. This arrangement also brought both groups within close proximity to one another and I noted some students exchanging comments, tapping fists, and shaking hands during this time.

Exploring cells. Following this transition, students that were originally stationed in the front of the bus leisurely made their way towards the back, randomly taking seats and chatting with one another upon the U-shaped benches positioned along the side and back walls. Dr. Leslie, who stationed herself in front of the curtain, briefly introduced herself and often asked students what they had done during their time in the front of the bus. Student responses mainly centered on their experience using microscopes and looking at *Daphnia*, although during some observations, these conversations deviated widely off course due to student questioning. For example, during one observation a student wanted to know how closely related horses and donkeys were to one another.

Following this short transition, students were asked by Dr. Leslie to share what they already knew about cells. Here again, discussions varied widely from observation to observation with some groupings providing more details and asking more questions than others. However, I did note that each conversation always took place in an unstructured and relaxed fashion such that student comments were made without hands being raised.

After probing for students' background knowledge, Dr. Leslie segued to using the three microscopes at the back of the bus. The first microscope students were introduced to was hand-held and used to magnify the skin cells and various clothing fabrics worn by students. To capture images, Dr. Leslie called for student volunteers to place their hand or clothing underneath the microscope. When this was done, an image was displayed on the large TV-monitor that was mounted in front of the curtain separating the two sections of the bus. Invariably, when students first observed what was on display, they often responded by saying, "Wow," or "Cool," and on one occasion, I noted that a student said, "Science is life," twice in a row. Increased animation, laughter and smiles from both students and Dr. Leslie often accompanied the 1 - 2 minutes during which the handheld microscope was used. Additionally, it was noted that students typically leaned forward and shifted in their seats as they awaited a chance to see their clothing and skin displayed on the TV-monitor.

After a few students had been given the opportunity to see their clothing or skin displayed on the monitor under a magnification of 40X, Dr. Leslie introduced the next microscope on the bus. To do so, she again asked for student volunteers to help prepare a slide of cheek cells. Typically one or two students were selected to scrape the inside of their cheek with a Q-tip and then spread the collected cells onto a glass slide. After this was completed, Dr. Leslie placed the slide under the compound microscope that was stationed off to the right side of the curtain. Next, Dr. Leslie described how the microscope was set up and explained that it required light to visualize specimens. Once the microscope light was turned on, Dr. Leslie brought the cheek cells into focus. In some instances, she encouraged students to draw and describe what they were seeing under a magnification of 200X on their worksheets. While students were recording their observations, Dr. Leslie encouraged them to share what they were seeing with the group. During this time some group discussions were lively, while others were relatively muted. In once instance, I noted that a student stated, "I feel so comfortable--I don't want to leave."

After sharing observations, Dr. Leslie asked students if they were able to identify the nucleus of the cell, to which students responded with a mixture of answers. Then, Dr. Leslie zoomed in on one of the cheek cells to a magnification of 400X, asking for student recommendations of whether or not to add more light and when to focus on the cells as she went. Once a single cheek cell was brought into focus, Dr. Leslie again asked students to try to identify where the nucleus of the cell might be. At this point, many students began pointing to the screen and describing the location of where they thought the nucleus was to Dr. Leslie and the classmates seated around them.

Now that the cheek cell had been brought fully into focus and magnified to the greatest extent of the compound microscopes abilities, Dr. Leslie removed the slide and placed it under the fluorescence microscope positioned along the opposite wall. After locating a number of cells on this microscope that were also simultaneously displayed on a digital monitor, Dr. Leslie demonstrated to students how they could take a picture of the image they were seeing.

Next, Dr. Leslie removed the cheek cells and placed a prepared slide of a cow's heart cells on the microscope's stage. After the cells were brought into focus, Dr. Leslie passed around a wireless mouse and allowed students to stain the parts of the cells they were seeing by clicking on various parts of the microscopes display screen. First students highlighted the nucleus in blue, then the mitochondria in red, and finally the cell's cytoskeleton in green. Also during this time, I noted that students not using the mouse fixed their gaze on the microscope display as their classmates manipulated the cursor around the screen. Comments heard during this time included statements like, "Oh that's cool," and more general questions like, "What is that?"

Once the three aforementioned cell organelles had been made visible, Dr. Leslie combined what had been at first three separate images into one. When this was done all three organelles glowed red, blue, and green in one image and elicited audible student responses. During one observation, I overheard two students remark to each other, "Oh, that's fire." and "Yeah, that's wavy." While in another, students were witnessed bumping fists with each other and Dr. Leslie. From here, Dr. Leslie encouraged a student to zoom in on the image they had just taken in order for the group to be able to look closely at one cell. After a single cell came into focus, Dr. Leslie led a discussion about cell organelles. Of particular note here was the fact that students across multiple observations were often surprised by the sheer number of mitochondria in a cell, with one student remarking, "I thought there was just one."

When the brief discussion on cell organelles came to a close, Dr. Leslie had students guide her through the wet-mount preparation of an *Elodea* plant. Here again, student volunteers were asked to help first select a leaf and then prepare it on a slide for visualization under the compound microscope. As student volunteers helped prepare the slide, they were often encouraged to complete the task by their classmates. In a few instances, volunteers nervously approached and then suddenly backed away from the dripping *Elodea* sprig; causing their classmates to erupt in supportive laughter.

Once the wet-mount slide had been successfully assembled, Dr. Leslie placed it under the microscope and brought it into focus. In some instances before this occurred, students were asked to predict what they were about to see, with some groups being able to call out specific cell parts, while others made made more general comments. Moreover, what students could see when the *Elodea* specimen was brought into focus, included the cell wall, a nucleus, and green chloroplasts that were circulating throughout the cytoplasm. During one observation, students began sketching and making observations of what they saw without prompting while Dr. Leslie recorded a video on the microscopes computer.

For a final activity, and now that both plant cells and animal cells could be viewed side by side on separate displays, Dr. Leslie asked students to compare the differences between the animal and plants cells they were seeing. However, before this discussion began, Dr. Leslie sometimes asked a student in control of the fluorescent microscope to zoom-out in order to get images that could be more easily compared with one another. When this suggestion was made, I noted that in both instances, the student using the microscope's mouse was able to do the

requested task with ease. Additionally, during most observations, students were quite talkative, making comparisons that detailed the differences in the general shape and pattern of each cell type. In one observation, a student responded to multiple questions being asked by Dr. Leslie and gave her chest a slight pound with a closed fist each time she answered correctly.
Finally, as the 20-25 minutes of time at the back of the bus had elapsed, Dr. Leslie thanked students for visiting and told them that any photos they had taken would be given to their teacher. As students slipped off the bus, some lingered behind to take one last look at the images displayed across various monitors while others asked questions like, “Can we come back tomorrow and every single day?” and “Can this be school?”

Participants

Participants for this study were primarily selected using purposeful sampling from schools previously visited by the BioBus. Purposeful sampling is a common qualitative research technique in which “the inquirer selects individuals and sites for study because they can purposefully inform an understanding of the research problem and central phenomenon in the study” (Creswell, 2007, p. 125). Furthermore, by utilizing pre-existing contacts of the BioBus, collaboration and facilitation of logistics were made easier. In this way, the sampling technique of the study was also considered one of convenience.

All participants in this study attended schools located within a major Northeast metropolitan area that primarily serve high-needs students, as defined by the amount of Title 1 funding they receive. Typically, a school is classified as serving a high-needs population and, as a result, receives Title 1 funding if 75% of their students receive free or reduced lunch. A focus on urban schools that serve a large number of high-needs students also aligns with the population centered upon within the purpose, overarching framework, and literature review of this study, as well as the mission of the BioBus.

This study collected data from four classrooms in four different schools (2 middle schools and 2 high schools). A variety of schools and grade levels was chosen as a means to increase the transferability of the findings. More specifically, this study included urban youth from Grades 6, 8, 9, 11, and 12, with each grade (besides 11 and 12) representing a different school. That is, Grades 11 and 12 were lumped together as one given their relatively small number and the fact that they attended the same school and had the same science teacher. As a result, readers should note that Grades 11 and 12 from this point forward are referred to as Grade 11/12. That said, the purpose of focusing on schools serving secondary students (Grades 6-12) was to provide me with the ability to juxtapose this work to previous findings that have demonstrated a decrease in students' attitude towards science as age increases (Atwater et al., 1995; Barmby et al., 2008; Bennett & Hogarth, 2009; Breakwell & Beardsell, 1992; Finson & Enochs, 1987; Francis & Greer, 1999; George, 2000; Greenfield, 1996; Haladyna & Shaughnessy, 1982; Hasan et al., 1995) and to assess whether or not the BioBus was able to slow or reverse this trend.

Instrumentation

Yin (2003) highlighted six possible methods of data collection for case study research: documentation, archival records, interviews, direct observation, participant observation, and physical artifacts. Of the six data collection methods listed, this study utilized two methods: interview and direct observation. In addition, data for this study were also collected from a Likert-style survey and an open-ended response questionnaire. From the 239 students who comprised the survey and open-ended response questionnaire portion of this study, 32 students

(8 students per school) were chosen for interviews following their BioBus experience. Direct observations, one for each school visited by the BioBus, were also completed.

Of note here is that the instruments utilized for this study primarily collected self-reported data. Moreover, these forms of data, which are open to potential bias are "nonetheless frequently used in studying outcomes with affective and attitudinal components because of the subjective nature of these outcomes" (National Research Council, 2009, p.59). As a result, I have deemed that the instruments selected for this study were appropriate for collecting data that would adequately address this study's two research questions. Finally, the data collection instruments of this study were similar to those used by other researchers looking to explore interactions between the cultures of urban youth and school science within the third space (Moje et. al., 2004, Rahm, 2008)

Survey. The quantitative measure of this study utilized the Attitude Toward Science in School Assessment (ATSSA) (Germann, 1988). This 5-point Likert-style attitude survey was chosen to primarily address Research Question 1 (How did the attitude towards science of urban youth change following a BioBus experience?) and its associated subquestions. This particular attitude survey was selected over similar attitude instruments because of the high marks it received in a review of 20 attitude towards science surveys by Blalock et al. (2008). The ATSSA scored high with regard to its validity, dimensionality, and theoretical underpinnings. Furthermore, Cronbach's alpha during field-testing the ATSSA was reported as being greater than 0.95 (Germann, 1988). To that end, Blalock et al. (2008) encouraged "Teachers, administrators, and investigators . . . to use those instruments that have the strongest psychometric data to support their validity and application" (p. 973). Besides the psychometric strength of the ATSSA, this survey was also chosen for its short number of items (see Appendix

B) and resulting ease of administration. Additionally, the ATSSA's holistic and general application of attitude towards science allowed it to be applied across all grade levels and the respective science classes in which this study's participants were enrolled. It should also be noted that basic demographic information (i.e., age, gender, grade, and name of school and science teacher) was collected anonymously from each survey respondent. The survey itself was administered within one week prior to and one week following the BioBus experience. Additionally, this particular survey was selected over others measuring the myriad forms of attitude due to the participants selected for this study. That is, because this study's participants were drawn from a variety of different grade levels with each presumptively learning a different type of science (e.g. biology, chemistry, physics), a survey like the ATSSA that was capable of measuring a more holistic definition of attitude towards science was necessary.

Open-response questionnaire. Following the completion of the post-BioBus ATSSA, each respondent was asked to complete one additional Likert item (hereafter referred to as Likert item 15) and four open-ended written response questions (see Appendix D). Providing space for students to respond to their BioBus experience in this manner added another layer of depth to the quantitative survey and further enhanced the study's internal validity. A similar data collection method was utilized by Basu and Calabrese Barton (2007) in their analysis of student work artifacts during a critical ethnography of 6th and 7th grade low-income urban students. Interestingly, the majority of attitudinal research overlooks student open-ended response questionnaire data, instead favoring quantitative survey and qualitative interview data collection methods. In addition to providing insight into the utility of open-ended questionnaire responses within the attitudinal research domain, this data collection approach was chosen to address Research Question 2 (How did urban youth respond to their BioBus experience?) of this study.

A note on this study's survey. Before presenting other instruments utilized in this study, it is necessary to note how the pre- and post-BioBus surveys differed from one another. That is while the pre-BioBus survey consisted solely of the 14-item ATSSA, which had already been established as a valid and reliable instrument, the subsequent post-BioBus survey included a 15th Likert item and was then followed by 4 open-response questions. As a result, one should note that the alteration of the ATSSA from its original form may have disrupted its validity and, subsequently, may lead one to question the findings drawn from this instrument. However, despite these possible negative consequences, the post-BioBus survey addendums were deemed a necessary and worthwile risk to take as they added another analytical layer and triangulation point for this study. Furthermore, these additional items helped narrow the lens through which a student's attitude towards science was being seen. That is, the ATSSA was designed to capture a broad view of a student's attitude towards science, while Likert item 15 and the open-response questionnaire were utilzed to focus specifically on participants' feelings towards their mobile science lab experience.

Interviews. Merriam (2009) classified qualitative interview approaches (listed from least to most restrictive) as unstructured/informal, semistructured, or highly structured/standardized. More specifically, and somewhat parallel in nature, Tellis (1997) viewed interviews used for case study research as being open-ended, focused, and structured. Open-ended interviews allow me to probe broadly for an informant's opinion; focused interviews utilize a predetermined set of questions and are often used to confirm data collected from another source, while structured interviews typically come in the form of a demographic survey (Tellis, 1997).

The interviews conducted in this study utilized a mixture of focused and semistructured interview questions (see Appendix C). A focused approach was used as a means to further analyze changes in pre- to post-BioBus ATSSA scores as well as to clarify student responses collected from the open-response questionnaire. This latter aspect also served as a form of member checking for the ATSSA data. Additionally, a semistructured interview approach was utilized to help me respond to this study's second research question. Of note is that all interviews occurred in person, and were audio-recorded and transcribed verbatim. Finally, each interview took place within one month of a study participant's experience on the BioBus.

Observations. Direct observation, which requires an investigator to make a site visit in order to gather data (Tellis, 1997), was the primary observation approach utilized for this study. Merriam (2009) referred to this approach as *observer as participant*, where the researcher's observation activities are given preference over the role of participant.

Over the course of this study, I made four observations. One science class from each school was observed for the duration of its BioBus experience for approximately 45 minutes. During each observation, I followed one of two groups through both BioBus stations. In this way, I was able to enact the observer as participant approach detailed above. Observations began when scientists welcomed each class to the bus, gave them a short overview of its green technology (green roof, solar panels, pellet stove), and then continued in the front of the bus where students were given a demo on how to use research-grade microscopes before using them to view *Daphnia* for themselves. The same group observed at the microscope station was then followed to the back of the BioBus where the observation concluded at an investigation station. At this station, select students created slides of plant and cheek cells, under the guidance of a scientist, before seeing them magnified under a microscope and displayed on a TV monitor.

Of note is that the procedure detailed above was followed for all four BioBus observations. Additionally, all of this study's participants interacted with the BioBus's scientists in a similar manner. That is, the same BioBus staff scientists were placed at the same stations within the bus throughout the course of the study. In this way, the researcher was able to enact as much control as possible for these particular variables.

During each observation, highly descriptive field notes were taken with enough detail to allow "readers [to] feel as if they are there, seeing what the observer sees" (Merriam, 2009, p. 130). This level of detailed note taking was deemed important as the researcher, due to budgetary and time constraints, made only one observation for each school that the BioBus visited. However, any potential unfamiliarity with the setting of this study was of little concern, as I had multiple prior opportunities to observe and reflect upon student interactions within the BioBus. These past observations came from time I spent volunteering on the bus and five separate occasions (from five different years) in which the BioBus visited my classroom. Finally, issues of access and approval to make observations during a BioBus experience were also of minimal concern as I have a close professional relationship with the bus's staff scientists.

Soon after each observation, field notes were used to construct a written narrative and reflective commentary that I referenced throughout data analysis proceedings.

A summary of the instrumentation used for this study is provided in Table 2. This table displays the instrument used, when it was implemented during the study, and the number of participants from which data were collected.

Data Analysis

The data set of this study consisted of 239 pre- and post-BioBus ATSSA surveys analyzed using common statistical methods, as well as 233 responses to both Likert item 15 and a coded open-response questionnaire. Also, interviews from 32 participants were audio-recorded

Table 2

Data Collection Instruments

Instrument	Timeframe	*N*
Pre-BioBus ATSSA	Within one week prior to Biobus	239
Observations	During the BioBus experience	4[a]
Post-BioBus ATSSA	Within one week following BioBus	239
Likert item 15 and open-response questionnaire	Immediately following post-BioBus ATSSA	239
Interviews	Within one month of the BioBus experience	32[b]

[a]One BioBus observation was completed per school for all study participants.
[b]Eight interviews were completed for each grade level.

and transcribed, eight of which were subsequently aligned with the three components of this study's overarching theoretical framework using codes constructed *a priori*. Additionally, for each of the eight interview participants, individual case studies were constructed utilizing both quantitative and qualitative collected data. Finally, the four BioBus observations were utilized to create a setting narrative and provide empirically based reasoning for this study's theoretical framework.

Data were managed using the database application Dedoose. This management technique was selected because "Using a database improves the reliability of the case study as it enables the researcher to track and organize data sources" (Baxter & Jack, 2008, p. 554). Dedoose was chosen from among other data management software applications because it is specifically designed for qualitative and mixed-methods research, is web-based, and as a result is easily accessed, secure, and user-friendly. By consistently managing data in this way throughout the course of the data collection process, the case study database (Yin, 2008) or the case record (Patton, 2002) was constructed, thus enabling me to locate necessary data during a final intensive analysis (Merriam, 2009). A more thorough inspection of each data analysis procedure is discussed below.

ATSSA Survey

Pre- and post-BioBus ATSSA surveys were completed by a total of 239 students: 84 in Grade 6, 71 in Grade 8, 49 in Grade 9, and 35 in Grade 11/12. Upon completion of the pre- and post-BioBus ATSSA, a participant's "attitude score" was tabulated by adding up the total of each of the 14 Likert items (see Appendix B). For four items of the ATSSA (2, 7, 10, 14), the inverse of the reported Likert score was utilized to take into account the negative connotations associated with that particular item (e.g., Item 14 - Science is boring). The highest attitude score (if a respondent replied 5 - "strongly agree" to all survey items) was 70, whereas the lowest score possible was 14.

After both pre- and post-BioBus ATSSA attitude scores were tabulated, a "change in attitude towards science score" was calculated by subtracting each participant's pre-BioBus ATSSA attitude score from their post-BioBus score. In this manner, I determined whether or not the study's participants had a positive, negative, or neutral change in their general attitude towards science following a BioBus experience. Further analysis included the completion of paired, two-tailed t-tests at the whole sample, grade, change in attitude score (positive, negative, neutral), and extreme change in attitude score (+/- 2 *SD* positive, negative) levels. Finally, a series of item analyses for the latter two groupings were completed to assess uniformity across samples and consistency of instrumentation.

Likert item 15 and open-response questionnaire. To address Research Question 2 and determine how students responded to their BioBus experience, I conducted the following analysis. For Likert item 15 (The BioBus has made my attitude towards science more positive), the proportion of students who responded to each of the item's answer choices (1 - strongly disagree to 5 - strongly agree) was calculated for the entire sample and across each grade level. In addition, mean scores were utilized to triangulate student responses across grade level and type of ATSSA attitude change score (positive, negative, neutral).

The four-item, open-response questionnaire, as with the case of Likert item 15, was also analyzed to address Research Question two. Each open-response questionnaire item was coded for whether or not it implied a favorable BioBus experience. A sample of positive responses across grade level and type of pre- to post-BioBus ATSSA attitude change score is available in Appendix E. It should be noted that blind coding was used, such that the type of ATSSA attitude change score (positive, negative, neutral) was unknown to each coder when reading the responses of study participants. In this manner, a sum of positive and negative tallies for each type of ATSSA attitude change score (positive, negative, neutral) and extreme cases (+/- 2 *SD* positive and negative) was compiled. The interrater reliability score tabulated was excellent (Cohen's kappa = .97) and determined by providing an outside rater with a sample of this study's participants open-response questionnaire answers and asking them to categorize them as being either positive or negative.

Interviews

For this study, 32 interviews were conducted approximately one month following a participant's BioBus experience. Interview participants were selected to represent as broad a range of changes in student attitude towards science following a BioBus experience as possible. For this to occur, results from the ATSSA survey at each grade level were utilized in three ways.

First, each participant's initial attitude towards science (positive/negative) was determined by referencing his or her pre-BioBus ATSSA attitude score (14-70). Participants were viewed as holding a negative attitude towards science if their pre-BioBus ATSSA attitude score was between 14 and 42, whereas students with a positive attitude towards science fell within the ATSSA range of 43 to 70. This particular cutoff was determined subjectively and should be questioned as to whether or not it accurately reflected the true attitude towards science of a participant. However, this study's purpose was more concerned with overall changes in attitude towards science and not necessarily assessing if a participant possessed one that was positive or negative. As a result, the aforementioned cutoffs were carried out with the intent to create a pool of interview participants with as large of a variety of attitudes towards science as possible. Additionally, the aforementioned cutoff was applied consistently throughout the interview selection process for each grade represented herein.

Once the initial attitude towards science groupings had been constructed, changes (positive/negative) in pre- to post-BioBus ATSSA attitude scores were utilized to create a second division. That said, students exhibiting zero pre- to post-BioBus ATSSA change were removed from the interview selection pool. Here again, the reason these participants were removed was due to the purpose of this study being to examine changes in the attitude towards science of urban youth after a BioBus experience.

From the four groups created by the above process, a final division of each was completed when examining the magnitude (small/large) of each participant's change in pre-/post-ATSSA attitude score. Small and large changes in pre-/post-BioBus ATSSA scores were determined at each respective grade level by splitting in half the number of participants within each of the four groupings. When finished, one participant from each of the eight groupings across each grade level was selected at random for an interview. In sum, each interview participant was sorted by their initial pre-BioBus attitude towards science (positive/negative), change in pre-/post-BioBus ATSSA score (positive/negative), and the size (small/large) of the change in pre-/post-BioBus ATSSA score.

Coding of interviews. The coding process can be approached in myriad ways. For case study research, Yin (2008) suggested choosing from among the following approaches: pattern-matching, explanation-building, and time-series analysis. Regardless of the data analysis approach chosen for case study research, "Conveying an understanding of the case is the paramount consideration in analyzing the data" (Merriam, 2009, p. 203). For this study, I utilized a pattern-matching approach. Pattern-matching (Yin, 2008), which can also be viewed as the constant comparative method (Glaser & Straus, 1967), has been argued to be one of the most desirable strategies for case study analysis (Trochim, 1989). Among the advantages of using the inductive pattern-matching or constant comparative approach for case study research is the opportunity to link empirical findings to theoretically predicted outcomes (Campbell, 1975; Tellis, 1997). Furthermore, if predicted patterns match those drawn from collected data, the internal validity of the study is enhanced (Tellis, 1997).

This study utilized the "lean coding" technique recommended by Creswell (2007). According to Creswell, this technique entails the creation of a short list of codes that are gradually expanded upon throughout the data analysis process and then winnowed down to themes or findings. For this study, the "lean coding" technique was applied in conjunction with the aforementioned pattern-matching process. In this way, a short list of *a priori* codes was aligned with the three components of this study's overarching framework.

It has also been suggested that coding categories come from three different sources: the researcher, the study's participants, and outside sources such as pre-existing literature (Merriam, 2009). In this instance, the initial short list of codes utilized was informed by the theoretical framework, research purpose, and research questions of this study. By emphasizing researcher-generated categories, I hoped to avoid constraints that can occur in borrowing the categories from outside sources (Merriam, 2009). The predetermined categories, or *a priori* "lean codes," were as follows.

1. attitude towards science prior to BioBus experience;
2. memorable aspect of BioBus experience;
3. stated change in attitude or perception towards science due to BioBus experience;
4. stated change in classroom behavior; and
5. stated connection of the BioBus to one's lived experience.

The pattern-matching and "lean coding" data analysis approach outlined above was utilized to construct individualized case studies for 8 of the 32 student interviews. Limiting the study in this was necessary due to the need to make this study more feasible. However, despite this limitation, I am confident that the in-depth case studies created from this data analysis approach were sufficient enough to draw meaningful conclusions. Moreover, only those participants demonstrating extreme changes (one positive, one negative) in pre- to post-BioBus ATSSA scores were ultimately selected for interview at each grade level. For clarification, an extreme case was considered to be an ATSSA change score greater than +/- 2 *SD* and was determined independently for each respective grade level. Also, when there was more than one potential interview candidate who met the selection criteria outlined above, an individual was chosen at random. Additionally, this particular approach was utilized to help address a subcomponent of Research Question 2 and critically analyze those participants whose attitude towards science was most greatly impacted by a BioBus experience. Finally, in the instance where there were no "extreme cases" available for interview (i.e., Grade 8 extreme negative ATSSA attitude change), the participant with the largest pre-/post-ATSSA attitude change score was selected. Following coding, interrater reliability for the lean codes utilized was determined to be borderline good/excellent (Cohen's kappa = .80). This score was determined by allowing an outsider rater to apply the aforementioned codes to a sample of the interview excerpts found within the constructed case studies in Chapter 4.

As alluded to earlier, purposeful and critical attempts were made during coding to connect student interview responses to the overarching theoretical framework of this research. As a result, the five *a priori* "lean codes" were aligned with three components of the theoretical framework constructed. The first theme to emerge detailed a participant's relationship to science before a BioBus experience and allowed me to determine whether or not one could be characterized as an outsider to the culture of school science. To do so, the resercher looked for comments within a participant's interview transcript that would indicate that they did not like science prior to their BioBus experience. The second theme, highlighting participants' most memorable BioBus experiences, was viewed as instances of third space sponsorship to the culture of school science. Finally, the third theme viewed instances of social capital transfer and enactment as changes in participants' attitude towards or perception of science following a BioBus experience. More specifically, social capital transfer was seen as having occurred when interview participants linked positive changes in their actions within the science classroom or lived experience to their time on the BioBus. For a better idea of how the *a priori* “lean codes” were connected to this study’s theoretical framework, see Table 3.

Observations

Soon after each observation, notes that were recorded in my field journal were copied into an electronic document. Next, I read through the notes from each observation and made comments along the margins. When finished a reflective summary was written. Following this step, I cross-referenced each of the four observations completed to construct the case setting narrative detailed in Chapter 3. When this was done, I attempted to recreate a timeline of events and provide readers with an accurate representation of some of the comments and interactions that they would have heard or seen during a typical BioBus experience. Indeed, my goal was as recommended by Merriam (2009) to provide readers with the feeling that they had witnessed the BioBus experience themselves.

Once the description of the study’s setting had been completed, the constructed narrative was used to determine whether or not the BioBus could a) be characterized as an informal science education setting, and b) serve as an example of a third space. To determine whether or not the BioBus was an informal science education setting, I utilized a sampling of terms from the informal science learning word cloud displayed in Figure 4. The terms selected primarily focused on those that were the largest in size and, in turn, indicative of the frequency in which they were used by researchers to describe informal science learning. These terms included: voluntary, learner-led, unstructured, open-ended, non-threatening, non-evaluative, and social. Next, utilizing the study setting narrative that was created, instances in which I thought the BioBus experience aligned with each aforementioned descriptor were collected. In this way I

Table 3

A priori "Lean Codes" and Theoretical Framework Components

Codes	Component of Theoretical Framework
1. Attitude towards science prior to BioBus experience	1. Outsider status to the culture of school science (code 1)
2. Memorable aspect of BioBus experience 3. Stated change in attitude or perception towards science due to BioBus experience	2. BioBus acts as third space sponsor to culture of school science (codes 2 and 3)
4. Stated change in classroom behavior 5. Stated connection of BioBus to lived experience	3. Evidence of social capital transfer and enactment (codes 4 and 5)

implemented an analysis approach similar to the pattern matching and constant comparative method mentioned above. However, due to the subjective, contentious, and unclear consensus in the field that surrounds what learning within informal settings entails, traditional assessment of reliability were deemed inappropriate. Instead, I used my own experience and views as a researcher-practitioner to outline my reasoning for when a BioBus experience could and could not be considered an informal science learning experience in Chapter 4. In addition, readers were also provided with a highly descriptive setting narrative in Chapter 3 so they would be able to make their own assessments on this matter.

To determine whether or not a BioBus experience could be viewed as a third space, I first heeded the recommendation of Soja (1996) that these settings be viewed as both social and physical in nature. Additionally, to help simplify data analysis, only a few of the many interpretations of the third space were utilized. In particular, I combined Bhabha's conceptualization that third spaces are "in between spaces" and Moje et. al.'s (2004) classification of these settings being able to navigate and build bridges between marginalized youths' home and school environs.

With this analytical lens in mind, I utilized the narrative that detailed the setting of a BioBus experience (see Chapter 3) to gather examples of the social and physical instances during which a student's home and school worlds may have been in between, navigated, or bridged. Additionally, due to the abstract nature of what the third space entails, the research did not utilize traditional reliability measures. Instead, I relied upon my insider's stance to provide a thick and rich description (Lincoln & Guba, 1985; Merriam, 2009) that outside readers could then use to assess whether or not the findings drawn from this study's setting description matched the collected data.

Observational data was also utilized to assess how this study's participants responded to the BioBus. To do this I returned to my field notes and looked to detail how participants interacted with scientists, the BioBus's scientific equipment, and each other. The purpose of this analytical approach was to not only gauge the level of interest and engagement students had during their experience, but also to identify where, when, and why attitudes towards science may have changed. More specifically, I looked for examples of on and off-task behavior, instances of both social (i.e. questions and conversation) and physical (e.g. body language, equipment manipulation) student participation, as well as other general indicators of engagement and interest (e.g. level of student activity, general noise levels).

Table 4 is a summative matrix of this chapter up to this point, and can be used to see how this study's data collection instruments, data analysis techniques, and research questions aligned.

