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Community College Student Participation in Undergraduate Research: An Explanatory Case Study for Faculty and Research Mentors

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COMMUNITY COLLEGE STUDENT PARTICIPATION IN

UNDERGRADUATE RESEARCH: AN EXPLANATORY CASE STUDY FOR

FACULTY AND RESEARCH MENTORS

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UNDERGRADUATE RESEARCH: AN EXPLANATORY CASE STUDY FOR

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Thesis Advisor: Dr. Rebecca VanBeneden

An Abstract for the Thesis Presented
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This study adapted the current model of science undergraduate research experiences (URE's) and applied this novel modification to include community college students. Numerous researchers have examined the efficacy of URE's in improving undergraduate retention and graduation rates, as well as matriculation rates for graduate programs. However, none have detailed the experience for community college students, and few have employed qualitative methodologies to gather relevant descriptive data from URE participants. This study included perspectives elicited from both non-traditional student participants and the established laboratory community.

The purpose of this study was to determine the effectiveness of the traditional model for a non-traditional student population. The research effort described here utilized a qualitative design and an explanatory case study methodology. Six non-traditional students from the Maine Community College System participated in this study. Student participants were placed in six academic research laboratories located throughout the

state. Student participants were interviewed three times during their ten-week internship and asked to record their personal reflections in electronic format. Participants from the established research community were also interviewed. These included both faculty mentors and other student laboratory personnel. Ongoing comparative analysis of the textual data revealed that laboratory organizational structure and social climate significantly influence acculturation outcomes for non-traditional URE participants. Student participants experienced a range of acculturation outcomes from full integration to marginalization. URE acculturation outcomes influenced development of non-traditional students' professional and academic self-concepts. Positive changes in students' self-concepts resulted in greater commitment to individual professional goals and academic aspirations.

The findings from this study suggest that traditional science URE models can be successfully adapted to meet the unique needs of a non-traditional student population – community college students. These interpretations may encourage post-secondary educators, administrators, and policy makers to consider expanded access and support for non-traditional students seeking science URE opportunities.

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Lastly, a tribute to my husband, Gerard, for all of the sacrifices he has made over the last seven years. Without his loyalty and his confidence, this would not have been possible.

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STATEMENT OF THE PROBLEM

…persistence and departure should be seen as one component of the larger process of career and identity formation. When those careers and identities are crystallized, that is, when individuals are more certain as to their futures, they are more likely to finish college. When plans remain unformulated over extended periods of time, that is, when uncertainty persists for several years, students are more likely to depart without completing their degree programs. (Tinto, 1993, p.41)

<u>Introduction</u>

The rationale for this study is two-fold. Currently, there exists an urgent societal need to attract and retain students in graduate programs in the sciences. The staffing needs of America's applied sciences and technology-based industries cannot be met unless existing undergraduate and graduate completion rates in the sciences are increased (National Academies of Sciences, "Rising above the Gathering Storm", 2005). Secondly, although numerous researchers have concluded that participation in undergraduate science research experiences promotes positive attitudes and increases academic and professional goal aspirations for traditional college students (Hathaway, Nagda & Gregerman, 2002), to date the model remains untested for a sub-population of non-traditional students – community college students. The purpose of this study was to determine the efficacy of the traditional undergraduate research model for a non-traditional student population. The broad research question that was addressed by this study was: In what ways are undergraduate research experiences (UREs) effective in promoting positive attitudes about graduate science study, while increasing academic aspirations and professional goals in the sciences for non- traditional students? The research effort described here utilized a qualitative design and an explanatory case-study

methodology. Six students recruited from community colleges in Maine participated in this study during the summer of 2008.

This chapter begins with a brief summary of the background and the context for the current study. A statement of the problem is described in the following section. The purpose for this study and the three specific research questions are detailed in the next section. An overview of the research methodology is included, followed by information that situates the researcher and the researcher's assumptions. In the final section of this chapter, the rationale and the significance of this study are discussed.

Background and Context

Development of Community Colleges in the U.S.

In higher education today, nearly 60% of all undergraduates begin their education at a public two-year community college (Zeidenberg, 2008). There are currently 1,053 community colleges in the U.S.; in 2007 they enrolled a total of 6.1 million students (Chronicle Almanac, 2007). It is only recently that public two-year institutions have gained sufficient status to be referred to as community colleges. Historically, these institutions were referred to as junior colleges or vocational-technical institutes. Traditionally, junior colleges and vocational-technical institutes provided access to post-secondary educational opportunities for adults in a local community. Their mission was to provide training to adult learners that would meet the human resource needs of local businesses and industry (American Association of Community Colleges, 2001).