Table *4*

Research Question, Instrument, and Data Analysis Matrix

Research Question	Instrument	Data Analysis
1. How did the attitude towards science of urban youth change following a BioBus experience? a. What changes occurred for the entire sample? b. What changes occurred at each grade level? c. What changes occurred for extreme cases at each grade level?	ATSSA survey	t-tests
2. How did urban youth respond to their BioBus experience?	Likert item 15	Mean responses
a. How did responses differ among grades?	Interviews	Lean coding, pattern matching
b. How did responses differ among positive, negative, and neutral groupings? c. How did responses differ between positive and negative extremes?	ATSSA survey	Extreme positive/negative attitude change score groupings
	Open-response questionnaire	Tallying of positive student responses
	Observations	Cross-referencing, pattern matching, thick-rich description

Rigor

> Validity . . . is a goal rather than a product: it is never something that can be proven or taken for granted. Validity is also relative: It has to be assessed in relationship to the purposes and circumstances of the research, rather than being a context-independent property of methods or conclusions. (Maxwell, 2005, p. 105, in Merriam, 2009, p. 215)

Internal Validity

The purpose of internal validity helps ensure that a study's findings are congruent with reality and that researchers are actually measuring what they believe they are observing (Merriam, 2009). Internal validity, also referred to as credibility (Lincoln & Guba, 1985) within some qualitative research circles, is often seen as a strength of qualitative research. This relative strength stems from the researcher having a closer connection to the subject being observed or interviewed than would be possible through quantitative data collection instruments. Two of the most common internal validity strategies within qualitative research are triangulation and member checks.

Triangulation, popularized by Denizen (1978), may be the most common internal validity strategy utilized by researchers carrying out qualitative research. Internal validity via triangulation is accomplished by comparing or cross-checking data collected at different times and places (Tellis, 1997). Within the context of this study, it means looking for common observations and themes among interviews, the setting narrative, ATSSA survey data, and responses to Likert item 15 and the questionnaire. Following comparison, if all three sources of data appear to reinforce one another, as was the case in many instances herein, one can argue that the findings of the study have internal validity.

Another internal validity strategy often used within qualitative research entails member checking. Member checking is the practice in which a researcher shares with the participants of a study their preliminary findings, thus providing each participant the opportunity to confirm or clarify the researcher's interpretations (Baxter & Jack, 2008; Merriam, 2009). Applied to this study, member checks occurred during student interviews. More specifically, I asked each interview participant to clarify his or her open-ended questionnaire responses and level of agreement with Likert item 15.

In addition to triangulation and member checking, three other internal validity strategies were utilized within this study. The first strategy, adequate engagement in data, has the intention of making a study able to acquire a level of saturation where no new observations are surfacing and alternative explanations to a phenomenon become unlikely (Merriam, 2009; Patton, 2002). That said, I am confident that the variety of data collection instruments utilized and the evidence they yielded were thorough enough to answer this study's research questions satisfactorily.

Another internal validity strategy utilized in this study was reflexivity or the researcher's position. Reflexivity is the process of a researcher explaining his or her biases, assumptions, and positionality in order to provide readers with a better understanding of how conclusions and data interpretations were made (Merriam, 2009). Within this study, reflexivity was an ongoing process that occurred throughout data collection and analysis in the form of a researcher journal. Furthermore, biases are addressed in a separate section below.

A final internal validity strategy used in this study was the peer review process. In this study, the peer review process was ongoing. To date, I utilized the peer review process when presenting the initial proposal of this study, in reviewing drafts of this work with the Teachers College Graduate Writing Center, presenting before fellow doctoral students, engaging in critical conversations both in person and electronically with advisors, hiring outside editors to review this work, and successfully completing my oral defense of this dissertation. In the future, I also plan on furthering the peer review process when submitting various elements of this work for publication in journals.

External Validity

While internal validity has been highlighted as being a strength of qualitative research, some see external validity, or the applicability of findings from one setting to others, as a weakness of this methodology (Johnson & Onwuegbuzie, 2004; Merriam, 2009). Criticisms of external validity also extend to qualitative case study research. In particular, case study research is criticized for having little applicability to real life (Tellis, 1997). Despite this perceived weakness, others have argued that external validity is inappropriate for qualitative research, using alternative terms like working hypotheses (Cronbach, 1975), transferability (Lincoln & Guba, 1985), extrapolations (Patton, 2002) dependability (Merriam, 2009), and naturalistic generalization (Stake, 1995) to emphasize the more holistic nature of qualitative research. Furthermore, supporters of these forms of external validity believe that the small number of participants and highly contextualized findings of qualitative research serve as the reason to examine a particular phenomenon in detail (Merriam, 2009).

While debates over the appropriateness of applying external validity to qualitative research continue, researchers can draw from a number of recognized strategies to enhance this form of validity. Perhaps the most commonly used strategy is the thick and rich description or "highly descriptive, detailed presentation of the setting and in particular, the findings of a study" (Merriam, 2009, p. 227) accompanying qualitative research. Furthermore, by providing a large number of details, readers of the research can make their own connections between the setting of the study and their own reality (Merriam, 2009). In this way, the lessons learned by the readers satisfy external validity requirements.

Within this study, I attempted to provide a rich and thick description when addressing all research questions and especially when crafting the eight case studies for participants exhibiting extreme changes in their attitude towards science following a BioBus experience. To do so, the most appropriate and meaningful excerpts from the interviews were highlighted along with the incorporation of data from all other instruments. As a result, readers were given an accurate portrayal and understanding of the various stances and feelings of each participant towards science and his or her BioBus experience. Moreover, the themes pulled from the student interviews were connected to the overarching theoretical framework of this study and allowed readers to follow my line of reasoning and subsequent conclusions.

While providing a rich and thick description was a stated goal of this study and on display throughout, I also utilized other external validity strategies. In particular, by examining the interactions of students, scientists, and teachers within the novel research setting of the BioBus, I added to the body of work completed in other informal science education settings like museums, science centers, and aquariums. In this way, the informal science education field as whole is broadened and external validity is enhanced.

A final external validity strategy that was implemented in this study was the use of maximum variation sampling. Given the constructs of the study, the maximum variation of the study's participants was satisfied through a survey and interviews with students in a variety of grades (6, 8, 9, 11/12). To that end, interview participants were comprised of both males and females. Finally, I attempted to represent as best a diversity of opinions as possible by interviewing students who exhibited both positive and negative changes in their attitude towards science following a BioBus experience,

Reliability

Traditionally, reliability “is the extent to which research findings can be replicated. . . . if the study is repeated would it yield the same results?” (Merriam, 2009. p. 221). However, this form of reliability can be problematic with qualitative social science research because human behavior is constantly changing and reality is viewed from a pluralistic, not a singular stance (Merriam, 2009). As a result, qualitative research is not necessarily concerned with whether or not any particular results can be replicated, but more so with whether or not the findings of a study match the data collected (Merriam, 2009). In this way, the results of a study can be viewed as being dependable or consistent (Lincoln & Guba, 1985). To that end, I made every attempt to ensure that the conclusions drawn from this study aligned with the data collection and analysis process. This was accomplished via the utilization of an iterative approach throughout this research and, in particular, during the construction of this study’s conclusions.

Reliability was also enhanced within this study via the internal validity strategies highlighted above (triangulation, peer review, reflexivity, member checks) and through the use of an audit trail (Lincoln & Guba, 1985). An audit trail consists of an independent reader concurring with the researcher’s findings, transparent data collection reporting and analysis, and a running record in the form of researcher diary or log detailing the history of a project (Merriam, 2009). As suggested by Merriam (2009), my diary was used to aid the data collection process, flesh out the manner in which decisions were made about data analysis, reflect upon thoughts and ideas, and record the ongoing interactions of the researcher with the data that were collected.

Ethical Considerations

The rigor of any study, and in particular case study research, is influenced by the ethics of the researcher and dependent upon researcher-participant relationships (Merriam, 2009). As a result, care was taken during the data collection process to ensure that all participants had informed consent and privacy and protection from harm. Interview questions were crafted to be of the low-stakes variety in order to avoid feelings of participant invasion of privacy, embarrassment, and any negative effects. Furthermore, all attempts were made to conduct observations as discreetly as possible.

Assumptions

A few assumptions were made during this study. First it was assumed that all participants responded to surveys, questionnaires, and interview questions in an open and honest manner. To ensure that trustworthy responses took place, the study's participants were assured that their responses would be kept confidential and not be linked to them directly. Furthermore, the study's participants were informed that they were able to drop out of the study at any time.

Second, it was assumed that the study's sample was representative of urban youth. To aid the likelihood of this occurrence, the participants in this study represented four different grade levels from four different schools.

Summary of Chapter 3

Chapter 3 outlined the methodology of this study. More specifically, the researcher decided that a case study approach using both qualitative and quantitative data would best address this study's two research questions. Following the detailing of a rationale for this approach, the instrumentation of this study was presented (see Table 3) and was followed by an outline of the researcher's data analysis approaches (see Table 4). Finally, issues of rigor, reliability, validity, and bias were broached.

CHAPTER 4: FINDINGS

This chapter presents the data that were collected from pre- and post-BioBus ATSSA surveys, Likert item 15, an open-response questionnaire, and interviews. In addition to the figure and various tables presented, a brief description of the general trends and findings is provided in accordance with their corresponding research question. The chapter concludes with eight case studies that were crafted using all three aforementioned data collection methods.

Findings—Research Question 1

What changes occurred in students' attitude towards science before and after a BioBus experience?

What changes occurred at the each grade level?

What changes occurred for extreme cases at each grade level?

The findings associated with Research Question 1 begin with a display of this study's most coarse-grained analysis, namely changes in attitude towards science (ATSSA) scores according to grade level (see Table 5). Following this display, a more fine-grained analysis is presented. That is, changes in ATSSA scores for participants are sorted by grade level and type of change (positive, negative, neutral) in Table 6. Next, an item analysis of the entire sample's ATSSA responses is presented in Table 7 for the purposes of measuring consistency and uniformity of scores across grade level and type of attitude change. Next, results for participants exhibiting extreme changes in ATSSA scores (+/- 2 *SD*) are presented in Table 8 and sorted by grade level and type of attitude change (positive/negative). The final table, Table 9, associated with Research Question 1 is an item analysis of those participants exhibiting extreme changes in pre- to post-BioBus ATSSA scores and completed for reasons similar to those mentioned above for the entire sample.

Table 5

ATSSA Scores Before and After a BioBus Experience by Grade

	Pre-Test		Post-Test				
Grade	*M*	*SD*	*M*	*SD*	Δ*M*	*p*	*d*
6[a]	49.2	10.7	50.3	10.7	1.1†	0.081	
8[b]	49.3	10.9	50.8	11.8	1.5†	0.096	
9[c]	46.1	10.9	47.2	10.4	1.1	0.246	
11/12[d]	49.1	10.0	48.2	11.3	-0.9	0.388	
Entire Sample[e]	48.5	10.7	49.5	11.1	1.0*	0.029	0.141

[a]$N = 84$ [b]$n = 71$ [c]$n = 49$ [d]$n = 35$ [e]$n = 239$
† $p < .10$ *$p < .05$

Table 5 displays changes in mean ATSSA scores before and after a BioBus experience for the entire sample ($N = 239$) and across grade levels. When examining the entire sample via a paired two-tailed t-test, the positive change of 1.0 was deemed to be statistically significant (p < .05) with a small effect size ($d = 0.141$). Additionally, when the entire sample was sorted by grade level, 3 of 4 (6, 8, and 9) showed positive pre- to post-BioBus attitude towards science changes while 1 of 4 (grade 11/12) showed a negative change. With that said, no grade level's pre-/post-BioBus changes were statistically significant, although Grade 6 and 8 changes were statistically significant at the p < .10 level. By contrast, significant changes were found when the data were analyzed by grade and type of attitude change (Table 6).

Table 6

Pre- and Post-BioBus ATSSA Scores by Grade and Type of Attitude Change

Grade	Type of ATSSA Attitude Change	*n*	% of *n*	Pre-Test *M*	Pre-Test *SD*	Post-Test *M*	Post-Test *SD*	Δ*M*	*d*
6	Positive	41	48.8	47.7	10.5	53.4	9.7	5.5***	1.4
	Negative	34	40.5	51.0	9.7	46.9	9.9	-4.1***	1.2
	Neutral	9	10.7	48.9	15.0	48.9	15.0		
8	Positive	31	43.7	48.4	11.3	56.0	9.7	7.6***	1.2
	Negative	36	50.7	49.4	10.9	45.7	11.9	-3.7***	1.5
	Neutral	4	5.6	56.3	6.6	56.3	6.6		
9	Positive	25	51.0	44.0	9.8	49.8	8.3	5.8***	1.2
	Negative	17	34.7	46.5	11.4	41.1	10.1	-5.4***	1.4
	Neutral	7	14.3	52.6	12.2	52.6	12.2		
11/12	Positive	12	34.3	48.3	9.8	54.0	9.4	5.7***	1.3
	Negative	18	51.4	50.3	10.7	44.7	11.9	-5.6***	1.8
	Neutral	5	14.3	47	9.0	47	9.0		
Entire sample	Positive	109	45.6	47.1	10.5	53.4	9.5	6.3***	1.2
	Negative	105	43.9	49.6	10.5	45.2	11.0	-4.4***	1.4
	Neutral	25	10.5	50.7	11.9	50.7	11.9		

***$p < .001$.

Sorting data, as displayed in Table 6, was deemed necessary because findings from the initial analysis of this study's entire sample were inconclusive. As a result, participants were grouped by the type change in attitude towards science exhibitied from pre- to post- BioBus experience and grade level. When this was done, it was revealed that positive and negative groupings for the entire sample displayed relatively similar pre-BioBus attitude towards science means (47.1 and 49.6, respectively). Moreover, there was a near even split between participants exhibiting positive and negative changes in their attitude towards science (45.6% and 43.9%, respectively) following a BioBus experience. Additionally, when the entire sample's positive and negative groupings were analyzed individually via a paired two-tailed t-test, each demonstrated statistically significant ($p < 0.001$) attitude changes with large effect sizes, ranging from 1.2 to 1.8.

Within Table 6, participants displaying positive and negative (as well as neutral) groupings were also matched to their corresponding grade level. When completed, this sort demonstrated that all positive/negative groupings across all grade levels had statistically significant changes ($p < .001$) in their attitude towards science with large effect sizes. To that end, it was also determined that lower grade levels (6, 8, and 9) had a higher percentage of students with positive pre- to post-BioBus ATSSA change scores (48.8%, 43.7%, and 51%, respectively) than grade 11/12 (34.3%). Conversely, these same lower grade levels had a smaller percentage of students with negative attitude change scores (40.5%, 50.7%, and 34.7%, respectively) in comparison to Grade 11/12 (51.4%), although with a less clear distinction. Moreover, neutral groupings, which represented participants with unchanged ATSSA scores following a BioBus experience, were more prevalent in Grades 9 and 11/12 (14.3% and 10.7%, respectively) than Grades 6 (10.7%) and 8 (5.6%).

Finally, more nuanced findings drawn from Table 6 include the finding that the initial differences between pre-BioBus attitude scores for positive and negative groupings across all grade levels were relatively similar. That is, the largest difference between positive/negative pre-BioBus ATSSA means was 3.3 in Grade 6. Also of note is that across all grade levels, the pre-BioBus means of negative attitude change participants were initially higher than those with positive changes, before reversing this relationship following a BioBus experience. Finally, it is worth noting that Grade 8 and 9 neutral groupings on average held relatively higher pre-BioBus ATSSA scores (56.3 and 52.6, respectively) than the positive and negative groups within each respective grade.

Within Table 7, uniformity and consistency across groupings were determined for each post-BioBus ATSSA survey item. (For a list of items, see Appendix B.) That is, an attempt was made to determine if positive groupings typically demonstrated the highest attitude scores for each survey item and if the converse was true for negative groupings. First, when all groupings (positive, negative, and neutral) were analyzed, it was determined that positive groupings had the highest mean across all grade levels for each ATSSA item 63% of the time.

In comparison, negative groupings held the lowest item mean 75% of the time. Additionally, in all but one instance, a lack of consistency was due to neutral participant groupings within each grade level, which typically had relatively higher pre-BioBus means and low sample sizes (see Table 6). Next, a similar analysis as the one described above was also completed, but this time with the neutral grouping removed. When completed, positive item means were higher than the means of all but one negative grouping (item 7 in Grade 6).

Survey item outliers were determined independently for the entire sample and each grade using the data displayed in Table 7. That is, the .75 *SD* value used to determine item outliers was set using the absolute difference between positive and negative means for each grouping under analysis. Once outlier values were set it was revealed that the entire sample had only one such

Table 7
Entire Sample Post-BioBus ATSSA Item Analysis

		Post-BioBus Attitude Towards Science in School Assessment (ATSSA) Survey Item Means													
Grade	Type of ATSSA Attitude Change	1	2	3	4	5	6	7	8	9	10	11	12	13	14
6	Positive	4.02	4.07	3.74	3.93	3.02	3.81	3.74	4.07	3.86	3.88	3.67	3.83	3.50	3.98
	Neutral	3.44	3.67	3.33	3.22	2.78	3.67	4.00	3.56	3.67	4.11	3.44	3.33	3.11	3.56
	Negative	3.38	3.82	3.09	3.32	2.56	3.35	3.88	3.15	3.59	3.59	3.12	3.32	3.12	3.62
	+/- Difference	0.64	0.25	0.65	0.61	0.46	0.46	0.14	0.92 [a]	0.27	0.29	0.55	0.51	0.38	0.36
	.75 *SD*	0.82	0.70	0.83	0.81	1.04	0.76	0.88	0.81	0.80	0.95	0.79	0.81	0.85	0.81
8	Positive	4.10	4.06	3.90	4.13	3.26	4.00	4.39	4.10	3.94	4.16	3.81	3.94	4.06	4.19
	Neutral	3.75	4.25	4.25	4.00	3.50	4.00	4.50	4.00	4.00	4.00	4.00	3.75	4.00	4.25
	Negative	3.47	3.56	3.25	3.19	2.64	3.33	3.67	3.22	3.22	3.42	2.97	3.19	3.19	3.44
	+/- Difference	0.62	0.51	0.65	0.93 [a]	0.62	0.67	0.72	0.87 [a]	0.71	0.74	0.83	0.74	0.87 [a]	0.75
	.75 *SD*	0.75	0.80	0.78	0.79	0.99	0.70	0.87	0.86	0.83	0.91	0.93	0.87	0.76	0.84
9	Positive	3.52	3.68	3.52	3.72	3.20	3.40	4.04	3.40	3.48	3.80	3.36	3.52	3.52	3.68
	Neutral	3.86	3.86	4.14	3.57	3.57	3.71	3.86	3.57	3.86	4.00	3.71	3.43	3.57	3.86
	Negative	3.24	2.88	3.47	2.94	2.12	2.94	3.12	2.94	2.94	3.12	2.94	2.88	2.94	2.65
	+/- Difference	0.28	0.80 [a]	0.05	0.78 [a]	1.08 [a]	0.46	0.92 [a]	0.46	0.54	0.68	0.42	0.64	0.58	1.03 [a]
	.75 *SD*	0.64	0.73	0.50	0.74	0.74	0.77	0.81	0.67	0.66	0.83	0.63	0.64	0.60	0.71
11/12	Positive	3.83	4.25	3.67	4.08	3.08	3.92	4.33	4.00	3.83	4.17	3.58	3.67	3.67	3.92
	Neutral	3.40	4.00	3.40	3.60	3.00	3.00	4.00	3.00	3.20	4.00	3.20	2.80	2.40	4.00
	Negative	3.28	3.61	3.17	2.89	2.67	3.06	3.72	3.11	3.17	3.50	2.61	3.11	3.22	3.44
	+/- Difference	0.56	0.64	0.50	1.19 [a]	0.42	0.86	0.61 [a]	0.89 [a]	0.67	0.67	0.97	0.56 [a]	0.44	0.47
	.75 *SD*	0.58	0.70	0.72	0.82	0.79	0.78	0.82	0.67	0.80	0.90	0.90	0.80	0.70	0.87
Entire Sample	Positive	3.92	4.00	3.73	3.96	3.15	3.79	4.06	3.92	3.80	3.98	3.64	3.78	3.70	3.97
	Neutral	3.60	3.88	3.72	3.52	3.16	3.60	4.04	3.52	3.68	4.04	3.56	3.32	3.24	3.84
	Negative	3.37	3.54	3.22	3.14	2.53	3.23	3.66	3.13	3.29	3.44	2.95	3.17	3.13	3.37
	+/- Difference	0.55	0.46	0.51	0.82 [a]	0.61	0.56	0.40	0.78	0.51	0.54	0.69	0.61	0.56	0.60
	.75 *SD*	0.74	0.76	0.74	0.79	0.93	0.75	0.85	0.79	0.79	0.90	0.82	0.80	0.76	0.84

[a]Difference between positive and negative groups is greater than the .75 *SD* value of the items combined positive and negative participants.

outlier; item 4. However, when each grade level was analyzed separately, a somewhat different finding emerged. That is, while Grade 6 had only one item outlier (item 8), Grade 8 had three (items 4, 8, and 13), Grade 9 had five (items 2, 4, 5, 7, and 14), and Grade 11/12 had four (items 4, 6, 8, and 11). Interestingly, two items (4 and 8) were determined to be outliers across three different grade levels. More specifically, item 4 was determined to be an outlier for Grades 8, 9, and 11/12 while item 8 was an outlier in Grades 6, 8, and 11/12.

Table 8 was constructed by aligning the type of extreme change exhibited by participants with grade level. When analyzed, it was found that more participants displaying any type of positive attitude change were considered extreme cases than those exhibiting any type of negative change. Indeed this pattern was seen for the entire sample and across all grade levels.

Another trend recognized within the data displayed in Table 8 is that changes in mean ATSSA scores were greater for the extreme positive groupings than the extreme negative groupings for the entire sample and across all grade levels. Also of note is that for all grades except Grade 8, where positive and negative groups started within 0.8 points of one another, extreme negative pre-BioBus means were greater than extreme positive means. Moreover, following a BioBus experience, this trend reversed; that is, all extreme positive groupings' means ended higher than those of negative groupings.

Table 9 displays post-BioBus mean scores for students exhibiting extreme positive and negative changes for each of the 14 ATSSA items. (For a list of items, see Appendix B.) As with Table 7, this item analysis was completed to look for consistencies between positive and negative groupings, except in this instance, only extreme change participant data were analyzed. One finding that resulted from this item analysis was that each extreme positive change item mean was greater than their negative counterpart. Additionally, a similar trend was seen across

Table 8

Extreme Cases of ATSSA Change Scores

Grade	Extreme ATSSA Attitude Change	*n*	% of N	Pre-Test *M*	Post-Test *M*	Δ*M*
6	Positive[a]	15	36.6	45.7	55.5	9.9
	Negative[b]	7	20.6	53.4	43.9	-9.6
8	Positive[c]	11	35.4	42.2	56.7	14.5
	Negative[d]	5	13.9	41.4	32.8	-8.6
9	Positive[e]	5	20.0	33.6	47.4	13.8
	Negative[f]	3	17.6	57.7	45.3	-12.3
11/12	Positive[g]	4	33.3	46.5	57.3	10.8
	Negative[h]	5	27.8	48.6	38.8	-9.8
Entire Sample	Positive[i]	35	32.1	42.9	54.9	12
	Negative[j]	20	19.0	49.9	40.1	-9.8

Note. Extreme change participants were selected by utilizing the 2 *SD* value of combined positive and negative participants within each grade. The 2 *SD* ATSSA change score value used to select extreme cases, both positive and negative for Grades 6, 8, 9, and 11/12, were 6.1, 7.5, 7.2, and 6.7, respectively.
[a]N = 41 [b]N = 34 [c]N = 31 [d]N = 36 [e]N = 25 [f]N = 17 [g]N = 12 [h]N = 18 [i]N = 109 [j]N = 104

all grade level groupings. That is, in all but two instances (Grade 6, items 7 and 10), extreme positive item means were higher than extreme negative means. Also of note is that the extreme positive change means for all items across grade levels, except item 5 for Grade 11/12, indicated a favorable attitudinal response (*M* > 3). In contrast, the negative grouping only had 17 items, six of which were within the Grade 6 level, that had a mean equal to or greater than a neutral response (*M* = 3).

Table 9 also allowed me to determine survey items with large mean differences between positive and negative groupiongs. In this way some items could be labled as outliers. These outliers were determined by calculating absolute differences between positive and negative groups for each item and comparing this difference to a 1.25 *SD* benchmark. In this instance, it was necessary to use a higher *SD* value than when the entire participant pool was analyzed in Table 7 as the .75 *SD* standard used therein was not sensitive enough to make distinctions among the extreme positive/negative groupings in Table 9. Once indicator values were set, it was determined that for the entire sample only item 4 was an outlier. Across grade levels, Grade 8 exhibited the largest number of total item outliers (7) followed by Grade 9 (5), Grade 6 (3), and Grade 11/12 (2). Interestingly, across all grade levels, item 4 (I would like to learn more about science) was an outlier.

Table 9

Post-BioBus ATSSA Item Analysis for Extreme Cases

		Post-BioBus Attitude Towards Science in School Assessment (ATSSA) Item Means													
Grade	Type of ATSSA Attitude Change (Extreme)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
6	Positive	4.33	4.47	4.00	4.20	3.40	4.07	3.60	4.13	4.20	3.67	3.87	4.00	3.47	4.13
	Negative	2.86	3.43	2.43	2.57	2.43	2.86	4.43	2.86	3.71	3.71	3.00	3.43	2.86	3.29
	+/- Difference	1.48[a]	1.04	1.57[a]	1.63[a]	0.97	1.21	0.83	1.28	0.49	0.05	0.87	0.57	0.61	0.85
	1.25 *SD*	1.46	1.18	1.53	1.46	1.93	1.24	1.69	1.45	1.12	1.65	1.32	1.26	1.29	1.24
8	Positive	4.09	4.09	3.64	4.36	3.55	3.91	4.45	4.00	4.18	4.27	3.82	3.91	4.18	4.27
	Negative	3.20	2.20	3.00	2.80	1.80	2.60	1.60	2.20	2.60	1.60	2.20	2.40	2.40	2.20
	+/- Difference	0.89	1.89[a]	0.64	1.56[a]	1.75	1.31	2.85[a]	1.80[a]	1.58	2.67[a]	1.62	1.51	1.78[a]	2.07[a]
	1.25 *SD*	1.39	1.77	1.58	1.51	1.77	1.44	1.88	1.51	1.69	1.88	1.97	1.64	1.51	1.88
9	Positive	3.52	3.68	3.52	3.72	3.20	3.40	4.04	3.40	3.48	3.80	3.36	3.52	3.52	3.68
	Negative	3.24	2.88	3.47	2.94	2.12	2.94	3.12	2.94	2.94	3.12	2.94	2.88	2.94	2.65
	+/- Difference	0.28	0.80[a]	0.05	0.78[a]	1.08[a]	0.46	0.92[a]	0.46	0.54	0.68	0.42	0.64	0.58	1.03[a]
	1.25 *SD*	0.64	0.73	0.50	0.74	0.74	0.77	0.81	0.67	0.66	0.83	0.63	0.64	0.60	0.71
11/12	Positive	4.00	4.50	4.00	4.50	2.50	4.50	4.50	4.00	4.00	4.50	4.00	4.00	4.00	4.25
	Negative	2.80	3.60	2.80	2.00	2.40	2.60	3.20	2.80	2.60	3.20	2.20	3.00	2.80	2.80
	+/- Difference	1.20	0.90	1.20	2.50[a]	0.10	1.90[a]	1.30	1.20	1.40	1.30	1.80	1.00	1.20	1.45
	1.25 *SD*	1.40	1.40	1.65	1.82	1.27	1.67	1.95	1.40	1.74	1.63	1.88	1.55	1.40	1.99
Entire Sample	Positive	4.14	4.23	3.80	4.17	3.34	3.91	3.94	3.97	4.06	3.89	3.77	3.89	3.74	4.09
	Negative	3.00	3.15	2.80	2.60	2.30	2.80	3.25	2.75	3.10	2.95	2.65	3.10	2.85	2.75
	+/- Difference	1.14	1.08	1.00	1.57[a]	1.04	1.11	0.69	1.22	0.96	0.94	1.12	0.79	0.89	1.34
	1.25 *SD*	1.37	1.38	1.48	1.51	1.67	1.38	1.70	1.38	1.42	1.66	1.58	1.35	1.29	1.57

[a]Absolute difference between positive and negative group means for this item is greater than the 1.25 *SD* value of all positive and negative participants constituting the given sample.

Summary of Findings—Research Question 1

Major findings drawn from Research Question 1 are summarized below.

- This study's attitude survey (ATSSA) demonstrated that approximately one-half of the participants had a more positive attitude towards science after their BioBus experience (45.6%), while a similar percentage had a more negative attitude towards science (43.9%) (see Table 5).
- When participants were grouped by their type of attitude change (positive/negative), mean changes in ATSSA scores were determined to be statistically significant ($p < .001$) with large effect size across the entire sample and all grade levels (see Table 6).
- Grade 6, 8, and 9 participants' changes in attitude towards science were relatively more positive following a BioBus experience in comparison to Grade 11/12 changes (see Tables 5 and 6).
- An item analysis revealed that positive groupings consistently made more favorable responses to the 14 questions of the ATSSA than their negative counterpart (see Table 7).
- A higher percentage of students with any type of positive change in attitude towards science were considered to be extreme cases (32.1%) than their negative counterpart (19%) (see Table 8). A similar trend was seen across grade levels.
- Changes in mean ATSSA scores were greater for the extreme positive groupings than the extreme negative groupings for the entire sample and across all grade levels (see Table 8).

- The extreme case item analysis revealed that extreme positive groupings responded consistently more favorably to each question on the ATSSA than their negative counterpart (see Table 9).
- ATSSA item 4 was determined to be an outlier in terms of how positive and negative change participants responded for the entire sample, across 3 of 4 grades (see Table 7) and for all extreme case groupings (see Table 9).

Findings—Research Question 2

How did urban youth respond to their BioBus experience?

How did responses differ among grades?

How did responses differ among positive, negative, and neutral groupings?

How did responses differ between positive and negative extremes?

Findings from Research Question 2, which addressed how students generally felt about their BioBus experience, are displayed in one figure (Figure 6) and several tables (Tables 10-13). As the only figure in the findings section, Figure 6 displays student mean responses to Likert item 15 (The BioBus experience has made my attitude towards science more positive). This item was added as an addendum to the 14-question post-BioBus ATSSA. In addition to the findings drawn from the figure and tables associated with Research Question 2, eight case studies that were crafted from student interviews are also presented to provide an in-depth analysis of how extreme cases responded to the BioBus.

Figure 6 displays how and in what proportion the participants of this study responded to Likert item 15 by grade level. A large majority agreed or strongly agreed (72%) to Likert item 15 that their BioBus experience positively affected their attitude towards science. More specifically,

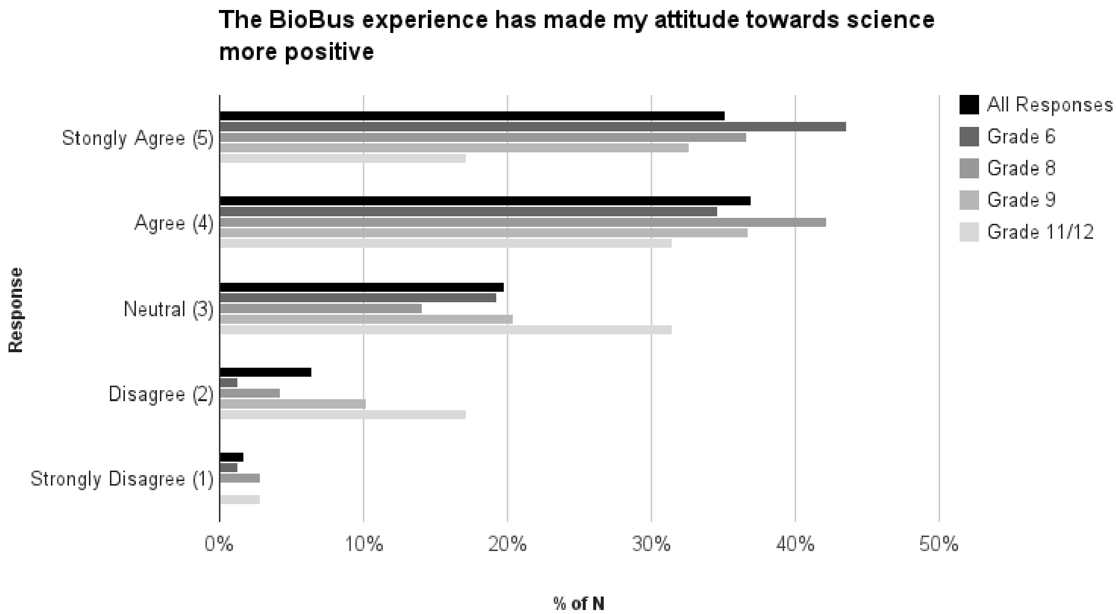


Figure 6. Graph of post-BioBus responses to Likert item 15 analyzed by grade level

students in Grades 6, 8 and 9 agreed and strongly agreed 78%, 79%, and 69% of the time, respectively, while those in Grade 11/12 agreed or strongly agreed 49% of the time. Interestingly, Grade 11/12 was the only grouping that did not have a majority of its students agree or strongly agree that the BioBus experience positively changed their attitude towards science.

For the entire sample only 8% of all participants disagreed or strongly disagree with Likert item 15. To that end, students in Grades 6 and 8 responded this way 3% and 7% of the time, respectively, while those in Grades 9 and 11/12 responded similarly 10% and 20% of the time, respectively.

In Table 10, all groupings (positive, negative, and neutral) responded in the affirmative that their BioBus experience positively influenced their attitudes towards science ($M > 3.0$). For

Table 10

Mean Responses to Likert Item 15 by Type of Attitude Change and Grade

Type of ATSSA Attitude Change	Entire Sample	Grade			
		6[d]	8[e]	9[f]	11/12[g]
Positive	4.3[a]	4.0	4.3	4.3	4.0
Negative	3.7[b]	4.0	3.9	3.2	3.1
Neutral	3.8[c]	4.3	3.8	4.1	3.2
M	3.9	4.1	4.0	3.9	3.4
+/- difference	0.6	0.0	0.3	1.1	0.9

Note. 6 participants in Grade 6 did not respond to this survey item.
[a]$N = 108$ [b]$N = 102$ [c]$N = 25$ [d]$N = 78$ [e]$N = 71$ [f]$N = 49$ [g]$N = 35$

the entire sample, positive groupings had a higher mean response and, consequently, greater agreement to Likert item 15 (The BioBus experience has made my attitude towards science more positive) than its negative grouping counterpart. Furthermore, positive groupings exhibited the strongest agreement with Likert item 15 across 3 of 4 grades (positive/negative means in Grade 6 were equal). Finally, when the data presented in Table 10 were analyzed by grade, it was determined that Grade 6, 8, and 9 participant means (4.1, 4.0, and 3.9, respectively) were in stronger agreement with Likert item 15 than students in Grade 11/12 ($M = 3.4$).

When examining the mean responses displayed in Table 11 for participants exhibiting extreme changes in ATSSA attitude towards science scores following a BioBus experience, it was evident that all means displayed besides the negative grouping of Grade 11/12 were greater than 3.0. This finding indicates widespread extreme case participant agreement with Likert item 15 (The BioBus has made my attitude towards science more positive). Additionally, mean responses for participants exhibiting extreme changes in their ATSSA scores in Grades 6, 8, and 9 had greater agreement (4.2, 4.2, 4.1, respectively) with Likert item 15 (and more uniformity with each other) than Grade 11/12 (3.1). To that end, Grades 6, 8, and 9 had smaller differences between extreme positive and negative groupings (0.7, 0.4, 0.9, respectively) than Grade 11/12 (1.8). Interestingly, when responding to Likert item 15, this study's extreme change Grade 11/12 participants were outliers.

Table 11

Mean Responses to Likert Item 15 for Cases of Extreme Attitude Change

Type of ATSSA Extreme Attitude Change	Entire Sample	Grade			
		6	8	9	11/12
Positive[a]	4.4	4.6	4.4	4.6	4.0
Negative[b]	3.4	3.8	4.0	3.7	2.2
M	3.9	4.2	4.2	4.1	3.1
+/- difference	1.0	0.7	0.4	0.9	1.8

[a]*n* = 35 [b]*n* = 20

Table 12 was created by tabulating the number of positive statements made by students about their BioBus experience on this study's open-ended response questionnaire (see Appendix D). That is, a tally was recorded each time it was determined that a participant had written something positive about their BioBus experience for any of the four open-ended response questions. In this way the total number of postitive statements made and the number of participants making at least one comment in this manner could be determined. Of note here is that only this latter categorization was used when presenting the findings below.

Table 12

Positive Statements About a BioBus Experience by Attitude Change

Type of ATSSA Attitude Change	n	Total Positive Statements	Number of Different Students	Different Students as a % of n
Positive	106	133	90	84.9
Extreme Positive	35	41	31	88.6
Negative	104	101	74	71.2
Extreme Negative	20	17	12	60.0
Neutral	25	23	19	76.0
Totals (positive, negative, neutral)	235	257	184	78.3
Totals (extreme)	55	58	43	78.2

Note. Not all students participating in this study responded to every part of the questionnaire.

When taken as a whole, a large majority of students (78.3%) made at least one positive comment about their BioBus experience. Additionally, participants with a positive change in pre- to post-BioBus ATSSA scores were more likely than participants with negative or neutral changes to make affirmative statements about their BioBus experience (84.9%, 71.2%, and 76%, respectively). A similar relationship was also seen for students exhibiting extreme positive and negative changes in ATSSA scores (88.6% and 60%, respectively). Finally, participants in the extreme positive grouping were more likely to make at least one positive statement about their BioBus experience (88.6 %) than participants exhibiting any type of positive change in ATSSA score (84.9%), while the opposite is true for non-extreme and extreme negative groupings (71.2% and 60%, respectively).

The data displayed in Table 13, which sorted the percent of participants by grade and type of attitude change, indicate that students in Grades 6, 8, and 9 were more likely to make at least one positive comment about their BioBus experience than students in Grade 11/12.

Table 13

Positive Statements About a BioBus Experience by Grade

	Change in Pre- to Post-BioBus ATSSA Score		
Grade	Positive	Negative	Combined
6	88.6[a]	71.4[b]	81
8	93.5[c]	72.2[d]	83.4
9	84.0[e]	64.7[f]	77.4
11/12	75.0[g]	66.7[h]	70

[a]*n* = 31 [b]*n* = 25 [c]*n* = 29 [d]*n* = 26 [e]*n* = 21 [f]*n* = 11 [g]*n* = 9 [h]*n* = 12

Somewhat similarly, students in Grades 6 and 8 with positive changes in their pre- to post-BioBus ATSSA scores were more likely to make positive comments about their BioBus experience than students in Grades 9 and 11/12. To that end, a more distinct division can be seen for students exhibiting negative changes in ATSSA scores when Grades 6 and 8 are compared to Grades 9 and 11/12.

Observational Findings

This study's field notes and the description of the case setting were utilized to analyze how students interacted with the scientists on board the BioBus, its scientific equipment, and each other. When doing so it was found that the BioBus was a rather engaging experience. However, levels of engagement fluctuated throughout and participants appeared to be most engaged when given the opportunity to manipulate microscopes and other scientific equipment in small groups and less so when being given direct instruction by scientists in larger groupings.

Interactions with scientists. Throughout a BioBus experience there were multiple and in some cases extended instances during which a scientist provided students with a formal presentation of information. These instances primarily occurred during the alternative energy introduction to the bus as well during the activity station at the back. Furthermore, immediately prior to the *Daphnia* experience in the front of the bus, students were given brief and direct instructions on how to use a microscope. During these instances, which in many ways reminded me of what I had seen occur within traditional urban science classrooms, this study's participants were the least likely to be active participants. However, during these moments I still noted that students asked wide-ranging and open-ended questions. For example, one student asked whether or not oil could be made in factories after learning about alternative energy while another wanted to know the relative relatedeness of a horse and donkey suggested. These wide-ranging questions have led me to belive that students were actively listening to what the BioBus scientists were speaking to them about and thinking critically about the content's relevance to their lifeworlds.

Despite a good portion of the BioBus experience being scientist-led, there were still multiple instances during which scientists took a more supportive role in student learning. In particular this more peripheral role took place during the *Daphnia* experience. While Dr. Wren sometimes presented students with "challeges" to identify and zoom in on specific *Daphnia* body parts he also frequently took a step back and bounced from group to group as questions arose. Sometimes students presented Dr. Wren with a question about an observation they had made that he did not have a clear answer to and it was during these moments that both students and scientists appeared to become co-conspirators in the scientific discovery process.

Other particularly powerful and engaging moments during the *Daphnia* experience came when Dr. Wren, who may have noted an interesting observation (e.g. a pregnant *Daphnia*) or question, asked all students to focus their attention on the visual display of one of the microscope stations. During this time, when both students and scientists were in close proximity to one another and looking at the same image, it felt as if something akin to a community of learners had formed. Indeed these moments were characterized by high levels of student interest and engagement and accompanied by thought provoking questions and observations like those that arose during the time when one student stated aloud that the pregnant *Daphnia* they were observing must be a female.

Interactions with scientific tools and equipment. I witnessed the best and highest levels of engagement by students on the BioBus during the time that they were actively manipulating scientific tools (i.e. pipets, slides, keyboard) and equipment (i.e. microscopes). In particular, when a student was able to directly use a microscope, adjusting its focus and zoom knobs, they were full engrossed in trying to create the clearest image possible for both themselves and their immediate group members. During this time I alos witnessed those students not at the controls of the microscope intently staring at the visual display mounted to the microscope station's scaffold.

This study's participants also had the opportunity to interact directly with scientific tools and equipment within the back activity station of the BioBus. For example, some students were directly involved with helping to prepare slides of both cheek and plant cells. Furthermore, other students came in direct contact with a hand-held microscope when their skin or clothing was placed under its viewfinder. Here again, I noted that students were more readily engaged and excited than during the more direct instruction characterized by scientist-led discussions.

Student interactions with each other. Student-to-student interactions were farily minimal when scientist-led discussions were taking place. However, interactions were heightened when students were given the opportunity to directly manipulate scientific tools and equipment. By all accounts, student-to-student conversations were most animated during the *Daphnia* experience. During this time I witnessed students helping and encouraging one another to bring a specimen into focus on multiple occasions. Furthermore, as the image of a *Daphnia* materialized on the visual display above them, students often excitedly began to make observations to each other about what they were seeing. Additionally, when students were given the challenge of identifying *Daphnia* body parts, it was not uncommon to hear them challenge and question the inferences their groupmates were making. Also of note, is that during the *Daphnia* experience student discussions did not stray off-topic. Finally, when I reflected upon differences between the student-to-student interactions amongst grade levels, I characterized those at lower grade levels to be much more animated during the *Daphnia* experience than those of grade 11/12.

Summary of Findings—Research Question 2 (Non-case Study)

- A large majority of this study's participants (72%) agreed or strongly agreed that the BioBus positively influenced their attitude towards science (see Figure 6).
- Mean responses to Likert item 15 across all types of attitude change (positive, negative, neutral) and grade levels (6, 8, 9, 11/12) indicated that the BioBus positively influenced participants' attitude toward science ($M > 3.0$) (see Table 10).
- Positive grouping mean responses to Likert item 15 were consistently higher than negative grouping mean responses (see Table 10).
- Students in lower grade levels (6, 8, and 9) were more likely to agree than students in Grade 11/12 to Likert item 15 that the BioBus positively influenced their attitude towards science (see Figure 6 and Table 10).
- A large majority of mean responses by participants exhibiting both positive and negative extreme changes in ATSSA attitude scores indicated agreement ($M > 3.0$) with Likert item 15 (see Table 11).
- Mean responses by participants exhibiting extreme changes in ATSSA scores in Grades 6, 8, and 9 were in greater agreement with Likert item 15 and more uniform with one another than students in Grade 11/12 (see Table 11).
- A large majority of students (78.3%) made at least one positive statement on an open-ended response questionnaire about their BioBus experience (see Table 12).
- Participants with positive and extreme positive changes in ATSSA scores were more likely to make at least one positive comment (84.9% and 88.6% of participants, respectively) about their BioBus experience than comparable negative and neutral groupings (see Table 12).

- Participants in Grades 6, 8, and 9 were more likely to make at least one positive comment about their BioBus experience on an open-ended response questionnaire than participants in Grade 11/12 (see Table 13).
- Positive and negative groupings in Grades 6, 8, and 9 were more likely to make positive statements on an open-ended response questionnaire about their BioBus experience than similarly grouped participants in Grade 11/12 (see Table 13).
- Observational findings suggested that students demonstrated the greatest levels of engagement on the BioBus during the *Daphnia* experience with younger students being generally more engaged than older students.

Evaluation of this Study's Thoeretical Framework

In Chapter 3, this case study was characterized as being instrumental. That is, one of its stated goals was to determine the merits of the theoretical framework utilized herein. To do so, I will detail in the section below why the BioBus served as both an informal science education setting and a third space. Once these two aspects of this study's theoretical framework have been justified, a series of case studies are presented in the attempt to demonstrate how these theoretical components may facilitate affective outcomes via social capital brokerage.

The BioBus as an Informal Science Education Setting

After data analysis of the setting narrative constructed, I have concluded that certain elements of the BioBus experience could be aligned with some of the characteristics used to describe informal science learning. Presented below is the evidence collected from the analysis of the aforementioned narrative and my assessment of how a BioBus experience does and does not align with terms commonly associated with informal science learning (i.e. learning that is voluntary, learner-led, unstructured, open-ended, nonthreatening, non-evaluative, and social, see Figure 4). In addition, to add nuance and depth, the original field notes taken during this study's four observations were referenced, albeit sparingly.

Voluntary. While students likely had little free-choice to decide whether or not they wanted to enter the bus, the argument could be made that if a student did not want to be a part of the experience they could have remained inside their school building. With that having been said, during one observation, I did note that a student who had entered the bus wanted to step off and did so after receiving their teacher's permission. This possibility was made all the more feasible due to the bus's close proximity to the student's school and would have likely been more problematic had her class been off-site at a museum or science center.

Other instances of voluntary learning mainly arose in regards to how students physically arranged themselves inside the bus. That is, students freely chose where to stand in the front and which bench to sit upon in the back. Additionally, I noted that students often chose when to circle up around Dr. Wren or one of the microscope stations when something of interest could be seen. In this way, these arrangements could also be viewed of instances during which the BioBus experience was unstructured, another characterization of informal science education settings. The other example of when students had the option to engage or not engage in the learning experience was in the back of the bus. Here, Dr. Leslie on multiple occasions, asked for student volunteers to help use the various microscopes available and prepare slides of cheek cells and *Elodea*. Additionally, these volunteer opportunities were somewhat learner-led, the next term associated with informal science education settings.

Learner-led. While much of a student's BioBus experience was determined by Dr. Wren and Dr. Leslie before they stepped aboard the bus, there were still instances during which students had the opportunity to take control of their learning. For example, students were often at the controls of microscopes, determining which knob of the microscope to adjust and what part of a specimen to focus upon. Additionally, students had some control over when, where, and what drawings and observations to make on their worksheet. Finally, observations detailing student arrangements have led me to believe that it was students who ultimately chose when to encircle Dr. Wren and the microscope stations during the alternative energy talk and *Daphnia* experience.

Unstructured. As similar to the learner-led characterization above, the set of activities completed by a student during their BioBus experience were primarily pre-determined. However, there were still instances during which learning time was unstructured. For example, I observed that student-student and student-scientist conversations lacked formality and students often asked any questions they deemed appropriate. Other examples of an unstructured learning environment also entailed the fluid student grouping arrangements detailed above.

Open-ended. While some of the questions students asked during their time on the BioBus were open-ended, the overall experience was not. Ultimately, the pre-determined start and stop times of the BioBus experience in many ways prevented learning from being open-ended. However, the researcher did note that during one observation Dr. Wren encouraged students to join him at the organizations community lab space in another part of the city to continue the explorations they had begun while on the bus.

Non-threatening. In many ways learning aboard the BioBus was non-threatening. First, the BioBus was parked directly in front of each students school, an environment most, if not every student was likely comfortable with. Next, the general appearance of the bus and the colors adorning its exterior were probably deemed by students to have been warm and welcoming. Additionally, Dr. Wren always greeted students on the sidewalk outside of a student's school where they were surrounded by the familiar sounds and, in some instances, the appearance of community members that they had perhaps grown accustomed to interacting with on a daily basis.

The interior environment of the bus and the activities that students took part in were also non-threatening. To begin, students took part in the BioBus experience with the classmates and teacher that they had likely become used to learning with throughout the course of the school year. Next, the microscopes aboard the bus, while research-grade, were not all that dissimilar from those students may have seen or used themselves within the classroom. Additionally, in all instances, I noted that students needed little if any guidance in how to operate each scope they interacted with. That is, the microscopes were easy to use. Moreover, the various digital displays throughout the bus made it easier for students to see specimens and circumvented the need for them to squint their eyes through an objective lens that, if not properly oriented, may have proved intimidating. Indeed, this very occurrence often occurs within my own classroom. Also, the double-sided worksheet (see Appendix A) given to each student contained few words, simple directions, and a large picture. Finally, the nature of the conversations held by students among themselves and the BioBus could be described as being friendly and supportive.

Non-evaluative. By almost all measures, the BioBus lacked a formal evaluation structure. Indeed there was no summative exam or high-stakes test students had to prepare for or take at the end of their experience. Furthermore, the worksheet students filled out were not collected or assessed. To that end, the time students spent using microscopes and preparing slides were not judged or scored in anyway. The only instances during which learning shifted towards a more evaluative environment was during some scientist questioning, but even here questions were typically asked in a way to assess prior knowledge and not as a means to determine supposed learned content.

Social. The BioBus experience was highly social. Whether through conversations taking place between students and Dr. Leslie in the back of the bus or those trickling through the curtain that separates the bus in half, the BioBus experience was almost always under a constant siege of sound. Furthemore, conversations were usually enhanced by the small physical space of the bus, forcing individuals to be in close proximity with one another. Interestingly, the circle was the dominant social structure and was on display in the small groups huddled around a microscope station in the front of the bus and the larger one that formed as students and Dr. Leslie convened in the back. Indeed it has been noted that these particular arrangements rarely occur within the urban science classroom (Emdin, 2010b).

Another social element of the BioBus experience occurred when the images being displayed above each microscope were made available for all to see and, in many instances, were viewed by a large group simultaneously. In many ways, this way of viewing microscopic images contrasts starkly with a student in isolation or, at best, alternatively sharing an objective lens with a partner in the science classroom. Moreover, when public viewings of images occurred, the observations being made were shared for all to hear. Even transitions between activities had a social element as students, having been brought into close alignment with one another, conversed freely and, in some instances, exchanged verbal and physical greetings. Lastly, students often encouraged one another to turn a microscope knob in one particular way or volunteer to view their skin or clothing under a handheld microscope.

Informal or formal? How should one characterize the type of learning that occurred within the BioBus? Was the evidence gathered on the type of learning that occurred therein, robust enough to classify it as an informal science education setting? While the answers to these questions are debatable, I have demonstrated that there is enough evidence to characterize the learning that took place within the BioBus as being more informal than formal. In particular, the time students spent at microscopes during the *Daphnia* experience most often facilitated the type of learning that occurs within informal science education settings. During this activity, when students were interacting with scientific tools and equipment, (i.e. microscopes, glass slides, cameras, and monitors) the BioBus appeared to have operated in a manner similar to the Cell Lab Exhibition at the Science Museum of Minnesota (National Research Council, 2009). When museum visitors are at this exhibition, they are able to work in groups while using all of the aforementioned tools and equipment in order to complete activities similar to those that this study's participants carried out when viewing *Daphnia*. To that end, this particular aspect of the BioBus experience will serve as the basis for deeming this setting as belonging within the realm of informal science education and fulfill this particular part of this study's theoretical framework. Moreover, one should also be cognizant that while the *Daphnia* experience represents informal learning at its best within the BioBus, it was not the only instance during which it occurred.

The BioBus as a Third Space

To examine whether or not the BioBus was a third space, I drew upon Soja's (1996) interpretation that these spaces are both physical and social, Bhabha's (1994) reflection that they are "in between spaces," and Moje et. al.'s (2004) characterization that they are able to provide avenues for marginalized youth to navigate and build bridges between home and school settings. Indeed, when I examined the narrative constructed of a typical BioBus experience, there were multiple instances during which these criteria were met.

Physical alignment. The elements of a BioBus experience that are physically aligned with those that may be found in a third space center on the fact that the setting itself typifies many aspects of living an urban lifestyle. To begin, students need to physically travel to a place between their school and home to experience the BioBus. Moreover, students start their interaction with scientists by being greeted on the street, the lifeblood of urban neighborhoods, and a place in between their home and school. Additionally, during their introduction outside of the bus, students were surrounded by a familiar urban landscape; its sounds, smells, and sights easily accessible while still being near their school building, classmates, and teacher. Next, when students placed one foot on the curb and another on the first step of the BioBus, a physical bridge was constructed between their home (the sidewalk/neighborhood) and school (science lab) worlds. With that said, the bridge constructed here is much different than the one students create when crossing the threshold between the sidewalk and their school building. Indeed as students ascended the BioBus staircase, the clomping sound made by their footwear and the proximity of being surround by the roof, walls, and windows likely created a sensory experience similar to the one that occurs when a city bus is boarded. However, when student's shifted their gaze and started making their way towards the center of the bus, what they saw was a drastically altered scene. This very feeling of being in a new space was exemplified by one student who exclaimed upon entering the BioBus, "Yo, where the seats at?"

As the BioBus experience continued, there were other brief, but meaningful physical elements that satisfied the criteria of a third space. First, while students transitioned between activity stations on the bus, its relatively cramped quarters and the resulting closeness that students were forced into evoked images of the rush-hour commute. Furthermore, the U-shaped arrangement of the benches in the back of the bus and the manner in which students leisurely arranged themselves, reminded me of instances when I had viewed similar scenes playing out when passing by nearby parks and public housing projects in nearby neighborhoods.

Social alignment. With the evidence for why the BioBus experience fulfills the physical requirements of a being a third space having been detailed, I will now turn to focus on how the social elements of these spaces were similarly fulfilled. To begin, it is necessary to note that much of the work detailing the social elements of a third space have focused on a setting's Discursive elements (Moje et. al., 2004). As such, I tried to highlight the aspects of a BioBus experience that were similarly aligned. First, I noted that one of the primary arrangements for student groupings and student-scientist conversations was a circle. In many instances these arrangements and the words that were spoken reminded me of a cypher, or, "a forum where individuals dialogue or rap pre-written or improvisational, also known as "free-styled" lyrics" (Emdin, 2010b, p. 117). For example, students were observed creating circular groupings outside of the bus during Dr. Wren's introduction and discussion about alternative energy as well as inside the bus when he held up a pellet from the wood burning stove or a vial containing an illuminated *Daphnia*. Additionally, these circular arrangements continued throughout a BioBus experience. For example, when students were positioned at microscope stations in the front of the bus they were arranged in small circular groupings. Moreover, these groupings could quickly and easily swell in size. Finally, when students were seated in the back of the bus, they were arranged in a U-shape that was made circular when Dr. Leslie seated herself in between the two parallel benches.

Returning to the image of the cypher and the dialogue that often occurs between individuals when circular arrangements are made on a street corner or within a more formal urban environment, I will present instances during which particular Discursive elements unique to urban culture, namely word choice and hand gestures were displayed during a BioBus experience. To begin, conversations during a BioBus experience could be described as being free flowing and unstructured. Similarly, the rap cypher has no pre-determined destination or outcome, instead individuals share and build upon each other's ideas, proclamations, and general vibes. Additionally, the rap cypher does not wait for it to be someone's "turn" as is frequently the case within the formal science classroom, instead one jumps in using ritualized verbal and visual cues (Emdin, 2010b).

Next, by comparing the image of the rap cypher to the conversations that took place during a BioBus experience, it is possible to see instances during which a social third space was constructed therein. A particularly poignant example of cypher/BioBus alignment occurred when a small group of students assembled at one of the three microscope stations in the front of the bus. During one conversation, when students were trying to identify whether or not the part of the *Daphnia* they were looking at was a heart, a cyclical conversation was overheard. While the specific details of what was said were not recorded, I did note that students challenged one another, built off of each other's ideas and hypotheses, and clenched and then pounded their fists against their chests. Additionally, this interaction was not the only instance during which I observed a closed fist, which is commonly used by urban youth to greet, affirm, emphasize, or part-ways just before, during, and after a cypher, being used as form of social interaction. Indeed, while students transitioned from the front of the bus to the back, I noted students "fist bumping," giving "pounds" or "dapping" with one another. Interestingly, this traditionally urban form of interaction made headlines when it was enacted by now President and First Lady Obama on television shortly before the 2008 Presidential Election. Furthermore, the media firestorm that followed this occurrence speaks to the non-mainstream way in which this type of social interaction was viewed; that is one that was out of the ordinary for those in positions of power. With that having been said, the fact that the participants of this study were comfortable enough to use this form of expression not only among themselves, but on at least one observed occasion with Dr. Leslie, speaks to the nature of the BioBus's setting as being able to serve as a social third space that is in between the home and lifeworlds of urban youth.

Other examples and instances during which a student's words matched those that might be commonly heard during a cypher also occurred when students were seated in a U-shaped arrangement in the back of the bus. In addition to the conversations in this part of the bus being free-flowing and unstructured, I typically heard what some might refer to as "urban slang" being used by students. For example, when the student-created images of red, blue, and green cell organelles was joined and displayed on the screen of the BioBus's fluorescent microscope, one student remarked, "Oh, that's fire," which could be implied as meaning the image was particularly interesting to look at. Immediately after this remark another student replied, "Yeah, that's wavy," indicating an affirmation of what had just been said. Here again, evidence of urban youth being comfortable enough to make a scientific observation using a dialect that they may not typically or possibly ever use within the science classroom was on display. As a result, it is again appropriate to deem this example as an instance where the BioBus setting served as a social third space; allowing urban youth with the opportunity to express and communicate themselves in ways that may normally be stifled in the formal science classroom.

Realization of the Third Space. In the section above I detailed the reasons why the BioBus and mobile science labs in general may be able to serve as a third space between the home and school settings of urban youth both physically and socially. However, I also alluded to the fact that a third space is not automatically created just because a learning experience takes place outside of the classroom. Indeed, during multiple instances of a students BioBus experience scientist conversations stifled those of this study's student participants. As a result, I will later return to detail ways in which a third space can be constructd in this dissertation's concluding chapter.

Also within the sections above I provided empirically based reasoning for why I viewed the BioBus experience as an informal science education setting. More specifically, it was determined that informal science learning was most apparent during the BioBus's *Daphnia* experience, although other instances of this type of learning were also present. When taken in combination, these findings have created a relatively firm theoretical and analytical foundation through which to examine how mobile science labs can be used to explain how social capital exchange and acquisition lead to affective outcomes. Indeed, I attempted to detail how this may have occurred during a BioBus experience within the eight case studies below.

Case Studies of Participants

This section includes an analysis of eight interviews from participants across all grades (6, 8, 9, and 11/12) exhibiting extreme changes (both positive and negative) in their pre- to post-BioBus Attitude Towards Science in School Assessment (ATSSA) scores. As a reminder, extreme cases were determined independently for each grade level and noted to be as such if changes in an individual's pre- to post-BioBus ATSSA scores were greater than +/- 2 *SD*. Also, within this section, connections are made between student interview responses and the three components of this study's theoretical framework (i.e., outsider status to the culture of school science, BioBus third space sponsorship, and social capital enactment). A brief review of each is presented below.

The first theoretical framework component of this study focused on characterizing a participant's relationship to science before his or her BioBus experience. More specifically, I sought to determine whether or not interview participants could be empirically identified as outsiders to the culture of school science. The second element of this study's theoretical framework focused on examples of each participant's most memorable BioBus experiences. Once identified, this experience was used to detail how the BioBus may have served as a third space sponsor to the culture of school science for each case study crafted. Finally, the third part of the framework noted instances in which this study's participants changed aspects of their behavior in the science classroom or lived experience. To that end, this third component was also representative of how BioBus third space sponsorship allowed for social capital transfer between the cultures of urban youth and school science and, in turn, may have influenced a participant's attitude towards science.

Each case study below begins with a summary of an interview participant's demographic information, ATSSA scores, and open-ended questionnaire responses (see Table 14 and Appendix F). Next, interview excerpts are presented and analyzed. Finally, ways in which each interview participant's collected data do and do not align with the three components of this study's theoretical framework are addressed.

Penelope

Data collected from sixth grader Penelope's BioBus experience aligned with all three components of this study's theoretical framework. These connections are presented through an in-depth analysis of her interview comments and after the brief summation of the data on display in Table 14.

Prior to her BioBus experience, Penelope's ATSSA score of 51 indicated that she already held a positive attitude towards science (ATSSA > 42). To that end, Penelope's ATSSA score increased by nine points immediately following her BioBus experience to 60 (70 is the highest score possible). When asked whether or not she agreed with Likert item 15 (The BioBus has made my attitude towards science more positive), Penelope strongly agreed (response of 5) that it did. This response was also supported by her open-ended response where she explained, "I finally proved that I love science." During her interview, when Penelope was asked to clarify what she meant by this statement, she responded that the BioBus allowed her to "explore" science in a way that was not possible in her normal science classroom. More details of Penelope's time exploring science and how she viewed the BioBus in comparison to her day-to-day science class are presented below.