Public two-year institutions first absorbed the surplus of adults seeking higher educational opportunities in the late 1940s, as the number of returning World War II veterans with GI Bill educational benefits challenged the admission capabilities of

America's four-year institutions. In the time span from 1950 to 1960, five hundred new junior and vocational-technical institutes were created (Cohen & Brawer, 2003). The higher education system was again challenged by overwhelming numbers of returning veterans after the Vietnam War ended. These adult learners also sought educational opportunities, but many were academically unprepared or unable to meet the admission requirements of the traditional four-year public universities. It was in the 1970s that many junior and vocational-technical institutes underwent a transformation to community colleges, with a focus on remediation and college preparation (Quigley & Bailey, 2003).

Development of Community Colleges in Maine

As in other states in the U.S., World War II veterans returning to Maine were anxious to utilize their new GI Bill benefits, which included tuition reimbursement at the local vocational-technical institutes. For the first-time in the history of higher education in this country, access to a college education became a possibility for those of lower and middle socio-economic status (Wild & Ebbers, 2002). The first vocational-technical institute in Maine was established in 1946 in Augusta and enrolled eighty students. Throughout the 1960s the vocational educational system in Maine expanded to six institutions. In 1994, the seventh and most recent addition to the vocational system was added, York County Technical College (MCCS website, ret. summer, 2007). Beginning in the late 1990s, Maine politicians and economic stakeholders began a series of public dialogues that culminated in the establishment of the Maine Community College System (MCCS) in 2003. MCCS is the youngest system in the country (MCCS website, ret. summer, 2007).

Comparison of Traditional Student and Non-Traditional Student Demographics

Today, community colleges have become a viable academic option for many students and are often the starting point for students seeking an undergraduate education (Merrow, 2007). Compared to public four-year institutions, community colleges, with their open admission policies, affordable tuition, and historical ties to local business and industry have remained more flexible in their course offerings and class scheduling (Parnell, 1985; Phelan, 2000). Often it is these alternative, innovative, course schedules that have allowed greater numbers of community college students who work full or part-time, access to post-secondary educational opportunities. For all these reasons: open admission policies, affordable tuition, flexible scheduling, the focus on academic remediation and transferrable college credits, community college student populations are diverse (O'Banion, 1997).

Many students who attend community colleges are non-traditional students. Nationally, students attending community colleges are more likely to be older, with an average age of twenty- nine (National Center for Education Statistics, NCES, 2004). Thirty-nine percent of all community college students are entirely self-supporting, while only 11% of students attending public four-year institutions declare themselves financially independent from their parents. Most community college students (80%) work either part-time or full-time while attending college. Sixty-one percent of all community college students are women and 17% of all students attending community colleges are single parents (NCES, 2004). Community colleges serve an ethnically diverse population, where 35% of all students nation-wide are students of color.

Approximately one-third of all community college students are the first in their families to attend college (Bryant, 2000).

Community College Students Degree Completion Rates

As more students today choose to begin their college educations at community colleges, rather than at four-year institutions, how do completion rates for community college students compare to those at the larger public universities? Community college students have the lowest rate of academic degree attainment compared to students at all other higher education institutions. Different researchers (Sorey & Duggan, 2008) have reported slightly different rates of academic achievement based on variables that include the length of time allowed for degree attainment and the way students who transferred were represented in the calculations. However, the conclusion reached by all of them is the same. Most students who begin their college educations at community colleges do not complete a degree program. It is also true that roughly 50% of all college students who leave school do so sometime during the first year (Sorey & Duggan, 2008). Moreover, first-year attrition rates for students leaving a community college are almost three times greater than those at a four-year university (Kojaku & Nunez, 1998). Locally, students between the ages of twenty-five and forty-four who begin their post-secondary educational experiences at Maine community colleges have a degree attainment rate of 35.2% for associate degrees. In comparison, the national average for associate degrees awarded to community college students of the same age category is 37.4% (Rosenbaum, Redline & Stephan, 2007). To reiterate, approximately two out of three Maine community college students will fail to complete an associate's degree and will not persevere to acquire an undergraduate degree.

Science in the U.S. Workforce

In 2004, the National Science Board (NSB) published a response to the National Science Foundation (NSF) *2004 Science and Engineering Indicators* report, which highlighted three significant trends in higher education that could seriously affect America's economic and homeland security. The first was the continued growth in jobs that require science and engineering skills. The second was the aging of the current science and engineering workforce and the third was the continued increase in the numbers of foreign-born scientists and engineers with advanced degrees working in the U.S. In their concluding remarks, the members of the NSB made the following recommendations:

> *We all share responsibility with our local communities to make quality education in science and math a priority and to recognize the impact this education will have on the national workforce far into the future. We share responsibility with our states to make colleges and universities strong and to make science and technology education accessible to all the citizens who choose them.* (NSB, 2004, preface).