The first question asked of Penelope during her interview entailed describing what she remembered about her BioBus experience. The following conversation resulted:

Penelope: I remember that it was fun. I didn't like science that much, but since like we got to use some stuff that we don't have in the classroom, I started liking science.

Researcher: Okay, so why do you think all of a sudden now you started liking science? Because of these things that you don't have in the classroom? Like what? Tell me a little more about that.

Penelope: Because I just thought that science was boring and that it wasn't that fun, but when we went on the BioBus, when they were showing us the *Daphnia* and stuff, I liked science.

Researcher: So being able to see new things, being able to be on the bus, because it was fun, you now think science is interesting and you like it more?

Penelope: Yes.

Researcher: Any other reasons why you like it more now? I am trying to figure out: what is it about the BioBus that made science fun? What is that you really liked about it?

Penelope: What I liked was that we had like different experiences.

Researcher: So let's talk a little bit about that. What is science like in the classroom for you and then what was it like on the BioBus? How are they different?

Penelope: Sometimes in class, it could get a little bit boring and in the BioBus it was just fun. It was like you didn't know what was going to happen next. Because at first, when we saw *Daphnia*, I am like it was good and then when we went on the back of the BioBus it was even more fun. But in class we already know what is going to happen and stuff and it's kind of like boring with the books and stuff.

Researcher: So part of the reason you liked [the BioBus] was because it was a new experience of something; you weren't expecting it; you didn't know what was going to happen. Whereas in the classroom it seems like you are saying you kind of do the same things over and over again?

Penelope: Yes.

Researcher: What are some of those things you do in the classroom? What is a normal science class like?

Penelope: We go in, we take the books, we listen to—sometimes our teacher—he gives us articles to read and to answer about a human's body part or about like the plants; how they make their own food and how animals get their food and stuff.

Researcher: Okay, is there any other way that your BioBus experience made you think differently about science, beside that you just like it more or you see it as fun?

Penelope: I think that now it's fun and that it's not that boring like I use to think it is.

Here we can start to align Penelope's comments about her experience aboard the BioBus with the theoretical framework of this study. To begin, Penelope can be viewed as an outsider to the culture of school science. This characterization is a direct result of Penelope stating she "didn't like science that much" before the BioBus and the fact that she referred to science as "boring" four times in her comments above.

We can also align Penelope's comments with another aspect of the theoretical framework, namely that the BioBus experience served as a third space sponsor to the culture of school science. Indeed, the justification for this is a result of Penelope's comments that after the BioBus experience she "started liking science" and because she stated four times that her time on

Table 14

Characteristics of Case Study Interview Participants

Name	Grade	Gender	Age	Attitude Towards Science in School Assessment (ATSSA) Pre-BioBus	Post-BioBus	Δ	Likert Item 15 Response	Open-ended Explanation to Likert Item 15
Penelope	6	Female	12	51	60	9	Strongly Agree (5)	I finally proved that I love science.
Janis	6	Female	12	56	48	-8	Agree (4)	The reason why I gave the score above is because I learned new things and did new things for example I used a real microscope. Also I saw a very interesting animal which is called *Daphnia*.
Oliver	8	Male	13	31	63	32	Strongly Agree (5)	The reasons why I gave the score above was because BioBus gave me another perspective of science. Also they showed me and taught me things about cells and living organisms that are difficult to learn or pay attention to in class.
Yom	8	Female	13	54	49	-5[a]	Neutral (3)	I put my score a 3 because I've never hated science. This just means that my attitude against science hasn't changed at all.
Sara	9	Female	15	36	56	20	Strongly Agree (5)	The BioBus experience has made my attitude towards science more positive because of the simple fact that I got to see and actual animal cell and look at eat. It made me more eager to learn and ask questions and not think that science is all about taking notes but discovering new things.
Bill	9	Male	14	45	34	-11	Neutral (3)	I put [neutral] because nothing will make my view of science [change] because I don't want to be a scientist and I don't get why we are being taught this stuff if I don't want to be a scientist.
Derek	12	Male	18	29	41	12	Agree (4)	I enjoyed it a little.
Indira	12	Female	18	30	18	-12	Disagree (2)	The BioBus was not interest to me.

[a]The Grade 8 negative interview pool did not include any candidates outside of -2 *SD*, although this participant did represent the greatest negative change in the selection pool.

the bus was “fun.” More specifically, Penelope’s sponsorship was enacted via her opportunity to use scientific tools and equipment that “we don’t have in the classroom” to view *Daphnia*. Furthermore, the “different experiences” provided via sponsorship were “cool to explore” and “fun.” Penelope also described these experiences in direct comparison to the repetitive routines found within the science classroom. Finally, we can also see evidence of third space sponsorship in Penelope’s response to Likert item 15, namely that she strongly agreed that her BioBus experience gave her a more positive attitude towards science.

Interestingly, third space sponsorship via the BioBus may have allowed Penelope to access and transfer social capital from the culture of school science back into her daily experience within the classroom. Below, evidence of Penelope’s social capital acquisition, which is also the mechanism within this study’s framework that helps to explain her positive change in attitude towards science, is fleshed out in more detail.

Soon after Penelope finished retelling what she remembered about her BioBus experience, she was asked what she thought she had learned during her time on the bus.

Penelope: I learned that all kinds of animals and like all kinds of human beings and creatures all have cells. And that it’s like good to explore.

Researcher: What do you mean by it’s good to explore?

Penelope: It’s like—I don’t know how to say it, but it’s like it’s good to find new things every day.

Researcher: Okay, like make discoveries maybe?

Penelope: Yeah.

Researcher: Okay. Do you think you have a different attitude towards science after your BioBus experience? It sounds like you do like [science] more, but is your attitude different as well?

Penelope: Well, at first, as I told you, I just used to sit in class and like do the work. I use to think, as I said, it was boring, but now my attitude changed. Now when I go in the class, I have a better understanding of science the teacher is talking about.

Researcher: And can you say for sure that this is because of the BioBus—this change?

Penelope: Yes, because as I said in class, we don't get to explore stuff like we did in the BioBus.

In the exchange above, we can argue that Penelope's conclusions, stating that it is "good to explore" and "find new things every day," are also likely to have arisen due to the third space sponsorship via the BioBus. To that end, we can also posit that Penelope was able to connect to the culture of school science in a way that was previously not possible for her within a "boring" science classroom. As a result of this sponsorship, Penelope confirmed that she now liked science more and had a new attitude towards science. In turn, this new attitude towards science has allowed Penelope to obtain a "better understanding of" science within the science classroom. These two instances, learning the benefits of exploring and having a better understanding of science, in addition to her explanation for her response to Likert item 15 which stated, "I finally proved that I love science," were viewed within the context of the framework as evidence of social capital transfer and one possible explanation for her positive change in attitude towards science.

In sum, excerpts from Penelope's interview in addition to other data that were collected, aligned with all three aspects of the theoretical framework. First, Penelope was characterized as an outsider to school science, revealing that she used to think science was boring. Next, Penelope's ability to have fun, explore, and utilize scientific tools on the BioBus were taken as evidence of this setting's capability to be used as a third space sponsor to the culture of school science. Finally, it was demonstrated how Penelope's ability to draw upon the social capital gained through BioBus sponsorship has led to her development of a new attitude towards science and a better understanding of content within the science classroom.

Janis

The data collected from Janis's BioBus experience did not readily align with the theoretical framework. In particular, Janis, a sixth grader, lacked the characterization of being an outsider to the culture of school science as well as any evidence suggesting she may have enacted any social capital acquired during her BioBus experience. Below, the data in Table 14 and Janis's interview comments are utilized to provide an analysis of how she perceived her BioBus experience and discuss why the evidence gathered does not correspond with the theoretical framework.

Janis, prior to her BioBus experience, had a positive attitude towards science as determined by the results of her ATSSA survey (score of 56). Following her BioBus experience, Janis's survey results still indicated a positive attitude towards science, albeit one that was now 8 points lower (48). In contrast to this negative shift, Janis agreed (response of 4) with Likert item 15 that her BioBus experience positively influenced her attitude towards science. She explained on her questionnaire, "The reason why I [agreed] is because I learned new things and did new things for example I used a real microscope. Also I saw a very interesting animal which is called *Daphnia*." Of note is the fact that Janis's self-report hinted at a positive BioBus experience while her ATSSA change score indicated an overall less favorable, albeit still positive, attitude towards science. To better investigate this finding, excerpts from Janis's interview about her BioBus experience are analyzed in more detail below.

When Janis was asked to recall the most memorable part of her BioBus experience, she stated, "Looking at the *Daphnia* from the microscope . . . because it was interesting." When asked to explain why she found *Daphnia* to be interesting, Janis explained, "Because [before] you put [*Daphnia*] on the microscope [they look] white and then when you zoom in you can see brown stuff inside of them." Janis also went on to explain how *Daphnia* looked "really small" before they were placed under the microscope and "really big" after.

Janis was also asked to respond to a question about what she thought she learned during her time on the BioBus. She replied, "Little insects sometimes can be different than you think, because at first I thought [*Daphnia*] was just like a little white thing, but then when I looked in the microscope it wasn't." From reading Janis's comments about viewing *Daphnia* (her most memorable BioBus experience), we can infer that her use of microscopes gave her a new perspective on science. In this instance, her new perspective appeared to be the realization that microscopes allowed her to see details not visible with the naked eye.

Janis also commented that being able to use microscopes was something different from her normal science classroom, explaining, "In the classroom, we don't have all that scientific tools—we don't have it that much and we usually just built it ourselves; but in the BioBus they have everything. They have a microscope and you can zoom in." In this instance, we see Janis highlighting her microscope experience as being something unlike anything she had done previously in science class. Following this response, Janis was then asked why she thought it was important to mention scientific tools as a difference between her BioBus experience and the science classroom. She replied, "Because you can see everything up closer and understand it." Interestingly, Janis correlated her ability to see things more closely under microscopes with increased understanding. This understanding was likely due in part, and highlighted above, to her observation of *Daphnia* with and without a microscope.

When asked whether or not her attitude towards science changed following her BioBus experience, Janis responded that her attitude was "a little bit" more positive without giving much more detail, despite researcher questioning. Instead, she mentioned that her science classroom had a Promethean (also known as a SMART) board and that it was the primary way in which she saw things in science class. In contrast, Janis mentioned that on the BioBus, she “actually got to see [things] in front of me.” Interestingly, instead of responding directly to the question, Janis responded by providing another example of how the BioBus differed from her normal classroom experience. Janis also highlighted this difference once again towards the end of her interview when stating that the most important thing she remembered about her BioBus experience was that “the BioBus has different technology [than] my usual class.”

Now that we have spent some time reviewing Janis’s comments regarding her BioBus experience, we discuss their connectivity to the theoretical framework. That said, it is clear Janis enjoyed her time on the BioBus. Likely, much of her enjoyment stemmed from her particular ability to see new things and use scientific tools not readily available to her in her normal science classroom. However, it is difficult to explain her changes in attitude towards science within the context of the overarching theoretical framework guiding this research.

That is, while it may be possible to utilize Janis’s description of microscopes to look at *Daphnia* as a third space sponsor, it is likely more apt to interpret this opportunity as, simply, an enjoyable science experience. Furthermore, at no point during her interview did Janis identify herself as an outsider to the culture of school science, despite researcher questioning. In fact, Janis had positive ATSSA scores both before and after her BioBus experience. To that end, evidence of social capital being transferred from the culture of school science back into Janis’s lived experience was lacking. Despite a clear connection between Janis’s measured outcomes and this study’s theoretical framework, it is still important to note that Janis did recognize the disparity between the scientific tools available to her in the classroom and the BioBus. This difference was important enough for Janis to mention it multiple times throughout the interview and even in one instance when unprompted.

Oliver

Oliver's collected data aligned with all three components of this study's theoretical framework. This alignment is presented through an in-depth analysis of his interview comments after a brief summation of the data on display in Table 14.

Prior to his BioBus experience, Oliver, an eighth grader, had an ATSSA score indicative of a negative attitude towards science (31), although immediately following his time on the BioBus, Oliver's score increased by 32 points to 63. As a result, Oliver's new attitude towards science could be classified as being very positive. It is also of interest to note that Oliver's change in pre- to post-BioBus ATSSA scores was the highest change of all participants in this study. Furthermore, Oliver strongly agreed to Likert item 15 that the BioBus positively influenced his attitude towards science, explaining on his open-response questionnaire, "[The] BioBus gave me another perspective of science. Also [the scientists] showed me and taught me things about cells and living organisms that are difficult to learn or pay attention to in class." During his interview, Oliver also confirmed that he still agreed with this written explanation.

When interviewed, Oliver was also asked to recall his BioBus experience and did so in great detail. Immediately following his recollections, Oliver was asked to reflect on why he thought he was able to remember so much of his BioBus experience. The following conversation ensued:

Researcher: Why do you think you remembered so much [about your BioBus experience]?

Oliver: Because actually, this is actually a rare time and one of the first times I've ever been so interested in science. Before, I was like (sighing) yes how would we be using [science] in the real life or anywhere in life. And then I realized, DNA, microscopes, everything is something connected to our everyday lives. There's things in our lives that we can't see that are around us every day.

Researcher: So it sounds like you thought about science one way before the BioBus and now you think about science in a different way. So let's talk a little bit more about that. What [were you] like before the BioBus in science and what are you like after the BioBus?

Oliver: Before the BioBus, I was like, (sighing) ugh here comes science; here comes that next period where you just knock out in class. That class where you just don't want anything to do with it. And that's how I thought about science, it's just boring; no way I'm going to use it in the real world; nothing to do with me. But then after—the BioBus was like, wow, I've never seen this before; this looks cool. I've never heard of this animal, a *Daphnia*. (I've actually seen my cheek cells before because I did that in seventh grade. We actually used iodine instead, with water and all of that.) But still, I wasn't able to look at my cheek cells that close before.

Researcher: Right, so even though you [had seen] your cheek cells before, you weren't able to see them in as much detail as you were on the BioBus.

Oliver: Exactly.

Researcher: So it sounds like you're a lot more interested in science after the BioBus than you were before. Has that interest continued on since the BioBus experience?

Oliver: It sort of has; it's made me more aware of my surroundings actually. Sometimes I go to the park and then I look at—I guess, I'll see a bug because I've actually never even noticed it before.

Researcher: So you've made some new observations and you've started to look at things a little bit differently than you have before.

Conversation pauses as a plane flies overhead.

Oliver: I actually want to be a pilot when I grow up and I already use a F simulator at home and I . . .

Researcher: Flight simulator?

Oliver: Yeah, flight simulator. And I'm so interested in it because I'm thinking [the flight simulator] must be mostly math and that's what I thought it initially mostly was but then I looked deeper and it's also usually science. Because even as we're learning flight now [in science class], I'm understanding why they make the wings a certain way, why the engines work this way; why the plane is shaped like this instead of like that.

Researcher: When did you start thinking about those kind of things?

Oliver: I started thinking about those things after the BioBus. Before the BioBus, it was just math; just plain old math.

Researcher: So before the BioBus, you saw this career that you were interested in, aviation, as being a lot more math-focused.

Oliver: Mm-hmm.

Researcher: Then you had the BioBus experience and you started looking at aviation in a different way as more of seeing the science part of it.

Oliver: Yes.

Connecting the excerpt above to the overarching theoretical framework, we can view Oliver as an outsider to the culture of school science. Nowhere was this outsider status more apparent than when Oliver detailed his feelings towards science class before his BioBus experience and compared the bus to his normal science classroom. His comments began with a sigh, an audible affirmation of his alienation to the culture of school science, followed by a clear description of his distaste for science class: "ugh here comes science; here comes that next period where you just knock out in class. That class where you just don't want anything to do with it . . . it's just boring; no way I'm going to use it in the real world; nothing to do with me." Given Oliver's distaste for the culture of school science, we would not be surprised if his BioBus experience had little, if any, effect on his attitude or perception of science. However, this was not the case. Indeed, it is possible to analyze how Oliver's BioBus experience can be viewed as evidence of third space sponsorship to the culture of school science.

When describing his BioBus experience, Oliver stated, "This is actually a rare time and one of the first times I've ever been so interested in science." This comment, along with some of the experiences Oliver completed (viewing *Daphnia* and cheek cells under a microscope), can be anchored to our framework as evidence of the BioBus servings as a third space sponsor to the culture of school science. Furthermore, Oliver's detailed comparison of his feeling towards science before and after the BioBus gave further credence to the BioBus experience itself being the main sponsor to the culture of school science and not some other experience back in or outside of the science classroom.

Another component of the theoretical framework, i.e., access to and transfer of social capital, was revealed in Oliver's comments above. Here, we can view the transfer of social capital as the connections Oliver made between the culture of school science and his own life due to his time on the BioBus. This was particularly true when Oliver commented, "I realized DNA, microscopes, everything is something connected to our everyday lives." Furthermore, we can see Oliver's newly acquired social capital being enacted when he spoke of the new observations he made of his surroundings in the local park—something he had not done prior to his BioBus experience.

An interesting point in my conversation with Oliver that was related to social capital arose when a plane flew overhead. Following a pause in the conversation, Oliver spoke in depth about his experience using a flight simulator at home. Based on these comments, we were able to characterize Oliver's realization that the flight simulator he used at home was also related to science, not just math as he originally thought, as another instance of social capital transfer. This transfer was apparent when Oliver commented, "I looked deeper and [the flight simulator is] also usually science." However, one could also argue that this social capital transfer may not have been a direct cause of Oliver's BioBus experience as he was also "learning flight" in the science classroom at the time of his interview. That said, I nonetheless argues that without the third space sponsorship provided by his BioBus experience, Oliver may have been less receptive to engaging in the flight unit being carried out in the classroom. In fact, very serendipitously, we were offered a glimpse of the transformative power of third space sponsorship thanks to an airplane that flew overhead during this interview.

Later in his interview, Oliver was asked more directly about how he thought his attitude towards science had changed following his BioBus experience. Oliver responded:

> Oliver: [My attitude towards science] did very much change. It changed from it being a boring subject that was a pain and nobody just wanted to deal with; even students who are in my class complain to me and we even talk about it at lunch; how oh I hate science, what's the point. It's just so much labs and the point of this, and it just kills us, you know. But now, now we see how one thing gets us to the understanding of another thing and another thing and another thing and another thing.
>
> Researcher: You're talking about your feelings before and after your BioBus experience?
>
> Oliver: Yeah, before and after.
>
> Researcher: So would you say now your attitude towards science is more positive?
>
> Oliver: Yes, I would.

In this excerpt, we once again see Oliver's intense and, at times, dramatized dislike of science prior to his BioBus experience. Oliver even extended this dislike of science to include the feelings of his classmates; retelling conversations that he has had with them at lunch. His classmates' sentiments were also included when Oliver described his new view on the interconnectivity of science understandings. As a result, we can once again see evidence consistent with the theoretical framework being enacted. First, Oliver self-identified as being an outsider to the culture of school science prior to his BioBus experience, describing science as "a boring subject," "a pain," and something he and his classmates "hate." Next, the BioBus experience can be seen acting as a third space sponsor that allowed Oliver to develop a more positive attitude towards science and transfer social capital into his lived experience—or in Oliver's own words, the ability to "see how one thing gets us to the understanding of another thing and another thing and another thing and another thing."

In the case of Oliver, it is possible to view all aspects of this study's theoretical framework enacted and triangulated across the collected data. That is, Oliver had a negative attitude towards science prior to his BioBus experience based on his ATSSA score of 31. To that end, Oliver could also be characterized as an outsider to the culture of school science based on his interview comments. Regarding the BioBus serving as a third space sponsor, we see triangulation between Oliver's response to Likert item 15, the open-response questionnaire, and interview comments. Finally, Oliver provided specific examples in his interview of how the social capital he gained via BioBus third space sponsorship has been utilized since his time on the bus.

Yom

Yom, an eighth grader, displayed evidence of BioBus third space sponsorship and social capital brokerage between the culture of school science and her lived experience. Evidence for this conclusion was drawn from the data displayed in Table 14 and an analysis of her interview comments below. Less clear is Yom's relationship to the culture of school science and whether or not she can be characterized as an outsider. As a result, only two of the three components of the theoretical framework can be aligned with the data collected. A discussion and evidence for why there was and was not alignment are presented below.

According to her pre-BioBus ATSSA result, Yom held a positive attitude towards science before her BioBus experience (score of 54 out of 70), although, immediately following her time on the BioBus, Yom's ATSSA score decreased by 5 points to 49, resulting in a slightly lower, albeit still positive attitude towards science (> 42). Yom self-reported in her response to Likert item 15 that the BioBus had a neutral effect on her attitude towards science, as she explained in her open-response questionnaire: "I've never hated science. This [neutral score] just means that my attitude [towards] science hasn't changed at all." At least superficially it appeared Yom's attitude towards science was relatively unaffected by her BioBus experience. Below, an analysis of her interview responses further clarifies if this was indeed the case.

During her interview, Yom was asked to compare her normal science classroom to her BioBus experience. The conversation below details two very different perceptions of science:

Yom: Well, they are different in many ways; like I wish science was actually in the bus because it was like cooler and stuff. But it's similar because we have some of the same tool[s], like the microscope—we use that; not all the time, but sometimes a lot. And it's different because we don't usually—we see animals but not rare animals like the *Daphnia*; we have never really seen them. And I think that that is what catches me the most during the BioBus.

Researcher: You said that you wish science class was in the bus. Why do you wish that?

Yom: Because it's cooler; even though we don't move, but the whole BioBus thing—like the shape of it, what is in it and how—you have to keep everything warm because of the animals; how you discover different things; it's like better, because in school, like in science class you can't really go outside and discover different things. We can't really go to a lake right now and find a fish or whatever, but if you are in the bus, then you discover different things.

Researcher: You talked about how you were able to discover things in the bus that you weren't able to discover in the science classroom. What were you able to discover?

Yom: Well, let me talk about last year. Last year we kind of did the same thing [as we recently did on the BioBus] with the cotton swabs; we took our cheek cells [and viewed them under a microscope], but we never put them together [with plant cells] to see the differences.

Researcher: Any other differences you can think about between the bus experience and your normal science classroom experience that you want to talk about?

Yom: Well, [the BioBus scientists] separated us in separate groups because like [the BioBus is] small, so you can't really have so much people in one area because all of the materials.

Researcher: Do you think that it is a good thing or a bad thing that they separate you?

Yom: I think that is good because—we still have to switch [ends of the bus] either way, but I think [being in groups is] better because I think we will listen to each other more instead of being in a big classroom than being together like at least seven people in a group. And I think you will do things faster because maybe we won't get distracted that easily.

Researcher: So it sounds like what you are saying is that you like being in a smaller group—having your class split in half is actually a good thing and helped you learn more.

Yom: Mm-hmm.

By stating "I wish science was actually in the bus," Yom hinted at a desire for science to occur in a venue different from her classroom. In terms of our theoretical framework, Yom's comment could also her to be viewed as an outsider to the culture of school science, although the written explanation for her response to Likert item 15, namely that she does not "hate science," left this characterization open to interpretation. As a result, I will return later to confirm whether or not Yom is an outsider to the culture of school science.

In her comments above, Yom also stated that the BioBus was a space in which she could "discover different things." These discoveries included her most memorable BioBus experience, the opportunity to view *Daphnia*, a "rare animal," under a microscope, as well as the chance to view the differences between plant and animal cells side by side. Furthermore, Yom's retelling of her time viewing *Daphnia* also speaks of the discovery process: "I have never seen [*Daphnia*] and I never even [knew] they existed until I saw it." To that end, Yom, later in her interview, was also able to give a detailed description of everything she remembered seeing and learning about *Daphnia,* from what they ate to how they excreted waste and reproduced. Ultimately, this led Yom to conclude also that *Daphnia* are "strange but kind of cool."

Interestingly, Yom's comments above implied that despite having had the opportunity to use microscopes, "sometimes a lot," in the classroom, the discoveries she made on the BioBus could not have occurred inside of her school. Perhaps, Yom's perception that her science classroom is not a place where discoveries can take place was linked to the constraints of science happening within a building. Indeed, this possibility was supported by Yom's comment, "in science class you can't really go outside and discover different things." Furthermore, the relatively large number of students in her class may have also contributed to Yom's feeling that the classroom is a place where discoveries do not take place. For example, when prompted to highlight further differences between the BioBus and the science classroom, Yom mentioned how the splitting of her class on the bus may have helped facilitate her learning: "I think we will listen to each other more instead of being in a big classroom. . . . And I think you will do things faster because maybe we won't get distracted that easily." Perhaps, in this instance, smaller groupings and the physical space of the BioBus, despite being "small," may have created opportunities for Yom to engage in the discovery process and connect to the culture of school science via third space sponsorship. This possibility is further explored below.

After being asked to make distinctions between the science classroom and the BioBus, Yom was then asked whether or not her experience on the bus made her think differently about science:

> Researcher: Did your BioBus experience make you think any differently about science?
>
> Yom: Yes—yeah, kind of, because I am not like a science person. I like science but I am not crazy about it, but being in the BioBus got me more interested in science because of like the different things. Like I said before, like discovering different animals—like I find that very interesting like—obviously I know that science is to discover different things, but like being in class we don't really think about that; we think about [the] lesson, but in the BioBus I thought like different things like what if I become a scientist, I will discover cool things.
>
> Researcher: So you talked a little bit about what if you were to become a scientist. Is this something you have actually thought about more now?
>
> Yom: Yeah, after the BioBus. After the BioBus we went to the gym and I actually told my friend; I was like, it's pretty cool to be like in the BioBus because you show other people like a scientist, like we had already know,

> but you are discovering the thing; like there are still things in the world that we haven't discovered yet and I find that pretty cool.

At this point, we can refer again to the theoretical framework to further characterize Yom's relationship to the culture of school science prior to her BioBus experience. By stating "I am not like a science person," Yom somewhat painted herself as an outsider to the culture of school science, although immediately following this statement, she offered, "I like science but I am not crazy about it." These two statements, as well as the evidence already presented above, cause ambiguity regarding Yom's relationship to the culture of school science. Despite this lack of clarity, Yom was definitive in mentioning that "the BioBus got me more interested in science." As a result, despite being unsure of Yom's relationship to the culture of school science, it is possible to view Yom's BioBus experience, in terms of this study's theoretical framework, as a third space sponsor. More explicitly, this sponsorship was enacted via the discoveries Yom made viewing *Daphnia* and cells aboard the BioBus.

Yom's newfound connection to the culture of school science and the social capital that it afforded may have led her to consider what it might be like to become a scientist pursuing new discoveries. Furthermore, the social capital Yom may have accessed via the third space sponsorship offered by the BioBus was also seen being incorporated into her lived experience. Evidence of social capital transfer was displayed in the following way, namely Yom found it "pretty cool" to be able to make new discoveries on the BioBus and, as a result, begin to wonder what it might be like to be a scientist and "discover cool things." To that end, Yom pointed out that this wondering about a scientific career and the scientific discovery process was not something that took place within her normal science classroom. As a result, one could argue that these new connections and thoughts about science were due to a direct result of her time spent on the BioBus.

Despite the connections to this study's theoretical framework above, one possible critique of the BioBus experience is how the relatively short amount of time students spend on the bus may inhibit third space sponsorship to the culture of school science and social capital transfer. In fact, it is appropriate to wonder if a one-off science experience has any long-term effect on student perceptions towards science. In the excerpt below, when Yom explained her change in attitude towards science after a BioBus experience, some support was given to this possibility.

Researcher: Do you think you have a different attitude towards science after the BioBus?

Yom: Yes. Like I think I am more positive about science because like talking about my grade in science, that is not really low; I have an eighty something; like an eighty-eight, but I am usually always struggling in science. Sometimes I never do get some formula or for example, we were learning about Newton's Third Law or something like that, but thinking about science, yeah. I think more positive about it because I have reviewed about cells and about different animals and stuff, but now that I actually went in the bus I actually [learned about cells and different animals] again. I think more positive about [science] and, yeah, I think I like science more.

Researcher: Because you were on the bus?

Yom: Yeah.

Researcher: Do you think that is something that will last for a while or do you think that . . .

Yom: Yeah, I think that is something that will last for a while because like I said, I have been thinking about like maybe if I become a scientist. I don't think I am going to become a scientist but what if.

Researcher: How often did you say you've thought about the BioBus since you actually did it?

Yom: Like four or five times.

In the exchange above, it is possible to see how the BioBus's third space sponsorship may allow for acquired social capital enactment. That is, we see third space sponsorship on display when Yom stated that because of the BioBus, she "think[s] more positive[ly] about" science and "like[s] science more now." Furthermore, it was apparent that Yom's BioBus experience and the third space sponsorship opportunity it provided to the culture of school science has had some lasting effect. Indeed, not only has Yom thought about the BioBus "four or five times" since being on it, but she has also thought about what it might be like to become a scientist. As a result, it is possible to hypothesize that some of the social capital Yom acquired during her time on the BioBus is continuing to influence her perceptions of science.

In closing, the case of Yom provides two clear connections to our theoretical framework. First, we see evidence of the BioBus acting as a third space sponsor to the culture of school science. This sponsorship occurred when the BioBus allowed Yom to make discoveries that were otherwise not possible in the science classroom. This ability was due, in part, to the physical setting of the bus itself. Next, we see Yom drawing upon the social capital she gained via the BioBus's third space sponsorship. This sponsorship was on display when Yom detailed her more positive attitude towards science, as evidenced by her new wonderings of what it might be like to become a scientist, although Yom's relationship to the culture of school science was not entirely clear. As a result, despite the temptation to classify Yom as an outsider to the culture of school science, the empirical evidence was not strong enough to do so. The implications of this occurrence, namely the alignment of the collected data with only two of the three theoretical framework components, are discussed in Chapter 5.

Sara

Below, an analysis and discussion of Sara's interview comments, in addition to how the data displayed in Table 14 aligned with all three components of this study's theoretical framework, are presented.

Sara, a ninth grader, had an ATSSA score of 36 before her BioBus experience; revealing an initial negative attitude towards science, although immediately following her time on the bus, Sara's survey score increased by 20 points to 56, indicating a positive attitude change and, consequently, an overall positive attitude towards science. Sara's positive change in attitude was coupled with a response to Likert item 15 in which she strongly agreed that the BioBus positively influenced her attitude towards science. When asked to clarify this response through an open-response questionnaire, she wrote that the BioBus "made me more eager to ask questions and not think that science is all about taking notes but discovering new things." To that end, Sara's interview further supported her more positive attitude towards science and detailed why the BioBus and her ability to make discoveries therein were directly responsible for this change.

When asked what she remembered about the time she spent on the BioBus, Sara was able to recall a wide variety of activities and aspects of the bus. She recalled information about the pellet stove that was used to heat the interior of the bus as well as her experience comparing her classmate's cells to those of a plant under a microscope. It should also be noted that Sara remembered asking a number of questions to BioBus scientists during her time aboard the bus. When asked why she asked so many questions, she replied, "because I was curious, I wanted to know."

Sara was also asked to explain which aspect of the BioBus was the most memorable. The following conversation resulted:

Sara: The *Daphnia* I think.

Researcher: Why?

Sara: Because it was the most thing that was mostly focused on; because I like it the most and I always go back to it—like remember because I have never seen like I never knew you could find it a type of water, like you could just scoop it from the water and you will actually see it.

Researcher: Where can you find it?

Sara: [The BioBus scientist] said around like the river, I think it was and he said that they just need water to survive—like this little food that it brings in the water that I think it was.

Researcher: You said that you have been thinking about [*Daphnia*]. How often have you thought about it since your [BioBus] experience?

Sara: Every time I am in [science] class, because it's like I bring it back to class because it's interesting and I want to know it was like a type of virus or like a bacteria.

From the exchange above, it was apparent that Sara's time viewing *Daphnia* was a memorable one and something she had thought about multiple times since being on the BioBus. In part, this lasting impression may have arisen from her realization that *Daphnia* even existed. Indeed, the discovery of new things aboard the BioBus was commented upon in Sara's open-response questionnaire (see Table 14) and also evident during her interview, as demonstrated below, when she was asked about what she learned during her time on the bus:

Sara: I learned that there is different things—like not everything has been discovered yet but you could find new things every day. And not all bacteria or everything around you need food to survive and even though smallest things, they are actually like—is a living thing—around you like the smallest thing you can probably find; probably has a living thing around it

Researcher: What did you mean by discoveries?

Sara: Like [the BioBus scientist] was just—like the [scientist] in the BioBus with the team in the bus, and then he stopped [the bus on the side of the road] and he scooped water and he looked at it; he discovered [*Daphnia*]; he wasn't expecting it but when he looked at it he found it.

Researcher: So you are talking about when the [BioBus scientist] first found the *Daphnia*, he wasn't expecting to find it in the place he found it. I remember him saying that. He found it in a puddle or some like that right?

Sara: Yeah.

Researcher: He wasn't expecting to see it, so that made you think like oh. . . .

Sara: You could find things anywhere.

Sara clearly remembered that the BioBus scientist was able to find *Daphnia* living in a puddle on the side of the road, although less clear was exactly what Sara thought a discovery entailed. For instance, did she think this was the first time *Daphnia* had ever been discovered or was the fact that the scientist found something he was not expecting to find count as a discovery? Although this distinction was unclear, perhaps more importantly, it was apparent that Sara viewed the BioBus as a place where discoveries have occurred.

Sara was also asked about how the BioBus compared to her normal science classroom. After briefly discussing how her classroom was not powered by solar energy, she focused on detailing the physical environment of the BioBus and noted that her experience took place "outside and on a bus" as the main difference to her science classroom. When asked why she thought it was important to highlight this difference, she explained:

> Because I find it interesting I think. I am used to being upstairs more as in everyday base I think like upstairs, so when we came outside I was like, wow. I am here thinking like they are going to come upstairs and we went outside, we climb the bus and we explore new things there.

Interestingly, despite her class being shown a short clip of what the BioBus looked like (although it was possible she was absent when the clip was shown), she was still surprised that the experience took place outside the walls of the science classroom. Furthermore, she coupled her surprise of leaving the physical space of the science classroom and entering the bus with an ability to "explore new things." This exploration of new things aligned with her comments above as the BioBus being a place of discovery.

Sara was also asked whether or not her BioBus experience made her think any differently about science. She replied affirmatively:

> Sara: Before [the BioBus], I used to think science was more about vocabulary mostly. I used to hate it, because I am really bad at vocabulary and it's like science is a boring subject, I am not going to be interested in this; but I gave [the BioBus] a shot. So when I went to the BioBus, I found [science]

easier because it's like fun and [the BioBus scientists] actually explain things. In science, if you take your time and you ask questions, you actually will understand it. So it helps in class because now I can ask questions and I won't be afraid that I may be wrong. So I think I could just ask my questions, participate better and actually be focused, because before, I use to—I gave up in science; I didn't care anymore about science, but now I just try my best.

Researcher: And that is all because of you BioBus experience?

Sara: I know; I couldn't believe it either. I like the BioBus though.

Researcher: Sounds like you had a really good experience. Just to make sure I heard what you are saying correctly. Before the BioBus, to you, science wasn't something you really were that interested in because it had a lot of vocabulary.

Sara: Yeah.

Researcher: Then you had this BioBus experience and you got to ask a lot of questions and answer your own questions through doing these discoveries; and now that you are back in the classroom, because of this BioBus experience you have started to ask more questions?

Sara: Yeah.

Researcher: And that [has] continued because of this BioBus experience?

Sara: Yeah.

Researcher: So what is it like in the science classroom now that you are asking more questions?

Sara: It's more helpful now because I understand things—like I can take notes now. It's easier for me; it's like I feel like I could actually ask about something I didn't know or like if I am curious, I write it down and ask it after [class] to see if I can actually get help. If not, I attend the study seminar.

Researcher: Were you doing that before the BioBus?

Sara: No. I just use to hate [science], science was not my thing.

Researcher: So would you say that you had a negative attitude toward science before the BioBus?

Sara: Yeah.

Researcher: And now that you have had the BioBus experience your attitude is more positive?

Sara: Yeah.

Researcher: And you can say for sure that it's all because of the BioBus?

Sara: I can say for sure that because of the BioBus.

At this point, it is possible to start connecting Sara's comments about her BioBus experience to our theoretical framework, that is, presenting evidence and examples of our three aforementioned themes (outsider status, third space sponsorship, and social capital transfer).

Sara's outsider status to the culture of school science and the ability of the BioBus to affect this feeling was evident multiple times throughout the excerpts presented above. Within her comments, Sara stated, "I used to think science was more about vocabulary mostly. I used to hate it, because I am really bad at vocabulary and it's like science is a boring subject." Then, when describing her feelings towards science prior to her BioBus experience, Sara again solidified her outsider status when she said, "I just use to hate [science], science was not my thing." Interestingly, in both instances when Sara was describing her feelings towards science prior to the BioBus, she used the past tense. Based on this grammatical analysis, it is possible to infer that Sara no longer had the same negative reaction towards science as she did pre-BioBus. Furthermore, by describing science as being "about vocabulary mostly," we catch another glimpse of how Sara viewed her normal science class. To that end, this depiction of the science classroom differed greatly from the questioning and discovery process that took place on the BioBus. Indeed, the questioning and discovery process aligned well with the second component of our theoretical framework: third space sponsorship. This connection is discussed below.

Sara's time observing *Daphnia*, comparing plant and animal cells, learning about alternative energy sources, having the opportunity to ask questions, and taking part in what she felt was the discovery process of science was representative of third space sponsorship to the culture of school science. Furthermore, Sara "can say for sure" that her shift from a negative to a positive attitude towards science was due to the BioBus experience itself. To that end, this same sentiment was also reflected in Sara's affirmative response to Likert item 15 and greatly improved post-BioBus ATSSA score.

Sara's comments above were also indicative of the third component of our theoretical framework: enactment of social capital. That is, since her time on the bus, Sara had used her third space sponsorship to draw upon the social capital she acquired from the culture of school science back within the classroom. In fact, prior to the BioBus, Sara stated that she "gave up in science" and "didn't care anymore." More recently, and because of her BioBus experience, Sara now tried her "best" and was no longer hesitant to ask questions or "afraid that [she] may be wrong." Furthermore, these behavioral and attitudinal changes, or in terms of this study's theoretical framework the newly acquired social capital she was drawing upon, were allowing Sara to better understand science content within the classroom. Sara also detailed how she now asked questions about things she was curious about and attended study sessions after school when she needed help. Interestingly, she was not doing these things prior to her BioBus experience. As a result, it is possible to conclude that Sara's BioBus experience acted as a third space sponsor to a previously inaccessible culture of school science and, in turn, allowed her draw upon newly acquired social capital back within her science classroom.

In closing, Sara represents a case in which all three elements of the theoretical framework are clearly represented. First, during her interview, Sara was quick to mention the distaste she had for science prior to her BioBus experience. To that end, Sara's pre-BioBus ATSSA score of 36 was also indicative of a negative attitude towards science and her outsider status to the culture of school science. Next, evidence of the BioBus serving as a third space sponsor to the culture of school science was apparent in the way Sara described her ability to make discoveries and ask questions to the staff scientists on board the bus. Other evidence for the BioBus acting as a third space sponsor to the culture of school science was evident in Sara's response to Likert item 15. Therein Sara strongly agreed that the BioBus improved her attitude towards science. Furthermore, an improved attitude towards science was also reflected in Sara's post-BioBus ATSSA score of 56, an increase of 20 points. Finally, Sara's interview comments reflected her ability to draw upon newly acquired social capital from BioBus third space sponsorship in the classroom. This social capital enactment was demonstrated when Sara told of her newfound ability to ask questions and reach new understandings within the science classroom as well as her recent attendance at afterschool study sessions.

Bill

Despite enjoying his BioBus experience, Bill, a ninth grader, had little data that aligned with this study's theoretical framework. Indeed, by analyzing the evidence in Table 14 and his interview comments, I found evidence of only one way in which data collected from Bill's BioBus experience displayed theoretical framework correspondence. Furthermore, the one component, outsider status to the culture of school science, that did demonstrate alignment did so weakly. A presentation of these data and areas of non-alignment is discussed below.

Prior to his BioBus experience, Bill's ATSSA score (45) revealed that he held a slightly positive attitude towards science (> 42). Immediately following his time on the bus, a second ATSSA score reflected a negative attitude towards science (34), a drop of 11 points. Furthermore, Bill self-reported that the BioBus had a neutral impact on his attitude towards science, explaining, "I put [neutral] because nothing will make my view of science [change] because I don't want to be a scientist and I don't get why we are being taught this stuff if I don't want to be a scientist." When Bill was asked to clarify this response during his interview, he replied, “I don’t want to be a scientist because—I guess I could get some of the stuff that we’re learning. Like evolution, I just don’t care about learning all of that.” While somewhat contradictory, the statements above nonetheless allow one to infer that some of Bill’s discontent and general disinterest with becoming a scientist may arise from evolution and the topic’s related concepts. Furthermore, these comments, when juxtaposed with Bill’s post-BioBus ATSSA score, indicated an outsider status to the culture of school science, although this characterization could not be confirmed during his interview. Furthermore, Bill’s interview told a somewhat different story about his attitude towards science and the time he spent aboard the BioBus. This difference, in addition to other places where the data collected from Bill’s BioBus experience aligned with the other two components of this study’s theoretical framework (third space sponsorship and social capital brokerage), is discussed below.

At the beginning of his interview, Bill was able to recall every aspect of his BioBus experience, including what he learned about the bus’s solar panels, stove, *Daphnia,* cells, and microscopes. When asked to explain why he was able to remember so much of his experience, Bill replied, “because I thought it was a cool kind of investigation.” Bill also had a hard time picking out which part (front or back) of the BioBus he found to be the most enjoyable, stating, “they both taught us a lot and [the scientists] made the activity fun.” Bill appeared to have enjoyed multiple aspects of his BioBus experience, an outcome somewhat unexpected given his post-BioBus ATSSA score, response to Likert item 15, and open-response questionnaire comments.

Bill was also asked to explain how his BioBus experience was different from his normal science classroom. The main difference here could be summarized as the fact that Bill felt the

BioBus was able to deliver only the most important aspects of a topic, while school provided much more detail.

Bill: We get more details from the school and with the bus they gave us just the main points.

Researcher: I just want to make sure I understand what you're saying. It sounds like you're saying that in the classroom, you're getting lots and lots of details?

Bill: Yes, since there's more time and then difference with the bus is that they gave us the main points.

Researcher: Main points—you mean, by main points do you mean—do you feel like you're only learning about the things that are really important?

Bill: Yeah, instead of giving us the small details.

Researcher: Okay, do you think that helps you learn in any way?

Bill: I think it did because instead of trying to figure it out yourself, kind of with the—putting together the small details and getting the main point, I think they just gave us the important facts right away instead of saying each little detail one by one.

In this exchange, Bill pointed out that the amount of time spent in the BioBus was shorter than within the science classroom. In Bill's mind, this time differential resulted in more detailed information being presented in the science classroom and only "the main points" being provided by the BioBus. Bill also believed that being given the most "important facts right away" instead of having to put together "the small details" himself was beneficial to his learning.

During his interview, Bill was also asked to explain if anything else was different between the BioBus and his classroom. To this query, Bill noted parallels in the "activities" and "lab studies" completed in the classroom and the BioBus, but emphasized that the bus "knew how to make it fun." He explained, "The structure of the bus and everything made it stand out from any regular bus."

Bill was also asked whether or not he thought any differently about science now that he had a BioBus experience. He replied, "I'm going to go with no, because in science we've learned about the ecosystem and all that stuff. So my perspective changed in science class but I think the BioBus just gave me more information about it." When asked to explain his response in more detail, the following conversation ensued:

> Bill: Because before we did the ecosystem, the lab unit [in science class]; before, I didn't really think about the environment that much. I was probably like—before, I would be like, oh yeah, we should save the environment but I wouldn't get into it. I would just be more independent and not more about the environment. But then after science [class], after I learned all these things, I changed my perspective.
>
> Researcher: So now you care more about the environment because of this experience you had in science class?
>
> Bill: Yeah, because before I didn't have that much information about it.
>
> Researcher: Right. And how does the BioBus fit into that, on the new perspective that you have?
>
> Bill: Because in the science—in our unit, we learned about the ecosystem, but what the BioBus did is that they actually brought a specimen in and we got to see and talk about it and analyze.
>
> Researcher: Anything else [on the BioBus] besides the specimen that has fit into your new perspective of science?
>
> Bill: Also the things that they have, like the furnace; they use the wood pellets to fuel the furnace and give—release heat so they can stay warm. I thought that was pretty cool instead of just wasting energy.

From this conversation, it was evident that a shift in Bill's feeling towards science and, more specifically, the environment, had taken place prior to his BioBus experience. Bill reported that learning about "the ecosystem" gave him more background knowledge and a subsequent new "perspective" about this topic. When asked how the BioBus meshed with his new viewpoint, Bill responded with two examples: a specimen (possibly the *Daphnia*) and the pellet stove. These elements of the BioBus seem to have reinforced, but not further changed, his perspective on the environment that originally occurred within the science classroom.

Bill’s experience aboard the BioBus did not align well with two of this study’s three theoretical framework components. With that said, it is possible to suspect, given Bill’s new “perspective” on the environment, that third space sponsorship to the culture of school science and social capital acquisition may have occurred within his science classroom. Indeed, Bill mentioned that prior to his BioBus experience, his science classroom’s ecosystem unit gave him a new perspective towards science. As a result, we can view the BioBus which “actually brought a specimen” to class for analysis and had a “pretty cool” energy-saving furnace as a reminder of Bill’s connections to the culture of science that occurred during the ecosystem unit. In turn, this reminder may have reinforced any social capital enactment that may have previously occurred within the classroom setting. Finally, the one theoretical framework component that did align with Bill’s collected data was limited. That is, Bill’s outsider status to the culture of school science, while alluded to in the data on display in Table 14, could not be empirically confirmed during his interview. Implications for the non-alignment of the data collected about Bill’s BioBus experience and this study’s theoretical framework are discussed in the next chapter.

Derek

Derek, a Grade 12 student’s data displayed evidence of all three components of this study’s theoretical framework. As a result, Derek could be characterized as an outsider to the culture of school science. Furthermore, Derek’s collected data provided instances in which his BioBus experience served as a third space sponsor. Finally, Derek enacted the social capital he gained via third space sponsorship. Below, utilizing the data in Table 14 and Derek’s interview comments, a more detailed explanation of the aforementioned theoretical connections are construed.

Derek held a negative attitude towards science prior to his BioBus experience, as measured by his ATSSA score (29). Following his BioBus experience, Derek's ATSSA score increased by 12 points and his resulting new attitude towards science could be viewed as being neutral. Derek's response to Likert item 15 demonstrated that he agreed his BioBus experience made his attitude towards science more positive; he wrote in his open-ended questionnaire response, "I enjoyed [the BioBus] a little." Derek's interview revealed some of the reasons why he somewhat enjoyed the BioBus and how this experience positively influenced his attitude towards science.

When asked to recall what he remembered about his BioBus experience, Derek mentioned that his overall experience was "good" and that the solar panels and green roof in particular made an impression on him. When asked to explain why his experience was "good," the following conversation ensued:

Derek:	I'd say, learning new stuff that I'd never learned from any of the other science classes I've had before. I might learn some new—some stuff for college that I can use from the BioBus.
Researcher:	So you say you learned some new stuff right?
Derek:	Yeah.
Researcher:	So what are some of those specific things that you remember learning?
Derek:	Well, I learned how to use that—what's that thing called? I can't remember, it had a long name. . . .
Researcher:	Microscope?
Derek:	Yeah, I learned how to use that, how to focus, how to get closer and all that. How to take my sample, either something from my cheek or spit.

In this instance, we see Derek, a senior in high school, learning something new and making a connection between what he experienced on the BioBus to what he may need to do in college. In particular, Derek highlighted his opportunity to use microscopes as being particularly relevant. Interestingly, Derek revealed later in his interview that this was the first time he had ever had the opportunity to use a microscope.

Derek was also asked to describe how his normal science classroom experience compared to the time he spent aboard the BioBus. When speaking about his science classroom, he explained:

Derek: I mostly just read a paragraph and then they make us do some group work together, write about stuff.

Researcher: This is in the normal science classroom?

Derek: Yeah.

Researcher: Do some reading, do some writing and some group work?

Derek: Yeah. That's all we do, and then on the BioBus you got all the [micro]scopes and technology, all the things that regular science classes don't have nowadays.

Researcher: What do you mean by that? "Things that regular science classes don't have nowadays." What kind of things don't science classes have that you think they should have?

Derek: Like the [micro]scopes, well, we got some flasks but I don't know, technology—we can see what's in the DNA all that type of stuff; really. Because in my science classes, we don't have any of that.

Researcher: So you felt like you had more access to technology on the BioBus that you don't necessarily have in the normal science classroom?

Derek: Yes.

Researcher: Okay. So if there's one thing you could take from the BioBus and put it into a normal classroom, what would it be?

Derek: I'd say the technology, we look at better cells; that type of stuff.

Researcher: So the technology is the key thing for you.

Derek: Yes.

The experience described by Derek in his normal science classroom (reading, group work, and writing) was different from the one he had on the BioBus (microscopes and technology). This stark contrast in technology was crystallized when Derek compared the resources available to him in his classroom, i.e., “flasks,” to what was accessible on the BioBus, i.e., “scopes.” Derek even went as far as singling out the technology available on the bus as something he would bring back into the science classroom if given the chance to do so.

Derek was also asked to describe his attitude towards science before his BioBus experience. He replied, “Originally, I didn’t really care that much for science because it was just something that I regularly learn. Just read, write, just that. And then when I went on the BioBus, I thought of [science] differently.” Furthermore, this comment and others presented below aligned well with Derek’s ATSSA pre- and post-BioBus scores, both of which in combination indicated a shift from a negative attitude towards science to one that could be considered neutral. Furthermore, when Derek was asked if he had a different attitude towards science now that he has been on the BioBus, he replied:

Derek: Yeah, [my attitude towards science] went up—I went to like I really don’t care that I might do [science], something around there.

Researcher: Okay. So your attitude’s a little more positive.

Derek: Yes.

Researcher: So what is it [about your BioBus experience] that made that change in your attitude towards science?

Derek: It was from everything that I had learned when I went on there. Learning about the thing—what’s the name?

Researcher: *Daphnia*.

Derek: Yeah, and about DNA all that type, made [my attitude towards science] go up for me a little bit.

Researcher: And then maybe the technology piece?

Derek: Yeah.

Researcher: So how come that couldn’t happen in your normal science classroom?

Derek: Because we didn’t really do that much—and that’s regular science. Like I said before, all we do is read about it and write and then we do some group work together. Never looking at our DNA, learning about—going outside, any of that stuff.

Researcher: So you like doing the hands-on stuff. You like getting out of the classroom.

Derek: Yeah.

Researcher: You like seeing things, visually.

Derek: Yeah.

Researcher: That was kind of the key for you; and if you had more experiences like that, do you think your attitude towards science would continue to improve?

Derek: Yeah, I believe so.

At this point in Derek's data analysis, it is appropriate to make connections between his BioBus experience and this study's theoretical framework. To begin, it is possible to view Derek as an outsider to the culture of school science based on both his low pre-BioBus ATSSA score of 29 and his comments above. That is, by Derek explaining that before his BioBus experience he "didn't really care that much for science," he indicated that science was not something he particularly enjoyed. Furthermore, this lack of "care" and outsider status may have been in part due to Derek's normal science classroom consisting mainly of repetitive reading, writing, and group work. In comparison, the "technology" on the BioBus provided Derek a different and more enjoyable science experience. The consequences of this experience and its applicability to the second component of our theoretical framework, third space sponsorship, are discussed below.

During his interview, Derek commented that his attitude towards science slightly improved to "I really don't care that I might do science." In turn, I interpreted this comment as evidence that Derek was somewhat more receptive to the culture of school science following his BioBus experience. Furthermore, Derek also reported in his interview that he held a somewhat more positive attitude towards science post-BioBus. This self-reported change also aligned with his change in ATSSA survey scores (+12). Based on this evidence, it was appropriate to use our framework to characterize Derek's BioBus experience as an example of third space sponsorship to the culture of school science. More specifically, Derek's third space sponsorship to the culture of school science can be viewed as his access to and use of technology, namely microscopes, for viewing *Daphnia*, DNA, and cells. Indeed, the technological component of Derek's BioBus experience was so important a link to the culture of school science that he mentioned it as being the one thing he would bring back with him into his classroom.

Despite the two theoretical connections above, it was somewhat more difficult to find evidence of our third framework component: social capital enactment. With that said, one instance in which I did interpret Derek drawing from social capital gained via third space sponsorship was when he spoke of his opportunity to utilize the BioBus's technology and microscopes. Indeed, Derek mentioned these two aspects of the BioBus experience as being a way in which he could be better prepared for college. To that end, given the data collected, it was difficult for me to get a true sense of whether or not Derek's BioBus experience allowed him to utilize any of the social capital he may have acquired via third space sponsorship. As a result, I suggested that Derek drew upon any gained social capital in a limited fashion.

In closing, the case of Derek provides evidence for all three components of our theoretical framework. To that end, Derek clearly identified as an outsider to the culture of school science across two data collection instruments (pre-BioBus ATSSA and interview). Furthermore, Derek mentioned specific aspects of his BioBus experience (microscopes and technology) as being responsible for his more positive attitude towards science and, in regards to our framework, provided evidence of the BioBus serving as third space sponsor to the culture of school science. Finally, albeit in a limited fashion, there is evidence of Derek utilizing the social capital he gained during his BioBus experience.

Indira

The case study of Indira provides strong evidence for only one of the three elements of the theoretical framework. That is, Indira's collected data allowed me to identify her easily as an outsider to the culture of school science, but did not provide evidence of this study's other theoretical framework component. Reasons for both theoretical framework alignment and non-alignment were drawn from the data in Table 14 and Indira's interview comments below.

Prior to her BioBus experience, Indira, according to her pre-BioBus ATSSA score of 30, had a negative attitude towards science. Furthermore, Indira's response to Likert item 15 revealed that she "disagreed" that the BioBus made her attitude towards science more positive. To that end, this sentiment was supported by her open-ended questionnaire response to Likert item 15, in which she explained, "The BioBus was not interest[ing] to me." Finally, following Indira's BioBus experience, her ATSSA score decreased by 12 points. Excerpts from Indira's interview support and unveil the underlying reasons for these occurrences.

When asked to recall what she remembered about her BioBus experience, Indira briefly mentioned the time she spent viewing *Daphnia* under the microscope. She explained this experience as being the most memorable because "the school really don't have microscopes and we don't get to look at cells like that." In fact, one reason why Indira may have mentioned her opportunity to use microscopes as being the most memorable part of her BioBus experience was because it was the first time she had used one in her life.

Indira also made other comparisons between her BioBus experience and her science classroom. There are detailed below:

Indira: The BioBus, *Daphnia*, is a real thing and from my class we do experiments but they're not from real-life experience. Or like—oh, what would happen to the average rate of a smoker. So the BioBus is like more real-life out there type science; and my class science is just like regular school, they're not outside experimenting with different things.

Researcher: So you were able—it sounds like you were able to make a real-life connection to the BioBus and not so much in the science classroom?

Indira: Yeah.

Researcher: Why do you think that is?

Indira: I think it's because—I don't know, maybe it's because the school doesn't let us do outside experiments because they're worried that some of us students might do something wrong, and on the BioBus it's out there. It's more interesting and it could help or fix or change the world than what we're learning in school.

Researcher: What do you mean it can help or fix or change the world? What do you mean by that?

Indira: Like—*Daphnia*, it cleans water. If we had more—if the school would let us do stuff like that, maybe we—as calling us the next generation, we can help by—not being only by being this age to help earth or our planet.

Researcher: So you feel like in some ways the school is handicapping you or not letting you do what you're capable of?

Indira: Yeah, like not letting us do what we're capable of.

Researcher: And the BioBus, you felt, gave you an opportunity to do those kind of things?

Indira: Mm-hmm.

From the exchange above, it is evident that Indira viewed school science and perhaps even school itself as constraining. In contrast, Indira described the BioBus as being more in line with the way she believed science should occur, namely, her BioBus experience was "like more real-life out there type science." Furthermore, Indira's comments allowed me to characterize her, in terms of this study's framework, as an outsider to the culture of school science. In fact, Indira saw a disconnect between what her school aspired for its students to be, “the next generation,” and what they were actually allowed to do in the science classroom—“the school doesn’t let us do outside experiments because they’re worried that some of us students might do something wrong.” While it may or may not be true that her school did not allow its students to experiment outside of the classroom, more importantly, Indira felt that this type of science experience was not likely to occur.

Later in her interview, Indira was asked to reflect on whether or not the BioBus positively influenced her attitude towards science:

> Indira: Not really, because I don’t know—science to me, some parts are interesting, other parts are not—and like I completely hate science. And it could do with the fact that it has a little bit to do with math, and I’m not that well in math.
>
> Researcher: Okay. I think that’s totally fine; science doesn’t have to be everybody’s thing. But you did say that maybe there was—it sounded like [previously in the conversation] you said there were some things maybe on the BioBus that you found enjoyable or made you maybe have a positive attitude towards science. What would those things be?
>
> Indira: I think it was the microscopes, looking at it, zooming into *Daphnia*—so I really—because I really don’t like science. I would say science during my four years was mostly my struggle points; after the BioBus it really hasn’t changed my impairments to science.

From this exchange, Indira’s outsider status to the culture of school science was cemented to our framework when she stated, “I completely hate science,” and then again later on, “I really don’t like science.” Even when pressed to highlight something she enjoyed on the BioBus, Indira briefly mentioned her time viewing *Daphnia* before quickly shifting into another explanation on her dislike of science and how the BioBus “really hasn’t changed my impairments to science.”

Later during in her interview, I asked Indira if there was anything on the BioBus she would have brought back into the classroom that could have made her science experiences more enjoyable during her four years of high school. Indira replied, “Well, let’s go outside of the school and experiment or let’s go out of the classroom besides the BioBus to other places that have science center[s] out there.” Interestingly, Indira selected something from her BioBus experience that had taken place outside, that cannot physically be brought back into the science classroom. Here again, Indira’s desire to physically get out of the science classroom was palpable. It is likely that this desire to leave the classroom, at least in part, stemmed from science being “mostly [her] struggle points” during her time in high school. In fact, it appeared that Indira had become so turned off by the culture of school science that she did not feel it was possible for science, at least how she defined it, to take place within the traditional science classroom.

In the case of Indira, we saw only one element of the theoretical framework that completely aligned with the data collected: outsider status to the culture of school science. In fact, this particular characterization was triangulated through Indira’s pre- and post-BioBus ATSSA scores (30 and 18, respectively), response to Likert item 15 (disagree), and interview comments. Unfortunately, though, Indira’s BioBus experience did little to reverse her outsider status. Indeed, there was only limited evidence of the second theoretical framework component, third space sponsorship, taking place in the form of Indira’s ability to view *Daphnia* under a microscope. Furthermore, this experience was not enough for Indira to overcome her past negative experiences in the science classroom. As a result, Indira’s collected data demonstrated that the BioBus was incapable of fully sponsoring her connection to the culture of school science and, consequently, not allowing for the third component of our theoretical framework, social capital enactment, to take place.

Summary of Participant Case Study Findings

In the eight case studies outlined above, the data collected from pre- and post-BioBus ATSSA surveys, Likert item 15, an open-response questionnaire, and interviews were presented for two students from each grade (6, 8, 9, and 11/12) from the four different schools within this study. Furthermore, of the two students interviewed in each grade, one exhibited extreme positive changes in pre- to post-BioBus ATSSA scores while the other displayed extreme negative changes. In this way, our case studies represented students who, at least in terms of the ATSSA survey, had much larger changes in their attitude towards science following a BioBus experience than their classmates.

Furthermore, for each case study, attempts were made to connect the data associated with each participant to this study's overarching theoretical framework. As a review, Table 15 contains a synopsis of whether or not, and in what fashion, these connections could be made to each of this study's three theoretical framework components. The viewing of this display indicates that the extreme positive change participant within each grade level (Penelope, Oliver, Sara, and Derek) demonstrated evidence in alignment with all three components of the theoretical framework. In comparison, none of the extreme negative change participants (Janis, Yom, Bill, Indira) in any grade aligned with all three theoretical framework components. The implications of this finding and those alluded to above are discussed in the next chapter.

Summary of Chapter 4

In this chapter, the findings related to each of this study's two research questions were presented. Findings were drawn from the data collected and analyzed from pre- and post-BioBus ATSSA surveys, Likert item 15, an open-ended questionnaire, the constructed case study setting narrative

Table 15

Case Study Findings and Theoretical Framework Alignment

Name	Grade	Type of Attitude Change	Is evidence present for element of theoretical framework?		
			Outsider Status	Third Space Sponsorship	Social Capital Enactment
Penelope	6	Positive	Yes	Yes	Yes
Janis	6	Negative	No	Limited	No
Oliver	8	Positive	Yes	Yes	Yes
Yom	8	Negative	Not clear	Yes	Yes
Sara	9	Positive	Yes	Yes	Yes
Bill	9	Negative	Yes, limited	No	No
Derek	12	Positive	Yes	Yes	Yes, limited
Indira	12	Negative	Yes	Limited	No

and associated observations, and eight interviews. Furthermore, data that led to this study's findings were displayed in a variety of tables and one figure. Finally, for purposes of convenience, summaries of the findings aligned with each research question were available at the end of each corresponding section.

CHAPTER 5: CONCLUSION

This study set out to explore the role informal science education settings like those represented by particular aspects of the BioBus experience may play in easing tensions between the cultures of urban youth and school science—a possibility often mentioned (Gutiérrez et al., 1997; Gutiérrez et al., 1999; Moje et al., 2001; Moje et al., 2004; Taylor, 2006) but not fully explored. Indeed, a large number of urban youth continue to sit in our nation's science classrooms disinterested and alienated (Basu & Calabrese Barton, 2007; Crane, 1994; Emdin, 2010a; Fadigan & Hammrich, 2004; Lemke, 1990; Osborne et al., 2003).

While this problem in itself is not a new one, the lack of progress made towards addressing it provides all the more reason for it to be further investigated. To that end, a failure to research and address this problem further will result in not realizing the goal of science education reformers to support a science-literate citizenry and losing the opportunity to develop a diverse and robust source of talent for science-related careers. In the opinion of this researcher, however, perhaps even more disconcerting is the fact that if this problem is left to fester, it will manifest in preventing urban youth from reaching their full potential. That is, by being barred access to the culture of school science, urban youth will miss the opportunity to acquire knowledge and skills that could otherwise be utilized to better oneself, one's family, and one's community.

To address the cultural clash between urban youth and school science, a number of scholars (National Research Council, 2009; Rahm & Ash, 2008; Stocklmayer et al., 2010) as well as this researcher have suggested that informal science education settings must play a role. Indeed, it was the purpose of this study to determine the validity of this claim by examining the perceptions urban youth had of their BioBus experience and the effect the experience itself had on their attitude towards science.

Before presenting the conclusion of this study, it should be noted that the discussion below addresses each of this study's research questions in sequence. This approach is utilized to make clear connections between the findings associated with each question and the conclusions being drawn from them. Moreover, after conclusions for each research question are presented, the implications of this study's findings, including a discussion of the merits of the theoretical framework guiding the research, are juxtaposed with prior science education research. Finally, this study's limitations and suggestions for further research are outlined.

Conclusion—Research Question 1

How did the attitude towards science of urban youth change following a BioBus experience?

What changes occurred for the entire sample?

The first conclusion associated with this study arose from an increasingly fine-grained data analysis of participants' pre- to post-BioBus ATSSA scores. When the entire sample was analyzed, it was determined that the ATSSA survey revealed a statistically significant ($p < .05$) positive change in participants' attitude towards science following a BioBus experience (see Table 5), although effect size was small ($d = .141$). The mixed signals received from these findings were further in evidence when participants were sorted by grade level. That is, 3 of 4 grades (6, 8, 9) displayed a mean positive shift in attitude towards science, while one grade (11/12) displayed a negative change. Moreover, none of these grade-level changes were statistically significant ($p < .05$).

To address what appeared to be mixed findings, I adjusted the data analysis grain size to a finer level. This was completed by grouping the study's participants by their change (positive, negative, or neutral) in pre- to post-BioBus ATSSA scores (see Table 6), thus providing a more definitive conclusion. That is, after a BioBus experience the ATSSA instrument detected both positive and negative changes in participants' attitude towards science.

One finding in support of this conclusion was the fact that both positive and negative groupings, when analyzed independently across all grade levels, exhibited statistically significant changes ($p < .001$) with a large effect size in their attitude towards science following a BioBus experience (see Table 6). Additionally, this finding helped explain why mixed findings were seen at a more coarse grain size. That is, the relatively similar percentage of participants from the entire sample with any type of positive or negative change in their attitude towards science (45.6% and 43.9%, respectively) had counteracted each other (see Table 6).

Other findings supporting the conclusion that participants' attitude towards science had both positive and negative changes after a BioBus experience came from a closer analysis of the type of attitudinal change (positive/negative) exhibited by participants across grade levels (6, 8, 9, 11/12). When this analysis was completed, it was determined that pre-BioBus attitude scores for all groupings were relatively similar (see Table 6). In fact, across all grade levels, negative groupings initially held a slightly more favorable attitude towards science than positive groupings. However, following a BioBus experience, these attitude score relationships were reversed. That is, all positive groupings' mean attitude scores were higher than their negative counterpart. Finally, of note here is that a similar trend as the one highlighted above was also on display when participants exhibiting extreme changes in their attitude towards science were analyzed in a similar fashion (see Table 8). As a result, when taken in combination, these findings suggested that participants exhibiting changes in their attitude towards science did not do so because they were already leaning in one particular attitudinal direction prior to their BioBus experience.

What changes occurred at each grade level?

The next conclusion drawn from the findings of this study was younger students' attitude towards science (Grades 6, 8, 9) changed more positively (and less negatively) than Grade 11/12 students after a BioBus experience. This conclusion was drawn from findings across grade levels (see Table 5), type of attitude change (see Table 6), and the 14 items within the ATSSA instrument (see Table 7).

One finding in support of the aforementioned conclusion was that, when taken as a whole, participants in Grades 6, 8, and 9 had a positive change in their mean attitude towards science following their BioBus experience, while participants in Grade 11/12 had a negative change (see Table 5). Another finding lending further support to this conclusion was that lower grade levels (6, 8, and 9) had a larger percentage of students displaying positive changes (and less negative changes) in their attitude toward science than Grade 11/12 (see Table 6). Additionally, the ATSSA item analysis (see Table 7) determined that Grade 6 and 8 mean responses across the instrument were generally more homogeneous, meaning there were fewer pronounced differences between positive and negative groupings, than high school grade levels (9 and 11/12). As a result, the aforementioned findings, when taken in combination, led me to conclude that younger participants' attitude towards science had more positive and less negative changes after a BioBus experience than those who were older.

What changes occurred for extreme cases at each grade level?

Findings from this study's finest grain size data analysis of the ATSSA came from participants exhibiting extreme changes in their attitude towards science following a BioBus experience. For the purposes of this study, extreme cases were considered to be participants whose change in pre- to post-BioBus ATSSA scores were outside of +/- 2 *SD* and determined independently for each grade level.

The first conclusion drawn from the findings of extreme cases was that participants exhibiting extreme positive changes in their attitude towards science following a BioBus experience could, in a sense, be characterized as being more "extreme" than those of participants exhibiting extreme negative changes. For example, 32.1% of all participants exhibiting any type of positive change in their attitude towards science following a BioBus experience were categorized as extreme, in comparison to 19% of participants displaying any form of negative change (see Table 8).

Similarly, when extreme case participants were grouped by grade, there were a larger proportion of extreme cases for positive change groupings than negative. Additionally, changes in mean scores of extreme positive groupings for the entire sample and across all grades were larger than those of their negative counterpart (see Table 8). Finally, when all 14 items of the post-BioBus ATSSA were analyzed (see Table 9), it was determined for the entire sample that the mean responses for extreme positive cases were all favorable ($M > 3$), whereas only seven items' mean responses for extreme negative cases were unfavorable ($M < 3$). Likewise, the same trend was seen again when grades were analyzed individually. Based on these particular findings, I concluded that after a BioBus experience participants exhibited more extreme positive changes in attitude towards science than negative changes.

Summary of Conclusion—Research Question 1

In closing, three conclusions were drawn from of an increasingly fine-grained data analysis of the quantitative pre- to post-BioBus ATSSA. First, it was determined that the attitude towards science of urban youth changed in statistically significant ways, both positively and negative, after a BioBus experience. Next, I concluded that lower grade level participants of this study (6, 8, and 9) exhibite more positive (and less negative) changes in their attitude towards science following a BioBus experience than participants in Grade 11/12. Finally, it was concluded that after a BioBus experience a larger portion of participants exhibiting any type of positive change in their attitude towards science being categorized as extreme, in comparison to participants displaying any type of negative change.

Conclusion—Research Question 2

How did urban youth respond to their BioBus experience?

Conclusions associated with Research Question 2 were drawn from findings associated with data collected after a BioBus experience. In particular, these findings came from student responses to Likert item 15 (The BioBus experience has made my attitude towards science more positive), an open-response questionnaire, and eight case studies that were constructed via an analysis of all aforementioned data collection instruments as well as survey data and participant interviews.

Overall, the participants of this study enjoyed their BioBus experience. This conclusion was made after responses to Likert item 15 demonstrated that 72% of all participants agreed or strongly agreed that their BioBus experience made their attitude towards science more positive (see Figure 6). To that end, the mean response for all participants to Likert item 15 was 3.9 out of a possible 5 (see Table 10), near the selection choice of “Agree” available on the ATSSA survey.

Additionally, a qualitative analysis of students' post-BioBus open-response questions revealed that 78.3% of all participants made at least one positive comment about their BioBus experience (see Table 12). As a result, I can confidently conclude that a large portion of this study's participants responded favorably to their BioBus experience.

How did responses differ among grades?

Another conclusion associated with this study's second research question is that younger participants tended to enjoy their BioBus experience more so than older participants. That is, this study's findings revealed that lower grade levels (6, 8, and 9) were likely to agree more strongly with Likert item 15, that their attitude towards science following a BioBus experience became more positive, than participants in Grade 11/12. More specifically, students in Grades 6, 8, and 9 agreed and strongly agreed (78%, 79%, and 69% of the time, respectively) that the BioBus positively changed their attitude towards science, while the same levels of agreement was true of participants in Grade 11/12 only 41% of the time (see Figure 6). Conversely, lower grade levels (6, 8, and 9) disagreed or strongly disagreed that the BioBus did not positively influence their attitude towards science only 3%, 7%, and 10% of the time, respectively, while Grade 11/12 selected one of these two responses 20% of the time.

A second finding in support of the conclusion that younger participants responded more favorably to their BioBus experience than older participants was revealed when students were grouped by the type of attitude change they exhibited (positive, negative, neutral) in pre- to post-BioBus ATSSA scores. That is, students in lower grades (6, 8, and 9) across all types of ATSSA changes consistently had mean responses to Likert item 15 greater than students of comparative groupings in Grade 11/12 (see Table 10). For example, when all participants in one grade were analyzed, it was found that those in Grades 6, 8, and 9 had higher mean responses to Likert item 15 (4.1, 4.0, and 3.9, respectively) than participants in Grade 11/12 (M = 3.4).

A final finding in support of lower grade level participants being more likely to enjoy their BioBus experience became evident when the open-ended response questionnaire was analyzed (see Table 13). From this analysis, I determined that participants in lower grade levels were more likely to make positive comments about their BioBus experience than older participants. That is 81%, 83.4%, and 77.4% of participants in Grades 6, 8, and 9, respectively, made at least one positive statement about their BioBus experience, while 70% of participants in Grade 11/12 did similarly. Finally, this finding was constant across virtually all types of changes (positive/negative) in participants' pre- to post-BioBus ATSSA scores. As a result, I was able to conclude further that younger participants enjoyed their BioBus experience more than older participants.

How did responses differ among positive, negative, and neutral groupings?

Another conclusion associated with the second research question was that a participant's enjoyment of his or her BioBus experience aligned with his or her type of ATSSA attitude change. That is, students exhibiting positive changes in pre- to post-BioBus ATSSA scores consistently responded more favorably to their BioBus experience than those with negative changes (see Table 10).

Evidence from the data displayed in Table 10 that supported this conclusion was that the mean response to Likert item 15 for students exhibiting a positive change in ATSSA scores was 4.3. This mean response was indicative of these participants being in stronger agreement than neutral and negative change groupings (3.8 and 3.7, respectively) regarding the positive effect their BioBus experience had on their attitude towards science. Additionally, positive groupings across all grades tended to agree more favorably than negative groupings that the BioBus had a positive effect on their attitude towards science. The only exception to this pattern occurred in Grade 6 in which positive and negative groupings had equal mean scores.

An additional finding that supported my conclusion above was that 84.9% of students within the positive change ATSSA grouping, 76% in the neutral, and 71.2% in the negative made at least one positive statement about their BioBus experience on the open-response questionnaire (see Table 12). As a result, I was able to conclude more strongly that a participant's enjoyment of the BioBus experience aligned with his or her type of change in pre- to post-BioBus ATSSA scores.

How did responses differ between positive and negative extremes?

Conclusions related to the responses that extreme case participants had about their BioBus experience were drawn from both quantitative and qualitative findings. Quantitative findings came from this study's attitudinal survey (ATSSA) and responses to Likert item 15, while qualitative findings came from both open-ended questionnaire responses and the eight case studies presented in the previous chapter. The choice to focus closely on extreme cases was done purposefully to provide a thick and rich description of a BioBus experience for those who were influenced by it to the greatest degree.

As a whole, all extreme cases, both positive and negative, enjoyed their BioBus experience. This conclusion was supported by a number of findings. First, it was determined that combined groupings of participants with extreme positive or negative changes in attitude towards science responded favorably ($M = 3.9$) to Likert item 15 (see Table 11). This mean response indicated that both groups, in combination, agreed that the BioBus experience made their attitude towards science more positive. Additionally, when groupings were analyzed individually, it was found that the extreme positive grouping had a mean in strong agreement with Likert item 15 (4.4) and that even the extreme negative grouping had a mean response demonstrating some form of agreement (M = 3.4).

Another finding supporting the conclusion that participants exhibiting extreme changes in their attitude towards science enjoyed their BioBus experience came from the responses to the open-ended questionnaire (see Table 12). That is, 78.2% of participants in combined extreme positive and negative groupings made at least one favorable statement about their BioBus experience. Moreover, almost all extreme positive participants (88.6%) and the majority of those constituting the extreme negative grouping made at least one positive statement about the BioBus on the open-ended questionnaire (60%).

When extreme case participants were sorted by grade level, it was concluded that younger students generally responded more favorably to their BioBus experience that older students. One finding to support this conclusion came from mean response scores to Likert item 15 (see Table 11). With all extreme cases within a grade combined, it was determined that Grades 6, 8, and 9 agreed more strongly that the BioBus experience positively affected their attitude towards science (M = 4.2, 4.2, and 4.1, respectively) than Grade 11/12 (M = 3.1). Additionally, when analyzed by type of attitudinal change (positive/negative), a similar trend emerged. That is, extreme positive change groupings for Grades 6, 8, and 9 were in greater agreement with Likert item 15 (M = 4.6, 4.4, and 4.4, respectively) than Grade 11/12 (M = 4.0). Similarly, extreme negative change groupings in Grades 6, 8, and 9 were also in greater agreement (M = 3.8, 4.0, 3.7, respectively) than Grade 11/12 (M = 2.2) with Likert item 15. As a result, differences between mean scores for positive and negative extreme change groupings were more homogeneous for Grades 6, 8, and 9 (0.7, 0.4, 0.9, respectively) than for Grade 11/12

(1.8), which speaks further to the differences between this study's younger and older participants.

Another set of findings supporting the conclusion that younger extreme case participants enjoyed their BioBus experience more so than older extreme cases was drawn from open-response questionnaires (see Table 13). When extreme cases were sorted by grade and type of attitude change, it was determined that when positive and negative participants were combined, a higher percentage of participants in Grades 6, 8, and 9 made at least one positive comment about their BioBus experience (81%, 83.4%, and 77.4%, respectively) when compared to those in Grade 11/12 (70%). To that end, a somewhat similar trend was noticed when extreme cases were analyzed by type of attitude change (positive/negative). However, this time, the division between young and old participants followed a separation that saw this study's participants within Grades 6 and 8 on one side of the divide and those in Grades 9 and 11/12 on the other.

For example, a higher percentage of extreme positive change participants in Grades 6 and 8 made at least one favorable comment about their BioBus experience on the open-response questionnaire (88.6% and 93.5%, respectively) than similar participants in Grades 9 and 11/12 (84% and 75%, respectively). To that end, extreme negative cases followed a similar and, in this instance, a more distinct division. That is, the percentage of extreme negative participants in Grades 6 and 8 who made at least one favorable comment about their BioBus experience was greater (71.4% and 71.2%, respectively) than similar participants in Grades 9 and 11/12 (64.7% and 62.7%). Once again, with the addition of open-response questionnaire findings, I can further conclude that younger participants who exhibited extreme changes in their attitude towards science enjoyed their BioBus experience more than older participants.

Observational Data

Observational data demonstrated that students were most engaged and interested in the BioBus experience during those instances when they were directly able to manipulate scientific tools and equipment and interact in small groupings under the guidance of a scientist. These heightened levels of engagement were determined to have occurred in particular during the *Daphnia* experience. That is, when students were using the research-grade microscopes in groups of 3 to 5 at the front activity station, their conversations were animated and focused at levels greater than what was witnessed during other aspects of a BioBus experience. Furthermore, it was during these times when scientists took a step back from their "expert" role and joined students in the discovery process of science that it appeared a community of learners was created.

Extreme Case Study Interviews

Eight semi-structured interviews were completed to gain a deeper understanding of how students within this study's extreme change groupings responded to their BioBus experience. A robust and detailed analysis of each student interview and the findings associated with them can be found in the preceding chapter (see Table 15). Based on these findings, I was able to conclude that, generally speaking, interview participants enjoyed their BioBus experience. That is, all eight students interviewed shared at least one thing they found interesting or liked about their time aboard the bus. That said, not all participants responded with equal enthusiasm, some giving much more praise to the BioBus experience than others.

While many students often stated that the BioBus was "cool" or "fun," others went as far as wishing that their normal science class was "actually in the bus." In fact, being able to get outside of the classroom and "explore" or make "discoveries" was often mentioned as one of the best parts of the BioBus experience. Other praise for the BioBus was generated from students who gained new perspectives towards science. A few students, many of whom initially disliked or even used to "hate" science, stated that their BioBus experience made them no longer think that science was "boring." Additionally, one student referred to his time on the bus as "one of the first times I've ever been so interested in science." Moreover, the reasons this study's participants gave for why they enjoyed their time on the BioBus varied, but in particular viewing *Daphnia* under microscopes and having access to materials and technology not available in a normal science classroom were often mentioned. To that end, a few also reflected on how their BioBus experience was the first time they had ever had the opportunity to use a microscope.

Besides being an enjoyable experience, many students also confirmed in their interviews that the BioBus had at least some positive influence on their attitude towards science. In fact, all four students interviewed who had demonstrated extreme positive changes in pre- to post-BioBus ATSSA scores stated during their interview that the BioBus had a positive effect on their attitude towards science. Furthermore, two students with extreme negative changes in their ATSSA scores (Janis and Yom) also self-reported that the BioBus had at least some positive effect on their attitude towards science. Of the other two students who did not feel that the BioBus positively influenced their attitude towards science, one responded that the BioBus reinforced a recent positive attitudinal shift that had occurred within the science classroom (Bill), while another participant's (Indira) responses indicated how an accumulation of negative classroom science experiences had completely turned her off to anything science-related.

In closing, the interview findings further supported the conclusion presented above that participants exhibiting both extreme positive and negative changes in their attitude towards science enjoyed the BioBus experience. Additionally, extreme positive change participants appeared to enjoy their BioBus experience more so than those exhibiting extreme negative changes in their attitude towards science.

Summary of Conclusion—Research Question 2

In sum, three conclusions were drawn from the findings associated with Likert item 15, an open-response questionnaire, observations, and the eight case studies. First, it was apparent that a large majority of this study's participants enjoyed their BioBus experience. Second, the level of enjoyment participants had on the BioBus generally corresponded with the type of change (positive/negative) in their pre- to post-BioBus ATSSA scores. Finally, this study's younger participants were more likely to enjoy their BioBus experience than its older participants.

Discussion of Research Questions 1 and 2

The purpose of this discussion is to outline and reflect upon the nature of the data that were collected herein and how their subsequent analysis may influence one's interpretation of this study's conclusions. To begin, this study utilized a mixture of both primary (i.e. survey, interview, questionnaire) and secondary (i.e. observational) level evidence. With that having been said, it is possible that those reading this dissertation may be more critical of the findings and conclusions being drawn from secondary observational evidence in comparison to those that are crafted from primary evidence sources like surveys and interviews. In particular, within Chapter 4 observational data were utilized to characterize certain student-to-student interactions taking place during the BioBus experience as being akin to a cypher. While what I described taking place during the BioBus likely fell short of the interactions that occur during a true cypher, readers should be aware that this image was evoked to characterize student-to-student interactions in these instances as being indicative of this study's participants being at ease within the research setting. Furthermore, the image of the cypher was presented as a means to provide evidence of times when heightened student engagement occurred during a BioBus experience.

Another interesting development that took place during this study's data analysis was that the survey data collected told a much different story than originally anticipated. At the outset of this research I had expected that a BioBus experience would positively change the attitudes towards science of a majority of this study's participants. In part, this assumption was made based on my students past experiences on the BioBus which I perceived at the time they took place to be overwhelmingly positive. However, when I analyzed the survey data collected, this assumption was somewhat off base. As a result, the even split between participants exhibiting positive and negative changes in their attitude towards science required another level of analysis. Interestingly, when participants were grouped by type of attitudinal change, a new lens through which to analyze other data collection intstruments was created. More specifically, attempts were made to detail why this particular split occurred. However, despite my effort to unearth an empirical reason for why this split took place, I was left with a more muddled picture. To help clarify this picture I have triangulated the survey data collected with the other instruments utilized within this study in the space below.

One misalignment that arose within this study's data analysis was that despite a relatively equal number of participants exhibiting both positve and negative changes in their attitude towards science, an analysis of Likert item 15 and the open-response questionnaire demonstrated that a majority of this study's participants enjoyed their BioBus experience. As a result of these findings I initially questioned whether or not the survey utilized for this study was chosen appropriately or capabale of reflecting this study's participants true attitude towards science. Indeed, the survey utilized herein was orginally developed to give a general snapshot of students' attitude towards science and may not have been sensitive enough to determine changes in the perceptions students held of the type of science they were presented with during a BioBus experience. That is, it is possible that when students were taking the attitude survey they responded based on their feelings towards classroom science and not the more real-world science typified by the BioBus.

Alternatively, and as alluded to above, one could suggest that Likert item 15 and the open-response questionnaire that this study's participants completed may have disrupted the reliability of the attitude survey utilized. However, the researcher feels that this occurrence is unlikely as participants probably did not view Likert item 15 or the open-response questionnaire until after they had completed the original attitude survey. Furthermore, each instrument was analyzed separately. As a result, I suggest that instead of viewing the variety of instruments utilized herein as disrupting reliability, they be viewed as creating a new opportunity to interpret the findings of this study. For example, because this study's attitudinal survey demonstrated that participants exhibited both positive and negative changes in their attitude towards science it is likely to suspect that something akin to a cognitive dissonance may have taken place during a BioBus experience. That is, perhaps students who initially thought they were interested in pursing science as a career came in contact with real scientists and research-grade equipment and, as a result, no longer felt an affinity towards this particular career path. Conversely, students who may have been turned off by the way science was presented within their classroom may have seen the type of science they participated in during their BioBus experience as being more attractive than they had originally thought.

Another way in which the conflicting results of this study's attitudinal survey and other data collection instruments created an opportunity for interpretation of the BioBus experience rested upon the fact that students did not necessarily need to have positive shifts in their attitude towards science to enjoy mobile science lab experiences. That is, a majority of participants exhibiting negative changes in their attitude towards science still responded favorably to their BioBus experience. This finding in itself has interesting implications for the field and will, alongside others, be discussed below.

Implications of the BioBus Experience

The implications of this study are presented in a manner that addresses the prior research domains of attitudinal, informal science, and the broader field of science education research. Herein, I put forth ways in which the conclusions and findings associated with this study aligned with and deviated from prior studies. In addition, suggestions for how lessons learned from this study can be utilized to inform future research are offered.

Findings from this study led me to conclude that this study's participants exhibited both postive and negative changes in their attitude towards science following a BioBus experience. The implications of this conclusion are many. To begin, this conclusion and its associated findings add to the already existing body of work that supports the position that short-duration informal science education experiences may influence student attitude towards science (Knapp, 2000; Koran et al., 1989; Laursen et al., 2007; Stocklmayer et al., 2010), be remembered well after a visit (Falk & Dierking, 1997; Knapp, 2007; Wolins et al., 1992), and encourage students to pursue a science career (Cosmos Corporation, 1998; Emdin, 2012; Salmi, 2003).

Additionally, this conclusion runs counter to the opionon those who may critique short-duration experiences as being incapable of causing changes in student attitudes towards science. That is, the finding of statistically significant results warrants additional attention. Moreover, by advocating for greater implementation of mobile science lab experiences like those offered by the BioBus, this researcher adds further support to those who have already suggested the necessary role informal science education settings must play in fully engaging urban youth with the culture of school science (Banks et al., 2007; Hofstein & Rosenfeld, 1996; National Research Council, 2009; Stocklmayer et al., 2010), and positively affecting changes in student attitude towards science (Finson & Enochs, 1987; Gibson & Chase, 2002; Haladnya et al., 1982; Jarvis & Pell, 2002a, 2005; Sorge et al., 2000).

That said, my suggestion for more widespread dissemination of mobile science lab experiences may seem irresponsible or incompatible with the total evidence from the study. This includes the finding in this study that demonstrated an equal number of participants exhibiting positive and negative changes in their attitude towards science. As a result, before mentioning further implications, this possible contradiction must be unpacked. Moreover, one should remember that the results displaying negative changes in participants' attitude towards science were drawn solely from the quantitative ATSSA survey instrument and did not include the findings from this study's qualitative data collection methods. As a result, some of the more nuanced findings uncovered from this study's qualitative methods have yet to be considered and, consequently, are addressed below.

First and most prominently, a finding that runs opposite to what was revealed by the ATSSA survey was one that demonstrated 72% of this study's entire participant pool agreed or strongly agreed with post-BioBus Likert item 15 (The BioBus experience has made my attitude towards science more positive). To that end, the mean response score to item 15 for the study's negative change sample showed similar agreement (M = 3.7 of 5). While it is true that these findings came from self-reported data, which in itself may have flaws, they nonetheless warrant careful consideration. That is, on one hand, this study used a validated quantitative instrument revealing that more than 40% of its participants exhibited some form of negative change in their attitude towards science following a BioBus experience. On the other hand, self-reported post-BioBus data revealed that many of these same participants believed their time on the BioBus improved their attitude towards science.

Another conclusion of this study that has helped uncover why some participants exhibited negative changes in attitude towards science came from the findings of the open-response questionnaire. More specifically, it was concluded that many of this study's participants, regardless of their measured change in attitude towards science, enjoyed their BioBus experience. Indeed, a majority (71%) of all negative change participants in this study made at least one positive comment about their BioBus experience. In addition, 60% of participants considered to have exhibited extreme changes in their attitude towards science did similarly. Interestingly, these finding demonstrated that it was possible for participants to exhibit a negative change in attitude towards science, but still respond favorably to a BioBus experience.

Finally, coming full circle, I return once again to this study's quantitative data to finish unpacking why some participants may have exhibited negative changes in their attitude towards science. This is accomplished by examining a noteworthy finding from the two ATSSA item analyses completed. In particular, a finding from the item analysis completed on the entire sample displayed mean responses to item 4 (I would like to learn more about science), with relatively large differences between positive and negative attitude change participants (M = 3.96, 3.14, respectively, see Table 7). Additionally, a similar trend was noted across 7 of the 8 grade level groupings in both item analyses completed (see Tables 7 and 9). Interestingly, it appears that item 4, an outlier in comparison to others in this study's quantitative survey, helps to partially explain why participants exhibited various changes in their attitude towards science.

That is, participants with a negative change in attitude towards science did not want to learn more about science as much as those participants who exhibited positive changes following a BioBus experience.

From the exercise above, a near-even split in student attitude changes towards science following a BioBus experience at first appeared to be a straightforward finding. However, this finding became more nuanced as qualitative data were analyzed. To that end, these findings, when taken in combination, seemed to give further support to my suggestion of a more widescale implementation of mobile science lab experiences similar to those offered by the BioBus for urban youth. Additionally, the iterative process outlined above has its own implications for other researchers interested in examining informal science education settings, attitudinal changes, and mobile science labs. Namely, I suggest that the utilization of a mixed-methods data collection approach should not be overlooked. Indeed, stating as much is necessary as almost all of the prior studies in the science education field dealing with attitudinal changes have relied solely on quantitative methodologies (Krogh & Thomsen, 2005; Petty et al., 1997; Schibeci, 1984).

Age

It has been commonly found that student attitude towards science generally becomes more negative with age (Atwater et al., 1995; Barmby et al., 2008; Bennett & Hogarth, 2009; Breakwell & Beardsell, 1992; Finson & Enochs, 1987; Francis & Greer, 1999; George, 2000; Greenfield, 1996; Haladyna & Shaughnessy, 1982; Hasan et al., 1995). This trend was echoed in this study. That is, younger students demonstrated a more positive change in attitude towards science following their BioBus experience than students in Grade 11/12. However, I should note that I did not find neither linear nor significant attitudinal declines between grade levels, as Bennett and Hogarth (2009) did in their study of 11-, 14-, and 16-year-old students. This discrepancy could be due in part to another conclusion of this study, namely that a large majority of students, regardless of their change in attitude towards science, rated their BioBus experience as an enjoyable one. Consequently, and as Gogolin and Swartz (1992) suggested, a student's direction (and magnitude) of change in attitude towards science could be directly linked to the perceived quality of the science experience in which the student participated. More concretely, this position suggests that if students with negative changes in their attitude towards science believed their BioBus experience to be one of quality (as this study's findings suggest), then participants displaying negative changes in attitude towards science were mitigated and less pronounced than if the experience had been of low quality.

Furthermore, as a result of concluding that younger participants' attitude towards science are more favorable after a BioBus experience than those who are older, I recommend that the mobile science labs and other informal science education settings consider targeting specific student age ranges with the services and programs they provide. For example, it may be prudent for these instituions to focus their programs on younger students if they are looking to have the greatest impact on student attitudes towards science. Or, if their goal is to provide a science experience that is enjoyed by as many indiviudals as possible, findings from this study would suggest that program offerings that serve a wide range of student ages would be appropriate. Finally, if the organization's goal is more long-term and specialized, for instance to inspire the next generation of scientists, they may consider targeting elementary-aged students, which Maltese and Tai (2010) found to be the time when many decisions to pursue science as a career are often made.

“Can This Be School?”

The question above, which was asked by a student as their BioBus experience came to an end, serves as a perfect reference point from which to begin my suggestions for in ways certain aspects of the mobile science lab BioBus experience could be incorporated into urban science classrooms. However, before detailing how this is possible, it is first necessary to outline what makes mobile science labs unique. To begin, the mobile science lab BioBus contained very expensive scientific equipment (i.e. research-grade microscopes) that required the expertise of highly trained professionals/scientists to setup, operate, and maintain. As a result, it is difficult for one to argue that the same level of enjoyment, engagement, and student interest found to have occurred during the BioBus could be achieved within the traditional science classroom by simply providing similar equipment to urban schools and properly training its science teachers.

Moreover, prior research has suggested that this is unlikely to happen. For example, Tobin, Seilier, and Walls (1999) as well as other researchers (Calabrese Barton, Tan, & Rivet, 2008; National Research Council, 2009) have detailed how urban schools are chronically underfunded, under resourced, and face difficulties trying to staff adequately trained science teachers. Indeed, this researcher happenend to know that two of the specialized magnet schools within the same school district as which this study occurred had difficulty maintaining and operating the type of microscopes found on the BioBus, despite having a highly specialized science teaching staff. For example, one school had a fluorescent microscope sitting in a classroom unused because it was broken while another housed a working, but idle electron microscope that collected dust due to a lack of expertise by anyone within the school’s science department to be able to operate it effectively.

However, despite the difficulties urban, or for that matter any school may be presented with when attempting to acquire and operate some of the microscopes found on the BioBus, the way in which learning was facilitated during a BioBus experience could be more easiliy replicated within the science classroom. In particular I argue that educators should challenge themselves to construct a third space within their classroom like the one that was created during certain components of the BioBus experience (e.g. during the *Daphnia* experience) to maximize student engagement and interest and help mitigate tensions that may be present between their students and the culture of school science. Indeed, this very notion that a third space can be constructed within the formal science classroom, has been previously demonstrated by Moje et. al. (2004).

Below, by focusing on what the findings of this study determined to be a third space and subsequently the most engaging aspect of a BioBus experience, I will detail how the constuction of similar spaces within the science classroom may help engage urban youth with the culture of school science.   However, before doing so it is worthwhile to note that not all aspects of a BioBus experience constitituted a third space. Indeed there were multiple instances highlighted in the observational findings of this study where scientists dominated and in some instances stifled student conversations. As a result, educators should understand that it is simply not enough to take students outside of the science classroom for a third space to be realized. Instead, I argue that educators must not only create physical constructs, but also social triggers before a third space can be realized within their classrooms. To do this I will make suggestions for how to best construct and leverage student engagement that occurs within the third space by drawing upon the findings of this study and personal experiences within my urban science classroom.

To begin, and as mentioned above, I argue that taking students outside, while likely a welcomed by most students, is not enough for a true third space between the cultures of urban youth and school science to be constructed. Indeed there were multiple instances during the BioBus experience where students were listening passively to a scientist despite being outside of the formal classroom. To that end, this mode of instruction during which findings from this study suggested students were relatively less engaged than when they were working collaboratively with each other and scientists (e.g. during the *Daphnia* experience) could be likened to what third space researchers Gutiérrez et al. (1995) referred to as teacher scripts dominating student counterscripts. Interestingly, by critiquing the BioBus experience in this manner, it is possible to see how even though the physical elements of a third space were satisfied, that is students were in between their home and school lifeworlds, the social components were not.

As a result I suggest that urban educators should provide opportunities for their students to take part in multimodal events, or experiences that rely on speaking, engagement in experiments, and the viewing of images (Jewitt, Kress, Ogborn, & Tsatsarelis, 2001). For example, teachers, instead of reading to their students about cells or studying images of them in a textbook could place the viewfinder of a document camera over the objective lens of a basic compound microscope in order to display the magnified image of a specimen through a connected digital projector. In this way, by replicating the way in which images were viewed and discussed during the *Daphnia* experience, a teacher and her students could view live specimens at the same time and make concurrent observations of what they were seeing. Additionally, an added benefit of this multimodal approach to science teaching, would be the elmination of the frustrations that can occur when students are first learning how to use a microscope. Indeed, I have used this very pedagogical approach within my own classroom with relative ease and seen first-hand the aforementioned student engagement benefits.

To more closely replicate the *Daphnia* experience and attempt to capitalize upon the high levels of scientitific interest and engagement witnessed therein, I also suggest that urban science educators further the multimodal approach detailed above by asking their students to subsequently prepare and then observe cells under a microscope in small groups. By doing so, not only will educators further disrupt the traditional classroom structure, but also help foster what third space researchers Gutiérrez et al. (1995) would refer to as authentic and transcedent dialogue. That is, by allowing students to work in smaller groupings, both the physical and social elements of a third space may be enacted. More specifically, small groupings will arrange students in circular formations not typically found within tradiational science classrooms (Emdin, 2010b) and replicate those that may be found in more casual settings outside of school. Furthermore, the social components of a third space can be enacted via the close arrangement of students and may help facilitate the free flowing and socially relaxed conversations that were found to have occurred during the Daphnia experience.

Another added benefit of attempting to create a third space via this multimodal approach is the opportunity for teachers to step out of their hierarchial role into one akin to a guide or coach. Not only will these instances foster a learning environment that more closely mirrors those that occurred during the scientific discovery process aboard the BioBus, but also provide opportunities for teachers to establish ritualized and encourage colloquial forms of expression. Indeed similar interactions were witnessed between scientists and students during the third space created during the *Daphnia* experience and other elements of a BioBus exeperience. Additionally, these more relaxed forms of expression have been noted as being an important form of urban youth culture and learning (Emdin, 2010b That is, by teachers encouraing the forms of expression that urban youth are most comfortable via multimodal learning arrangements they are also demonstrating that there culture is welcomed within the science classroom.

The next suggestion for ways in which to construct the third space within the science classroom will help address the concerns of those who may note that the access to the equipment mentioned above may be difficult to for some urban science educators. Indeed, findings from this study demonstrated that there were multiple instances when participants noted that their BioBus experience was the first time they had ever interacted with a microscope. As a result, I suggest that teachers who may lack access or familiarity with the scientitific tools and equipment mentioned above adopt the Socratic Seminar within their classrooms.

At base, a Socratic Seminar is a discussion, but instead of this discussion being teacher-led, the drivers of the conversation are students. This form of discussion has been suggested as a means to increase student engagement in the science classroom (Chowning, 2009) and is pedagogical approach I have utilized for this very purpose. More specifically I utilize the Socratic Seminar in my own classroom to help my students access science-focused nonfiction texts from magazines, newspapers, and books. To do so, I first assign my students a reading and ask them to highlight, annotate, and write down questions they have as they are reading. Then, during the day of the Socratic Seminar I split my class into two groups. The first group of students is seated in a circular arrangement of chairs while the second group is perched behind this inner circle on desks. In this way a clear distinction is made between the students who are expected to be discussing the text (inner circle) and those observing (outer circle).

A Socratic Seminar begins when I provide the inner circle with a question. From that point forward the expectation is that the inner circle uses textual evidence and one another to answer my question. During this time, I do not speak and students are asked not to raise their hands before participating. Instead, students are encouraged to create a community of learners with the explicit goal of deepening their own and their classmates understanding of the assigned text and scientific content within.

Typically, as the inner circle engages in a discussion, the outer circle takes notes on the nature of the conversation. Often times students make text-to-text, text-to-self, and text-to-world connections at a rate higher than those that have occurred during my normal teacher-led discussions. In this way Socratic Seminars have resulted in some of the most powerful moments I have been a part of as an educator. Not only have these discussions resulted in class periods where every single one of my students participated, but they have also created opportunities for my students to delve beneath the superficial level of my question and make the aforemented connections between science and their own lives. Furthermore, I would argue the physical and social constructs of a Socratic Seminar help facilitate the construction of third space within the classroom and blur the lines between the cultures of urban youth and school science.

In sum, before transitioning to ways in which urban science educators can leverage the physical environment outside of their classroom as a means to engage urban youth to connect to the science, I want to note the leap of faith that I am asking science educators to take when implementing the aforementioned pedagogical practices. Indeed, it may be intimidating for a teacher to relinquish control of classroom conversations and as a result they must be provided with the necessary support for the aforementioned classroom practices to be fully levereaged. However, the means by which this support occurs is somewhat outside of the scope of this dissertation. Instead, I argue that the findings from this study on a mobile science lab and my own anecdotal evidence could be utilized by those intent on reforming science teacher classroom practices.

Before concluding I will turn to ways in which the immediate neighborhood and physical environment outside of the classroom may help engage urban youth in the culture of school science. At base this suggestion comes from the fact that the BioBus experience itself took place outside of the classroom which was often alluded to by this study's interview participants as being a stifling environment. However, before continuing, I would like to reiterate that it is not enough for teachers to simply take their students outside of the classroom in order for a third space to be constructed. With that said, I do not doubt (and findings from this study suggest) that being outside of the classroom does help to facilitate a third space. Indeed I would argue that one possible benefit of taking students outside of the classroom is that teachers are able to more readily focus on fostering the social components of a third space. In fact, I have found this very benefit to ring true within my own classroom. That is, by focusing on the immediate physical environment surrounding my school; I have found that my students are more willing to engage with the science that we were learning within the classroom.

For example, during one of my classes we spent the entire semester learning about our city's water supply including where it came from, how it got to our taps, and what happened to it when we were finished using it. In this way I was able to draw upon the physical environment surrounding my school by taking trips outside of the classroom. Trip included taking water samples and canoeing on a local river, visiting one of our city's reservoirs, raising and then releasing trout into a local stream, and touring a wastewater treatment plant. During this topic of study I found that I could continually return to the physical experiences my students had outside of the classroom to trigger the social compnents of a third space. For example, during a culminating project, students compared the quality of our city's tap water to the water provided by the bottled water industry and then presented their work at a city-wide forum. Interestingly, during this project I found that by asking my students to become experts about something in their physical environment and creating a social situation in which they could share their newfound knowledge I felt I had levereaged the power of the third space witnessed during a mobile science lab experience within my classroom.

In the example above I was able to construct a third space within my classroom thanks to the flexibility of a course not married to a end-of-year exam. However, what about the teacher who does not have this luxury? Can they still construct the third space within their classroom? While I have faced this very predicament within my own teaching career, I have nonetheless attempted to leverage the power of a third space both physically and socially within my classroom. For example, during an evolution I taught this topics related concepts and ideas through the lens of a pigeon. Pigeons, which all urban youth likely interact with on a daily basis, also happened to be studied deeply by Charles Darwin and written about extensively to support his arguments for natural selection within the *Orgin of Species*. Utilizing this knowledge I had students conduct fieldwork on pigeons and then asked them to draw upon their observations back inside the classroom. To do so, students used what they noted in the field to make connetions between a pigeons characteristics and evolutionary content knowledge like adapations, variation, and survival of the fittest. In this way I attempted to create a third space by merging the physical components of our fieldwork with social elements of the science classroom.

Before concluding I would like to return to and reflect upon this sections title, namely, "Can this be school?" When first attempting to answer this question I sought to make direct connections between the most effective elements (e.g. *Daphnia* experience) of the mobile science lab BioBus and how they could be implemented within the science classroom. However, when doing this I came to realize that much of what I belived to be the most attractive learning components of mobile science labs, was their potential for creating a third space. Indeed, I have attempted to demonstrate within this study that the third space, when constructed, can mitigate tensions between urban youth and school science. Furthermore, this tension dissolution is something I have attempted to do in my own clasrroom throughout my 10-year career as an urban science educator. As a result, I hoped to have provided mobile sciene lab operators, those within the field of science education research, and other urban science educators with empirically and anecdotally based means by which to construct and leverage the third space. Indeed, findings from this study and others have suggested that culturally relevant pedagogical practices are one of the strongest ways by which to engage urban youth in science.

Theoretical Framework Implications

Here, I will further examine the merits of the theoretical framework utilized in this study to determine if it should be adopted more broadly by researchers intent on examining how to best mitigate tensions between the cultures of urban youth and school science. That is, I attempted to reveal how informal science education settings and the third space helped ease cultural tensions and influence affective outcomes during a student's BioBus experience. Indeed the possibility of this occurrence was informed by the positions held about the transformative power of these spaces by a number of science education researchers (Gutiérrez et al., 1997; Gutiérrez et al., 1999; Moje et al., 2001; Moje et al., 2004; National Research Council, 2009: Taylor, 2006).

While the approach utilized to evaluate the merits of the aforementioned theoretical framework was narrow in scope due to a relatively small sample size, it nonetheless came from this study's most robust form of analysis: participant case studies. Indeed, this form of analysis provided myriad opportunities for me to critique and make suggestions for how the framework herein could be used and adapted for future studies. Additionally, this comprehensive analysis, which made use of all forms of data collected from this study, also allows readers to judge and appraise the utility of this framework for their own purposes across a variety of research settings.

To begin, the greatest support in favor of using this study's theoretical framework to examine how third space sponsorship can allow for the transfer of social capital and, as a result, ease tensions between urban youth and the culture of school science came from the four case studies of participants exhibiting extreme positive changes in their attitude towards science following a BioBus experience. To that end, it was determined that all four students comprising the extreme positive change in attitude grouping aligned with all three aspects of this study's theoretical framework. Conversely, none of the extreme negative change participants' interview findings could be aligned in a similar manner.

More specifically, all extreme positive change participants made comments within their interview that connected to the first component of our framework: outsider status. That is, each extreme positive change case study participant was characterized as belonging to a clique network (Burt, 2001) or made comments indicating they were an outsider to the culture of school science. For example, many participants classified as outsiders also made comments within their interview that demonstrated how they used to think science was "boring" prior to their BioBus experience. Additionally, some students even went as far as saying that they "used to hate" science. This declaration is not dissimilar from the argument made (and noted often herein) that many urban youth sit in this nation's science classrooms disinterested and marginalized (Basu & Calabrese Barton, 2007; Crane, 1994; Emdin, 2010a; Fadigan & Hammrich, 2004; Lemke, 1990; Osborne, Simon, & Collins, 2003) or at odds with the culture of school science (Aikenhead &

Jegede, 1999; Calabrese Barton et al., 2008; Emdin, 2010a; National Research Council, 2009; Norman et al., 2001; Tobin et al., 1999).

For these reasons above, I argue within the context of this study that urban youth who comprise a clique network (Burt, 2001) of outsiders need a hierarchical network (Burt, 20001) sponsor via the third space of a BioBus experience to move past the gatekeeper (Brown, 2004; Moje et al., 2001) barring them access to the entrepreneurial network (Burt, 2001) and the vast array of connections held by the culture of school science. Additionally, I suggest that this sponsorship, which occurred during the most memorable aspects of a BioBus experience, allowed this study's four extreme positive case study participants to access and draw upon newfound social capital from the culture of school science when they returned to the science classroom and in their own lived experience.

Indeed, all of the extreme positive change case study participants mentioned that the opportunity to use microscopes to view *Daphnia* and to access technology not found in their science classroom was responsible for changes in their attitude towards science. Interestingly, I determined that the *Daphnia* experience was also an instance during which the BioBus most aligned with the charateristics used to characterize informal science education settings. Furthermore, the BioBus experience itself was often mentioned as being the reason why students no longer felt that science was boring—an indication that a student's outsider status to the culture of science had diminished. To that end, the ability of urban youth to connect to the culture of school science via the BioBus's third space sponsorship and transfer the social capital therein was represented by stated changes in attitude towards science, new understandings of science concepts, connections to one's lived experience, increased participation in the science classroom, and feelings of more preparedness for college. Of note here is that the means by which third space sponsorship occurred (i.e., access to microscopes and technology) was similar across all interview participants, while the way in which newly acquired social capital was enacted varied.

Given these considerations, what should one make of those participants exhibiting extreme negative changes in their attitude towards science and their non-alignment with this study's theoretical framework? While it is easy to suggest that the framework constructed did not align with these participants because they simply did not exhibit positive changes in their attitude towards science, the answer to this question is more nuanced. Indeed, there were some instances in which the components of this study's framework did align with the comments made by extreme negative attitude change case study participants. For example, in two interviews, it was revealed that the BioBus did act as a third space sponsor and allowed for social capital brokerage, but interview participants could not be characterized as being outsiders to the culture of school science. Also, in a third interview, this study's framework did not align with a negative participant due to an extreme dislike of science that had resulted from a series of struggles in the classroom. Finally, the fourth participant's case study suggested that third space sponsorship and social capital transfer had recently occurred within the science classroom.

The two students who did not identify as outsiders (Janis and Yom), and in fact had positive attitudes towards science prior to their BioBus experience, may not have needed third space sponsorship to access the social capital within the culture of school science. However, even with this acknowledgment, there is limited evidence for third space sponsorship having occurred when student interview comments were analyzed. Be that as it may, an argument could be made that a variety of urban youth, not just those individuals characterized as outsiders, are capable of utilizing third space sponsorship to access the social capital held by the culture of school science.

The second reason for non-alignment with this study's theoretical framework appears to have resulted from a participant (Indira) having been jaded by past science experiences. In addition, this student, a 12th grader about to graduate from high school, told me of prior science experiences that suggested an irreparable negative attitude towards science. As a result, I once again suggest that the BioBus and similar organizations offering short-term informal science education experiences consider targeting younger students who, as the findings of this study have demonstrated, are more likely to hold an attitude towards science that can be positively influenced. If this suggestion is outside the scope of the mission of the BioBus and other organizations, I recommend tailoring program offerings to meet the needs of individual students like Indira, whose past science experiences in the classroom have been damaging.

Finally, the third reason the theoretical framework did not align with an extreme negative change participant (Bill) occurred because they had recently experienced what appeared to be a form of third space sponsorship in their science classroom. Indeed, this example indicates, as have other third space researchers (Calabrese Barton et al., 2008; Calabrese Barton & Tan, 2009; Gutiérrez et al., 1999; Gutiérrez, 2008; Moje et al., 2001; Moje et al., 2004), that a variety of settings, not just those occurring within informal ones, can be places where tensions between urban youth and the culture of school science can be mitigated.

Based on the findings above, I conclude that the theoretical framework developed for this study has been demonstrated to be of some use when attempting to explain how and why students participating in a BioBus experience developed a positive attitude towards science, although some of the rationalizations involve more nuanced interpretations of the positive and negative evidence. The main finding in support of this proclamation is that every case study participant exhibiting extreme positive changes in their attitude towards science had supporting findings that could align with all three major components of the framework. That is, students demonstrating extreme positive changes in their attitude towards science identified as outsiders to the culture of school science and utilized their BioBus experience as a third space sponsor to access and transfer social capital into classroom and lived experience.

Despite all that being said, an analysis of interview participants exhibiting extreme negative changes in their attitude towards science following a BioBus experience demonstrated that the theoretical lens developed is by no means a perfect model. However, the findings from this study suggest that the developed framework is one researchers should consider utilizing when designing studies that examine urban youth, attitudes towards science, the third space, and informal or formal science education settings.

Limitations

While many of the limitations associated with this study were addressed in Chapter 3, one that has gone unmentioned is the relatively short duration of a BioBus experience. A common critique of short-duration science experiences is that they have little, if any, lasting impact on student attitudes towards science. Furthermore, research occurring within short-duration informal science education settings like museums has demonstrated that attitude is not typically influenced within these spaces without subsequent reinforcement (Anderson, Storksdieck, & Spock, 2007).

Despite this critique, multiple findings have demonstrated to the contrary (Knapp, 2000; Koran, Koran, & Ellis, 1989; Laursen, Liston, Thiry, & Graf, 2007; Stocklmayer et al., 2010).

For example, brief encounters with informal science education, such as those offered by field trips, have been found to be remembered well after a visit (Falk & Dierking, 1997; Knapp, 2007; Wolins, Jensen, & Ulzheimer, 1992) and able to influence the pursuit of science careers (Cosmos Corporation, 1998; Emdin, 2012; Salmi, 2003). Furthermore, Anderson et al. (2007) noted that a general decline in attitudes over time from immediate post-visit field trip measures tend to remain higher than attitudes prior to the visit.

Another limitation of this study was the possibility of results, in particular post-BioBus ATSSA survey results, being skewed due to novelty effects. As the BioBus is a unique science setting and one that the study's participants had never experienced before, any results indicating changes in student attitude towards science should be tempered with the possibility that they were influenced by a novelty effect. To help mitigate these possible occurrences, a pre-trip orientation is often recommended for short-term informal science education settings (Anderson & Lucas, 1997; Falk, 1983, Orion & Hofstein, 1994). As a result, all students who visited the BioBus watched a short informational video within one week of their experience. In this manner, the video clip served as a virtual tour of the BioBus with the intention of reducing, at least in part, the novelty of the setting.

The next limitation of this study is that it analyzed a very specific student population and type of informal science education setting. That said, this approach was purposefully selected to clearly define the boundaries of the case study and ensure alignment with other aspects of this study's chosen methodology. Furthermore, by providing a thick and rich description, I have allowed others to apply this work to other science settings (both informal and formal) and a variety of student populations.

The final limitation of this study arose from the rather contentious debate surroundings how to exactly define what informal science education settings entail. A consequence of this ambiguity was that the theoretical assumptions used to analyze the intereactions that occurred within this study's setting were, at times, difficult to empirically support. As as result, I suggest researchers be wary of marrying their theortetical lens to informal science education until the field provides a more clear definition. With that said, I also suggest that the informal science education field return to the suggestions of Eshach (2006) whose work has suggested the need for further distintinctions between in and out-of-school science settings. However, despite the aforementioned struggles, I was nonetheless satisfied that the theoretical discussion surrounding whether or not mobile science labs are informal or formal when juxtaposed with the third space provided me with a unique lens through which to examine the cultural clashes between urban youth and school science. Furthemore this lens also provided a window through which to begin to explain how affective outcomes may occur within these aforementioned settings. As a result, I do not hesitate to recommend the theoretical framework constructed herein, albeit with modifications, for future studies looking to examine similar cultural interactions.

Bias

I have worked as a science educator in low-income schools for the past 10 years within the metropolitan area in which this study took place. Based on past experiences, I have come to realize that informal science education settings are ripe with opportunities to connect urban youth culture to the culture of school science. One particular informal science setting that I believe has helped connect the lived experience of my current and former students to the culture of school science is the one provided by the mobile microscope laboratory BioBus. Since the first visit of the BioBus to the researcher's classroom seven years ago, the researcher has developed a close relationship with the organization and currently serves on its board of directors. This study is an outgrowth of the researcher's ongoing connection with the BioBus and his interests as a doctoral student. By making others cognizant of prior experiences I have had working with urban youth and an ongoing involvement with the BioBus, I hope to provide readers with insights into the potential sources of bias that these connections could create. Nevertheless, the researcher is also confident that the integrity of this study has been upheld.

Despite possible bias, however, the connections between the BioBus and myself did provide some benefits for this study's successful implementation. For example, my familiarity with and connections to both urban youth and the BioBus provided me with an insider's stance that was leveraged and drawn upon throughout all aspects of the study. To that end, my close relationship with the BioBus also made the logistical planning of this study more manageable.

Further Research

While the data collected here did satisfactorily answer this study's research questions, the data also raised or highlighted opportunities to explore further research objectives. Indeed, the findings from this study are modest, slightly nudging the body of work done by this and other science education researchers toward a better understanding of how to fully connect urban youth to the culture of science. To further pursue this end, I recommend three next steps: a) an assessment of how time and repetitive informal science education experiences affect attitudinal changes, b) an examination detailing the perspectives held towards informal science education and third space settings from teachers and scientists, and c) further exploration of the theoretical framework used here in additional studies attempting to characterize informal science education settings, the third space and cultural conflicts. Each of the aforementioned suggestions for further research is discussed below.

While this study has demonstrated that students exhibited significant changes in student attitudes towards science following a BioBus experience despite its short duration, I am nonetheless still curious about the lasting impression it left on the study's participants. More explicitly, I suggest that it would be prudent to investigate whether or not a BioBus experience has the ability to influence student attitudes towards science months and possibly years later. In addition, I also suggest the development of a study intent on uncovering the impact that multiple mobile science lab experiences may have on continuing, sustaining, or reversing the changes in attitude towards science initially observed in this study. Indeed, if it was found that repetitive experiences have the ability to influence these aforementioned changes, perhaps then this particular setting could be determined to be the cause of such changes and further lessons could be learned on how to engage urban youth with the culture of school science.

Alternative viewpoints could also shed further light onto how mobile science labs are capable of changing urban youths' attitude towards science. To that end, insight from insiders to the culture of school science, namely the teachers of urban youth and informal science education educators/scientists, may prove to be useful. Individuals interacting directly with urban youth as they engage with the culture of school science may offer ideas that could, in turn, be utilized within the formal science classroom. Thus, if specific pedagogical approaches can be identified as having undue influence on assisting urban youth to engage with the culture of school science, they could warrant dissemination. Furthemore, teachers who are allowed to watch their students instead of lead them through a mobile science lab experience could use their observations as a reflective practice on changes they might like to make within their own classrooms.

Finally, the theoretical framework developed for this study warrants further exploration. That is, more studies that view informal science education settings and the third space as capable of mitigating cultural tensions, and, as a result, allow for social capital brokerage and resulting affective outcomes, should be completed. In this way, the mechanism that would detail how such changes happen and solutions to address the reasons for why so many urban youth do not engage with the traditional science classroom can be further developed. Additionally, the value of methods, techniques, pedagogical approaches, and learning environments that could potentially reverse cultural clashes could also be evaluated. Finally, it would be worth exploring this framework in other informal science education settings as well as in the formal science classroom to determine its transferability and merits as a theoretical model.

Summary of Chapter 5

The purpose of this study was twofold: to examine how a BioBus experience changed urban youths' attitude towards science and to explore students' perceptions of this informal science education setting. Ultimately, this purpose arose from a desire to address the oft-cited position that the culture of urban youth is at odds with the culture of school science (Emdin, 2010a; National Research Council, 2009; Norman et al., 2001; Tobin et al., 1999) and the suggestion that informal science education settings may ease these cultural tensions (Banks et al., 2007; Hofstein & Rosenfeld, 1996; National Research Council, 2009; Schwarz & Stolow, 2006; Stocklmayer et al., 2010). Indeed, this study was not only able to provide myriad findings and conclusions addressing the research questions associated with its stated purpose, but also take a stance on how they may potentially influence those within the field. Furthermore, I provided the field (and myself) with some potential next steps to continue the work started before and herein. As a result, before this body of work comes to an end, each conclusion, implication, and suggestion for further research that were informed by the limitations of this study will be summarized.

One major conclusion from this study suggests that after a BioBus experience urban youth demonstrated statistically significant changes in attitudes towards science, both positively and negatively. This conclusion, along with another that outlined how a majority of this study's participants enjoyed their time on the BioBus regardless of their attitudinal change, led me to advocate for more widespread dissemination of mobile science lab experiences. Additionally, when these two conclusions were juxtaposed with one another, I was able to highlight the benefits of utilizing a mixed-methods approach and to suggest its adoption by those in the field of attitudinal and informal science education research.

Another conclusion from this study, namely the one that highlighted younger participants as more likely to exhibit positive shifts in their attitude towards science following a BioBus experience, led to its own implication. That is, I suggested that the BioBus and other informal science education settings think critically about the age of the target population to whom they provide services and how it aligns with their organization's goals.

Additionally, I examined in what ways certain aspects of a BioBus experince could be implemented within the urban science classroom. To that end, a multimodal approach to teaching science that allowed for both physical and social arrangements that are culturally relevant were suggested.

Moreover, an implication from this study that stands on its own was drawn from findings that indicated the potential value of using the theoretical framework developed herein as a way to examine how cultural tensions between urban youth and school science can be mitigated and lead to affective outcomes. That is, a mechanism for how urban youth can gain access to the culture of school science through an informal science education setting that is also a third space and acquire social capital for their own use was proposed and empirically supported in a limited fashion. To that end, this finding in its own right also became a recommendation for further research in that it was suggested that those interested in examining ways to ease cultural tensions between urban youth and school science adopt this theoretical approach.

Finally, a series of next steps for further research was also provided. First, I presented the case for the creation of a longer duration study with the intent of examining how changes in student attitude towards science following a BioBus experience hold up and change over time. Next, it was suggested that it would be worthwhile to gather viewpoints from those within the culture of school science, namely teachers and scientists, and examine what insights could be gained from their views on how a BioBus experience influences urban youths' attitude towards science.

In closing, I have satisfactorily addressed the purpose of this study by exhaustively answering the research questions developed. However, the lessons learned from this study by no means solve the problem examined herein. To that end, it is undeniable that there continue to be far too many urban youth removed from the spark of wonder that science can ignite when it is presented at its best. Certainly much more work must be done before this problem is rectified. Be that as it may, I hope that this study has contributed in some small way to one day ensuring a means to this end, and that the field as well as all parties involved with science education are now that much closer to reaching a time when all students, regardless of their background, can engage with and utilize science to better themselves, their community, and the world.

REFERENCES

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27,* 1-52.

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching*, *36*(3), 269–287. doi:10.1002/(SICI)1098-2736(199903)36:3<269::AID-TEA3>3.0.CO;2-T

Allen, S., Campbell, P. B., Dierking, L. D., Flagg, B. N., Friedman, A. J., Garibay, C., Korn, R., et al. (2008). *Framework for evaluating impacts of informal science education projects*. (A. J. Friedman, Ed.) (pp. 1–117). Retrieved from http://insci.org/resources/Eval_Framework.pdf

Anderson, D., & Lucas, K. (1997). The effectiveness of orienting students to the physical features of a science museum prior to visitation. *Research in Science Education*, *27*(4), 485–495. Retrieved from http://link.springer.com/article/10.1007/BF02461476

Anderson, D., Storksdieck, M., & Spock, M. (2007). Understanding the long-term impacts of museum experiences. In J. H. Falk, L. D. Dierking, & S. Foutz (Eds.), *In principle, in practice: Museums as learning institutions* (pp. 197–215). Lanham, MD: AltaMira Press.

Atwater, M. M., Wiggins, J., & Gardner, C. (1995). A study of urban middle school students with high and low attitudes toward science. *Journal of Research in Science Teaching*, *32*(6), 665–677.

Banks, J. A., Au, K. H., Ball, A. F., Bell, P., Gordon, E. W., Gutiérrez, K. D., Heath, S. B… Zhou, M. (2007). *Learning in and out of school in diverse environments: Life-long, life-wide, life-deep* (pp. 1–40). Seattle, Washington.

Barmby, P., Kind, P. M., & Jones, K. (2008, June). Examining changing attitudes in secondary school science. *International Journal of Science Education, 30*(8), 1075-1093.

Basu, S. J., & Calabrese Barton, A. (2007). Developing a sustained interest in science among urban minority youth. *Journal of Research in Science Teaching*, *44*(3), 466–489. doi:10.1002/tea

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report*, *13*(4), 544–559.

Bennett, J., & Hogarth, S. (2009). Would you want to talk to a scientist at a party? High school students' attitudes to school science and to science. *International Journal of Science Education*, *31*(14), 1975–1998. doi:10.1080/09500690802425581

Bhabha, H. (1994). *The Location of Culture*. London, UK and New York, NY: Routledge.

Blalock, C. L., Lichtenstein, M. J., Owen, S., Pruski, L., Marshall, C., & Toepperwein, M. (2008). In pursuit of validity: A comprehensive review of science attitude instruments 1935–2005. *International Journal of Science Education*, *30*(7), 961–977. doi:10.1080/09500690701344578

Bourdieu, P. (1986). Forms of capital. In J. E. Richardson (Ed.), *Handbook of theory of research for the sociology of education* (pp. 241–258). Westport, CT: Greenwood Press.

Boyer, L., & Roth, W.-M. (2006). Learning and teaching as emergent features of informal settings: An ethnographic study in an environmental action group. *Science Education*. doi:10.1002/sce20162

Breakwell, G. M., & Beardsell, S. (1992). Gender, parental and peer influences upon science attitudes and activities. *Public Understanding of Science*, *1*, 183–197. doi:10.1088/0963-6625/1/2/003

Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journal of Research in Science Teaching*, *37*(5), 441–458. doi:10.1002/(SICI)1098-2736(200005)37:5<441::AID-TEA4>3.0.CO;2-3

Brown, B. A. (2004). Discursive identity: Assimilation into the culture of science and its implications for minority students. *Journal of Research in Science Teaching*, *41*(8), 810–834. doi:10.1002/tea.20228

Burt, R. S. (2000). The network structure of social capital. *Research in Organizational Behavior*, *22*, 345–423.

Burt, R. S. (2001). The social capital of structural holes. In M. F. Guillen, R. Collins, P. England, & M. Meyer (Eds.), *New directions in economic sociology*. New York: Russell Sage Foundation.

Bybee, R., & McCrae, B. (2011). Scientific literacy and student attitudes: Perspectives from PISA 2006 science. *International Journal of Science Education*, *33*(1), 7–26. doi:10.1080/09500693.2011.518644

Calabrese Barton, A., & Tan, E. (2009). Funds of knowledge and discourses and hybrid space. *Journal of Research in Science Teaching*, *46*(1), 50–73. doi:10.1002/tea.20269

Calabrese Barton, A., Tan, E., & Rivet, A. (2008). Creating hybrid spaces for engaging school science among urban middle school girls. *American Educational Research Journal*, *45*(1), 68–103. doi:10.3102/0002831207308641

Campbell, D. T. (1975). Degrees of freedom and the case study. *Comparative Political Studies*, *8*(2), 178–185.

Campbell, D. T., & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research on teaching. In V. Richardson, *Handbook of Research on Teaching* (pp. 171–

246). Boston, MA: Houghton Mifflin.

Carey, N., & Shavelson, R. (1988). Outcomes, achievement, participation, and attitudes. In R. J. Shavelson, L. M. McDonnell, & J. Oakes (Eds.), *Indicators for monitoring mathematics and science education* (pp. 147–191). Los Angeles, CA: Rand Corporation.

Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. *Journal of Research in Science Teaching*, *32*(3), 243–257.

Chowning, J.T. (2009). Socratic seminars in science class. *Science Teacher, 76*(7), 36–41.

Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, *94*, 95–120.

Cosmos Corporation. (1998). *A report on the evaluation of the National Science Foundation's informal science education program*. Washington, DC: Author.

Crane, V. (1994). An Introduction to informal science learning and research. In V. Crane, H. Nicholson, M. Chen, & S. Bitgood (Eds.), *Informal science learning: What the research says about television, science museums, and community based projects* (pp. 1–14). Dedham, MA: Research Communication.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches*. Thousand Oaks, CA: Sage.

Cronbach, L. J. (1975). Beyond the two disciplines of scientific psychology. *American Psychologist*, *30*, 116–127.

Denizen, N. K. (1978). *The research act: A theoretical introduction to sociological methods* (2nd ed.). Thousand Oaks, CA: Sage.

Dierking, L. D., Falk, J. H., Rennie, L., Anderson, D., & Ellenbogen, K. (2003). Policy statement of the "informal science education" ad hoc committee. *Journal of Research in Science Teaching*, *40*(2), 108–111. doi:10.1002/tea.10066

Ebenezer, J. V., & Zoller, U. (1993). Grade 10 students' perceptions of and attitudes toward science teaching and school science. *Journal of Research in Science Teaching*, *30*(2), 175–186.

Emdin, C. (2009). Urban science classrooms and new possibilities: On intersubjectivity and grammar in the third space. *Cultural Studies of Science Education*, *4*(1), 239–254. doi:10.1007/s11422-008-9162-5

Emdin, C. (2010a). Affiliation and Alienation: Hip-hop, rap and urban science education. *Journal of Curriculum Studies*, *42*(1), 1–25.

Emdin, C. (2010b). *Urban science education for the hip-hop generation*. Rotterdam: Sense Publishers.

Emdin, C. (2012, June 15). Re: Geniuses unite: The intersection of hip-hop and science [Web log message]. Retrieved from http://www.huffingtonpost.com/christopher-emdin/geniuses-unite-the-inters_b_1596947.html

Eshach, H. (2006). Bridging in-school and out-of-school learning: Formal, non-formal, and informal education. *Journal of Science Education and Technology*, *16*(2), 171–190. doi:10.1007/s10956-006-9027-1

Fadigan, K. A., & Hammrich, P. L. (2004). A longitudinal study of the educational and career trajectories of female participants of an urban informal science education program. *Journal of Research in Science Teaching*, *41*(8), 835–860. doi:10.1002/tea.20026

Falk, J. H. (1983). Field trips: A look at environmental effects on learning. *Journal of Biological Education*, *17*(2), 137-142.

Falk, J. H., & Dierking, L. D. (1997). School field trips: Assessing their long-term impact. *Curator*, *40*, 211–218.

Feagin, J., Orum, A., & Sjoberg, G. (Eds.). (1991). *A case for case study*. Chapel Hill, NC: University of North Carolina Press.

Finson, K. D., & Enochs, L. G. (1987). Student attitudes toward science-technology-society tesulting from visititation to a science-technology museum. *Journal of Research in Science Teaching*, *24*(7), 593–609.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research.* Reading, MA: Addison-Wesley.

Fordham, S., & Ogbu, J. U. (1986). Black students' school success: Coping with the "burden of 'acting white.'" *The Urban Review*, *18*(3), 176-206.

Francis, L. J., & Greer, J. E. (1999). Measuring attitude towards science among secondary school students: The affective domain. *Research in Science and Technological Education*, *17*(2), 219–226. doi:10.1080/0263514990170207

Fraser, B. J. (1982). How strongly are attitude and achievement related? *School Science Review*, *63*(224), 557–559.

Freedman, M. P. (1997). Relationship among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching*, *34*(4), 343–357. doi:10.1002/(SICI)1098-2736(199704)34:4<343::AID-TEA5>3.0.CO;2-R

Gardner, P. L. (1975). Attitudes to science: A review. *Studies in Science Education*, *2*, 1–41.

Gee, J. P. (1996). *Social linguistics and literacies: Ideology in discourses* (2nd ed.). London, UK: Falmer.

George, R. (2000). Measuring change in students' attitudes toward science over time: An application of latent variable growth modeling. *Journal of Science Education and Technology*, *9*(3), 213–225. Retrieved from http://www.springerlink.com/index/R47QU08133663887.pdf

George, R., & Kaplan, D. (1998). A Structural model of parent and teacher influences on science attitudes of eighth graders: Evidence from NELS: 88. *Science Education*, *82*, 93–109. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/(SICI)1098-237X(199801)82:1%3C93::AID-SCE5%3E3.0.CO;2-W/abstract

Gerber, B. L., Cavallo, A. M., & Marek, E. A. (2001). Relationships among informal learning environments, teaching procedures and scientific reasoning ability. *International Journal of Science Education*, *23*(5), 535–549. doi:10.1080/095006901750162892

Germann, P. J. (1988). Development of the attitude toward science in school assessment and its use to investigate the relationship between science achievement and attitude toward science in school. *Journal of Research in Science Teaching*, *25*(8), 689-703.

Gibson, H. L., & Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. *Science Education*, *86*(5), 693–705. doi:10.1002/sce.10039

Glaser, B. G., & Strauss, A., (1967). *The discovery of grounded theory.* Chicago, IL: Aldine.

Glasson, G. E., Mhango, N., Phiri, A., & Lanier, M. (2010). Sustainability science education in Africa: Negotiating indigenous ways of living with nature in the third space. *International Journal of Science Education*, *32*(1), 125–141. doi:10.1080/09500690902981269

Gogolin, L., & Swartz, F. (1992). A quantitative and qualitative inquiry into the attitudes toward science of nonscience college students. *Journal of Research in Science Teaching*, *29*(5), 487–504.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis*, *11*(3), 255–274. doi:10.3102/01623737011003255

Greenfield, T. A. (1996). Gender, ethnicity, science achievement, and attitudes. *Journal of Research in Science Teaching*, *33*(8), 901–933. doi:10.1002/(SICI)1098-2736(199610)33:8<901::AID-TEA5>3.0.CO;2-#

Gutiérrez, K. D. (2008). Developing a sociocritical literacy in the third space. *Reading Research Quarterly*, *43*(2), 148–164. doi:10.1598/RRQ.43.2.3

Gutiérrez, K. D., Baquedano-Lopez, P., & Turner, M. G. (1997). Putting language back into language arts: When the radical middle meets the third space. *Language Arts*, *74*(5), 368–378. Retrieved from http://eric.ed.gov/ERICWebPortal/recordDetail?accno=EJ555343

Gutiérrez, K. D., Baquendano-López, P., & Tejeda, C. (1999). Rethinking diversity: Hybridity and hybrid language practices in the third space. *Mind, Culture, and Activity*, *6*(4), 286–303.

Gutiérrez, K. D., Rymes, B., & Larson, J. (1995). Script, counterscript, and underlife in the classroom: James Brown versus *Brown v. Board of Education*. *Harvard Educational Review*, *65*(3), 445–471.

Haladnya, T., Olsen, R., & Shaughnessy, J. (1982). Relations of student, teacher, and learning attitudes toward science. *Science Education*, *66*(5), 671–687.

Haladyna, T., & Shaughnessy, J. (1982). Attitudes towards science: A quantitative synthesis. *Science Education*, *66*(4), 547–563. Retrieved from http://onlinelibrary.wiley.com /doi/10.1002/sce.3730660406/abstract

Hasan, O., Hill, G., Atwater, M., & Wiggins, J. (1995). Attitudes toward science of urban seventh-grade life science students over time, and the relationship to future plans, family, teacher, curriculum, and school. *Urban Education*, *30*(1), 71–92. doi:10.1177/0042085995030001006

Hofstein, A., & Rosenfeld, S. (1996). Bridging the gap between formal and informal science learning. *Studies in Science Education*, *28*, 87–112.

Jarvis, T., & Pell, A. (2002a). Changes in primary boys' and girls' attitudes to school and science during a two-year science in-service programme. *The Curriculum Journal*, *13*(1), 43–69. doi:10.1080/09585170110115 26

Jarvis, T., & Pell, A. (2002b). Effect of the challenger experience on elementary children's attitudes to science. *Journal of Research in Science Teaching*, *39*(10), 979–1000. doi:10.1002/tea.10055

Jarvis, T., & Pell, A. (2005). Factors influencing elementary school children's attitudes toward science before, during, and after a visit to the UK National Space Centre. *Journal of Research in Science Teaching*, *42*(1), 53–83. doi:10.1002/tea.20045

Jewitt, C., Kress, G., Ogborn, J., & Tsatsarelis, C. (2001). Exploring learning through visual, actional and linguistic communication: The multimodal environment of a science education. *Educational Review*, *53*(1), 5–18.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, *33*(7), 14–26. doi:10.3102/0013189X033007014

Johnson, R. B., & Turner, L. A. (2003). Data collection strategies in mixed methods research. In A.Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (pp. 297-319). Thousand Oaks, CA: Sage.

Knapp, D. (2000). Memorable experiences of a science field trip. *School Science and Mathematics*, *100*(2), 65–72.

Knapp, D. (2007). A longitudinal analysis of an out-of-school science experience. *School Science and Mathematics*, *107*(2), 44–51.

Koballa Jr., T. R. (1988). Attitude and related concepts in science education. *Science Education*, *72*(2), 115–126.

Koran Jr., J. J., Koran, M. Lou, & Ellis, J. (1989). Evaluating the effectiveness of field experiences: 1939-1989. *Visitor Behavior*, *4*(2), 7–10.

Krogh, L. B., & Thomsen, P. V. (2005). Studying students' attitudes towards science from a cultural perspective but with a quantitative methodology: Border crossing into the physics classroom. *International Journal of Science Education*, *27*(3), 281–302. doi:10.1080/09500690412331314469

Laursen, S., Liston, C., Thiry, H., & Graf, J. (2007). What good is a scientist in the classroom? Participant outcomes and program design features for a short-duration science outreach intervention in K–12 classrooms. *Cell Biology Education--Life Sciences Education*, *6*, 49–64. doi:10.1187/cbe.06

Lemke, J. L. (1990). *Talking science: Language, learning and values.* Norwood, NJ: Ablex.

Lincoln, Y. S., & Guba, E. A. (1985). *Naturalistic inquiry.* Beverly Hills, CA: Sage.

Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education*, *32*(5), 669–685. doi:10.1080/09500690902792385

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: Jossey-Bass.

Moje, E. B., Ciechanowski, K. M., Kramer, K., Ellis, L., Carillo, R., & Collazo, T. (2004). Working toward third space in content area literacy: An examination of everyday funds of knowledge and Discourse. *Reading Research Quarterly*, *39*(1), 38–70.

Moje, E. B., Collazo, T., Carrillo, R., & Marx, R. W. (2001). "Maestro, what is 'quality'?": Language, literacy, and discourse in project-based science. *Journal of Research in Science Teaching*, *38*(4), 469–498. doi:10.1002/tea.1014

National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits*. P. Bell, B. Lewenstein, A. W. Shouse, & M. A. Feder. (Eds.) Washington, DC: The National Academies Press. Retrieved from http://books.google.com/books?hl=en&lr=&id=vdOIlY7WdJUC&oi=fnd&pg=PT1&dq=Learning+Science+in+Informal+Environments+People,+Places,+and+Pursuits&ots=PQTEgA3Q8w&sig=VFV2pZVXMn6H3VrXLL4aexfTEm0

Noll, V. H. (1935). Measuring the scientific attitude. *Journal of Abnormal and Social Psychology*, *30*(2), 145–154.

Norman, O., Ault, C. R., Bentz, B., & Meskimen, L. (2001). The black-white "achievement gap" as a perennial challenge of urban science education: A sociocultural and historical overview with implications for research and practice. *Journal of Research in Science Teaching*, *38*(10), 1101–1114. doi:10.1002/tea.10004

Oliver, S. J., & Simpson, R. D. (1988). Influences of attitude toward science, achievement motivation, and science self concept on achievement in science: A longitudinal study. *Science Education*, *72*(2), 143–155.

Oppenheim, A. N. (1992) *Questionnaire design, interviewing and attitude measurement*. London, UK: Pinter.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049–1079. doi:10.1080/0950069032000032199

Orion, N., & Hofstein, A. (1994). Factors that influence learning during a scientific field trip in a natural environment. *Journal of Research in Science Teaching*, *31*(10), 1097-1119.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.

Pearson, P. D. (1996). Reclaiming the center: The search for common ground in teaching reading. In M. F. Graves, P. van den Broek, & B. M. Taylor (Eds.), *The first R: Every child's right to read* (pp. 259–274). New York, NY: Teachers College Press.

Pearson, P. D., & Johnson, D. D. (1978). *Teaching reading comprehension*. New York, NY: Holt, Rinehart, and Winston.

Petty, R. E., Wegener, D. T., & Fabrigar, L. R. (1997). Attitudes and attitude change. *Annual Review of Psychology*, *48*, 609–647. doi:10.1146/annurev.psych.48.1.609

Portes, A. (1998). Social capital: Its origins and applications in modern sociology. *Annual Review of Sociology*, *24*, 1–24. doi:10.1146/annurev.soc.24.1.1

Rahm, J. (2008). Urban youths' hybrid positioning in science practices at the margin: A look inside a school–museum–scientist partnership project and an after-school science program. *Cultural Studies of Science Education*, *3*(1), 97–121. doi:10.1007/s11422-007-9081-x

Rahm, J., & Ash, D. (2008). Learning environments at the margin: Case studies of disenfranchised youth doing science in an aquarium and an after-school program. *Learning Environments Research*, *11*, 49–62. doi:10.1007/s10984-007-9037-9

Ramey-Gassert, L., & Walberg, H. (1994). Reexamining connections: Museums as science learning environments. *Science Education*, *78*(4), 345–363. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/sce.3730780403/abstract

Rennie, L. J., Feher, E., Dierking, L. D., & Falk, J. H. (2003). Toward an agenda for advancing research on science learning in out-of-school settings. *Journal of Research in Science Teaching*, *40*(2), 112–120. doi:10.1002/tea.10067

Salmi, H. (2003). Science centres as learning laboratories: Experiences of Heureka, the Finnish Science Centre. *International Journal of Technology Management*, *25*(5), 460-476.

Schibeci, R.A. (1984). Attitudes to science: An update. *Studies in Science Education, 11,* 26-59.

Schibeci, R. A., & Riley II, J. P. (1986). Influence of students' background and perceptions on science attitudes and achievement. *Journal of Research in Science Teaching*, *23*(3), 177–187.

Schwarz, E., & Stolow, D. (2006). Twenty‐first century learning in afterschool. *New Directions for Youth Development*, *110*, 81–99. doi:10.1002/yd

Shrigley, R. L., Koballa Jr., T. R., & Simpson, R. D. (1988). Defining attitude for science educators. *Journal of Research in Science Teaching*, *25*(8), 659–678.

Simpson, J. S., & Parsons, E. C. (2009). African American perspectives and informal science educational experiences. *Science Education*, *93*, 293–321. doi:10.1002/sce.20300

Simpson, R. D., & Oliver, S. J. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. *Science Education*, *74*(1), 1-18.

Soja, E. (1996). *Thirdspace: Journeys to Los Angeles and other real-and-imagined places*. Oxford, UK: Basil Blackwell.

Sorge, C., Newsom, H. E., & Hagerty, J. J. (2000). Fun is not enough: Attitudes of hispanic middle school students toward science and scientists. *Hispanic Journal of Behavioral Sciences*, *22*(3), 332–345. doi:10.1177/0739986300223004

Stake, R. (1995). *The art of case study research.* Thousand Oaks, CA: Sage.

Stocklmayer, S. M., Rennie, L. J., & Gilbert, J. K. (2010). The roles of the formal and informal sectors in the provision of effective science education. *Studies in Science Education*, *46*(1), 1–44. doi:10.1080/03057260903562284

Talton, E. L., & Simpson, R. D. (1987). Relationships of attitude towards classroom environment with attitude toward and achievement in science among tenth grade biology students. *Journal of Research in Science Teaching*, *24*(6), 507–525.

Taylor, P. C. (2006). Cultural hybridity and third space science classrooms. *Cultural Studies of Science Education*, *1*, 201–208. doi:10.1007/s11422-005-9007-4

Tellis, W. (1997). Application of a case study methodology. *The Qualitative Report*, *3*(3), 1–17.

Tobin, K., Seiler, G., & Walls, E., (1999). Reproduction of social class in the teaching and learning of science in urban high schools. *Research in Science Education*, *29*(2), 171–187.

Trochim, W. (1989). Outcome pattern matching and program theory. *Evaluation and Program Planning*, *12*, 355–366. Retrieved from http://www.sciencedirect.com/science/article/pii/0149718989900529

Turnbull, D. (1997). Reframing science and other local knowledge traditions. *Futures*, *29*(6), 551–562. doi:10.1016/S0016-3287(97)00030-X

U.S. Department of Education. (2007). *Report of the Academic Competitiveness Council*. Washington, DC: Author.

Vygotsky, L. S. (1978). *Mind in society.* Cambridge, MA: Harvard University Press.

Walczak, M. M., & Walczak, D. E. (2009). Do student attitudes toward science change during a general education chemistry course? *Journal of Chemical Education*, *86*(8), 985. doi:10.1021/ed086p985

Weinburgh, M. H. (2003). The effects of systemic reform on urban African American fifth grade students' attitudes towards science. *Journal of Women and Minorities in Science and Engineering*, *9*, 53–72. Retrieved from http://www.eric.ed.gov/ERICWebPortal/recordDetail?accno=EJ679771

Weinburgh, M. H., & Steele, D. (2000). The modified attitudes toward science inventory: Developing an instrument to be used with fifth grade urban students. *Journal of Women and Minorities in Science and Engineering*, *6*, 87–94.

Wellington, J. (1990). Formal and informal learning in science: The role of the interactive science centres. *Physics Education*, *25*, 247–252. doi:10.1088/0031-9120/25/5/307

Wolins, I. S., Jensen, N., & Ulzheimer, R. (1992). Children's memories of museum field trips: A qualitative study. *The Journal of Museum Education*, *17*(2), 17–27.

Yin, R. K. (2003). *Case study research: Design and method* (3rd ed.). Thousands Oaks, CA: Sage.

Yin, R.K. (2008). *Case study research: Design and method* (4th ed.). Thousands Oaks, CA: Sage.

Zacharia, Z., & Calabrese Barton, A. (2004). Urban middle-school students' attitudes toward a defined science. *Science Education*, *88*(2), 197–222. doi:10.1002/sce.10110

Zembylas, M., & Avraamidou, L. (2008). Postcolonial foldings of space and identity in science education: Limits, transformations, prospects. *Cultural Studies of Science Education*, *3*(4), 977–998. doi:10.1007/s11422-008-9121-1

Appendix A: BioBus Student Worksheet

BIO BUS

DISCOVER DAPHNIA

Name:

Today, we will use professional microscopes to discover DAPHNIA, a small freshwater crustacean.

PART I. Place a SLIDE containing a daphnia onto the STEREOMICROSCOPE. Use the microscope to MAGNIFY in on daphnia and bring it into FOCUS.Try to identify daphnia's ORGANS.

Label daphnia's organs on the picture below

Draw Daphnia's Actual Size

Record your questions

Record your observations

PART II. Zoom in further on one or more of daphnia's organs and try to find its CELLS.

Draw and label what you find

BIO BUS

CAPTURE CELLS

Name:

CELL #1

cell type & magnification

draw & describe

CELL #2

cell type & magnification

draw & describe

CELL #3

cell type & magnification

draw & describe

CELL #4

cell type & magnification

draw & describe

notes, observations & questions

Appendix B: Attitude Towards Science in School Assessment (ATSSA)

Directions: Respond to your level of agreement to following statements using the scale below.

5 – Strongly Agree

4 – Agree

3 – Neither Agree nor Disagree - Neutral

2 – Disagree

1 - Strongly Disagree

---

1. Science is fun
2. I do not like science and it bothers me to have to study it
3. During science class, I usually am interested
4. I would like to learn more about science
5. If I knew I would never go to science class again, I would feel sad
6. Science is interesting to me and I enjoy it
7. Science makes me feel uncomfortable, irritable, restless, and impatient
8. Science is fascinating and fun
9. The feeling that I have towards science is a good feeling
10. When I hear the word science, I have a feeling of dislike
11. Science is a topic which I enjoy studying
12. I feel comfortable with science and I like it very much
13. I feel a definite positive reaction to science
14. Science is boring

Appendix C: Sample Student Interview Questions

1. What do you remember about your BioBus experience? Please tell me some specific things you remember doing.
    a. Which part of your BioBus experience was the most memorable?
2. What did you learn during your time on the BioBus? Please tell me some specific things you think you learned.
3. How did your BioBus experience compare to what you normally do within the science classroom?
4. Is there anything you didn't understand or got in the way of your learning during your time on the BioBus?
5. What did you think about the physical space and layout of the BioBus?
6. Did your BioBus experience make you think differently about science or scientists?
7. In what ways, if any, did your BioBus experience make you think differently about science and scientists?
8. Do you think your BioBus experience caused a change in your attitude towards science? Why or why not? Please explain.
9. The surveys you took revealed that you had a (positive, neutral, negative) change in your attitude towards science after the BioBus experience. Would you agree with this finding?
10. In your survey you (strongly agreed, agreed, neutral, disagreed, strongly disagreed) that the BioBus gave you a more positive attitude towards science and explained (student questionnaire response). Can you explain to me what you meant by that and whether or not you still agree with your responses?

Appendix D: Post-BioBus Likert Item 15 and Open-response Questionnaire

Likert item 15

The BioBus experience has made my attitude towards science more positive.

5 – Strongly Agree

4 – Agree

3 – Neither Agree nor Disagree - Neutral

2 – Disagree

1 - Strongly Disagree

Open-response questionnaire

1. Explain the reason for your response [to Likert item 15] above in detail.
2. Describe what you did during your BioBus experience.
3. What did you learn during your BioBus experience?
4. What do you think was you most important takeaway (something thing you did or learned) during your BioBus experience? Explain your response.

Appendix E: Examples of Positive Comments About a BioBus Experience

From an Open-ended Response Questionnaire

Type of attitude change	Grade			
	6	8	9	11/12
Positive	I gave it a 5 [strongly agree] because [the BioBus] did make me more positive about science. It helped me be more positive because I noticed how fun it was in the BioBus with all the scientist tools like the microscope and the slide I felt like a real scientist when I was in the BioBus. The trip on the BioBus made me realize that science is fun and that my science class is actually interesting and fun even with or without doing experiments.	I gave a score of 5 [strongly agree] because after I went to the BioBus it got me even more interested in science then I was before. Also because when we used the microscope it got me interested on the animals that we observed and it made me think that I really like science a lot and I will like to study it more.	I gave the score above because in the BioBus I realized that science can have something to do with our everyday lives. One of the BioBus teacher told us he discovered the *Daphnia* in the [neighborhood] which was interesting because I didn`t know *Daphnia*s lived around us!	[The BioBus] gives me more of a brighter experience and I fall in love with science more. The activities and the little creatures that we see amuse me so much that I become more interested.
Extreme positive	The BioBus was amazing and it was very interesting how they demonstrated the insects and how it was half lobster and half crab and I was supposed to adjust the [focus] of the microscope so we can see the amazing insect	The reasons why I gave the score above was because BioBus gave me another perspective of science. Also they showed me and taught me things about cells and living organisms that are difficult to learn or pay attention to in class.	I really liked the BioBus because it was more interesting to do hands on science than sit in a class room take notes and listen to teachers talk. I also really liked having all that advanced science equipment, we get to see how real science is like when your a pro.	I gave the score above because it entertained me to learn about organisms such as the *Daphnia* and how to use microscopes.
Negative	When I got in the bus I felt a great feeling of excitement. When we looked at the flowers cells I thought that I was meant to be there. I also liked looking at real living cells under the microscope.	I gave the score above because the BioBus was a fun experience and it was cool to see the things you can look at as a scientist.	I gave that score to the statement above because I saw very interesting things on the BioBus. For one thing, I really enjoyed the magnifications of the *Daphnia*. It made my attitude towards science more positive because it was extremely interesting to me and I hope we get to do stuff like that in science class.	After going on the bio bus I realized science is more then just studying and paper work. The experiments you do in science is really fun and amazing.
Extreme negative	I will remember how cool it was learning about this bug that lives in the water that actually looks like a bacteria it jiggles and moves like a horse. We could see my cells it was so weird at the same time it was awesome.	I gave them a 4 [agree], because my experience in the BioBus was fun, and we did share a couple of laughs & the because i got to view many know things what I won't normally get to in my normal science class.	I gave the score above because I didn't know that looking closely at your skin or other peoples skin or any other things was so fun.	I was able to see and also interact with seeing new cells. I was the one chosen to do the cheek cell and I was able to see my own cells. Pretty awesome to see this happen. Also interesting to see those huge [microscopes] which can zoom in that much.

Appendix F: Characteristics of Case Study Interview Participants

Name	Grade	Gender	Age	Attitude Towards Science in School Assessment (ATSSA)			Likert item 15 response	Open-ended explanation to Likert item 15
				Pre-BioBus	Post-BioBus	Δ		
Penelope	6	Female	12	51	60	9	Strongly Agree (5)	I finally proved that I love science
Janis	6	Female	12	56	48	-8	Agree (4)	The reason why I gave the score above is because I learned new things and did new things for example I used a real microscope. Also I saw a very interesting animal which is called *Daphnia*.
Oliver	8	Male	13	31	63	32	Strongly Agree (5)	The reasons why I gave the score above was because BioBus gave me another perspective of science. Also they showed me and taught me things about cells and living organisms that are difficult to learn or pay attention to in class.
Yom	8	Female	13	54	49	-5[a]	Neutral (3)	I put my score a 3 because I've never hated science. This just means that my attitude against science hasn't changed at all.
Sara	9	Female	15	36	56	20	Strongly Agree (5)	The BioBus experience has made my attitude towards science more positive because of the simple fact that I got to see and actual animal cell and look at eat. it made me more eager to learn and ask questions and not think that science is all about taking notes but discovering new things.
Bill	9	Male	14	45	34	-11	Neutral (3)	I put [neutral] because nothing will make my view of science [change] because I don't want to be a scientist and I don't get why we are being taught this stuff if I don't want to be a scientist.
Derek	12	Male	18	29	41	12	Agree (4)	I enjoyed it a little.
Indira	12	Female	18	30	18	-12	Disagree (2)	The BioBus was not interest to me

[a]The Grade 8 negative interview pool did not include any candidates outside of -2 *SD*, although the selected interview participant did represent the greatest negative change of the grouping.