Science in the Local Workforce

In 2004, the Milken Institute released "*State Technology and Science Index*" (DeVol, Koepp & Ki, 2004), an analysis of each state's current and potential growth capacity for science and technology-related business and industry. Maine was the only state in the New England region that was categorized as a third-tier state (the lowest ranking). All other states in the New England region were categorized as at least second-tier, while Massachusetts and Connecticut were listed in the top ten states in the country for both current and potential economic growth capacity. On a separate comparative composite index, Maine dropped from thirty-fifth in the nation in 2002 to thirty-seventh in 2004 on the *Technology and Science Workforce Index*, an index that factors the

numbers of undergraduate and graduate science degrees awarded in the state with the numbers of working scientists, medical professionals, engineers, and computer scientists in the state (DeVol et al., 2004).

So it seems that, at both the national and the local level, the number of students beginning and completing undergraduate and advanced degrees in science and engineering currently does not meet the workforce demand. Many analysts now predict that this downward trend may continue for the next twenty years (NSB, 2004). Over 50% of undergraduates who intend to major in science and engineering have changed their majors by the end of their sophomore year in college (Seymour & Hewitt, 1997). Although modest gains (4%) have been made in attracting students of diverse racial and ethnic backgrounds to science and engineering majors over the last ten years, there is much room for improvement (NSB, 2004). Lastly, more undergraduates begin their college education at community colleges, where the attrition rate for these students is three times greater than the attrition rates for undergraduates beginning at public four-year institutions (Venezia, Kirst & Antonio, 2003; Schraeder & Brown, 2008).

Undergraduate Science Programs

In 2007, the National Science Foundation (NSF) published a comprehensive report examining the gains in science and engineering degrees awarded in the U.S. between the years 1995 to 2004 (NSF07-308, 2007). In 1995, 51,300 undergraduate degrees in biological science were awarded to Caucasian students, while 6,300 degrees were awarded to students who were Black or Hispanic. By 2004, the number of undergraduate degrees in biological science awarded to Caucasian students had increased to 54,500 while the numbers of degrees awarded to Black and Hispanic minority students

increased to 9,500. In all, as a percent of the total undergraduate degrees awarded in biological sciences, degrees to underrepresented minorities made a modest 4% increase in those nine years.

How do the undergraduate and graduate completion rates for Maine students compare to these national statistics? Recently (2006), the University of Maine published the findings of a special task force commissioned to examine the failings of graduate programs in Maine. There is no doubt that the University of Maine system produces more undergraduate degrees in the natural sciences and engineering than the national average, (based on comparisons of institutions of comparable size and rank), the equivalent of 9.7 degrees per 1,000 degrees conferred. The national average is equal to 7.9 degrees per 1000 degrees conferred. However, Maine ranks fiftieth out of the fifty states and two U.S. territories in the number of doctoral degrees awarded in science and engineering and fifty-first in the number of doctoral students enrolled in science and engineering programs (Graduate Research, Education and Scholarship at the University of Maine, 2006).

Undergraduate Science Research Experiences

The academic science education community has responded to the current situation with attempts to offer more realistic, "hands-on" laboratory experiences for undergraduates (DeHaan, 2005). As the undergraduate science reform movement has gained momentum, numerous federal agencies (National Science Foundation provides funds for Research Experiences for Undergraduates), research institutions (Howard Hughes Medical Institute provides support for Science Education Initiatives and the American Association of Colleges and Universities provides assistance for Project

Kaleidoscope) and academicians now offer extended research experiences for undergraduate students (Hunter, Laursen & Seymour, 2006). Although the format varies from institution to institution, many of these opportunities are scholastically competitive and require that participating students have completed their junior year in college. Selected students are matched with a research faculty mentor and temporarily join the academic research laboratory team. The selected students interact with undergraduate and graduate students in an authentic research setting.

The Study

Problem Statement

As more non-traditional students with diverse backgrounds seek post-secondary educational opportunities it becomes imperative to either develop new models, or to adapt current intervention models which have demonstrated success in recruiting and retaining these student populations in the sciences. Higher undergraduate degree completion rates ensure increases in graduate science program enrollments. Increased numbers of researchers with diverse backgrounds in the scientific workforce contribute to America's global economic competitiveness and homeland security (Business Roundtable, 2005). Surprisingly, the dearth of research reported in the literature suggests that currently few resources and fewer studies have examined the adaptability of these models to new student populations.

Statement of Purpose and Research Questions

The purpose of this study is to determine the efficacy of the traditional undergraduate research model for a non-traditional student population. Six students from community colleges in Maine participated in UREs that lasted from eight to ten weeks,

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during the summer of 2008. The cross-case research methodology was purposely chosen so that different student perspectives might be described and compared among laboratory triads. Each laboratory triad was comprised of the research mentor, the student participant and the lab colleague(s). The current model for traditional URE's was used to determine if non-traditional students might describe benefits similar to those described by traditional undergraduates. The following research questions served as the framework for this study:

1. In what ways does the organizational structure of an academic research laboratory influence acculturation for non-traditional URE participants?

2. In what ways does the social climate structure of an academic research laboratory influence acculturation for non-traditional URE participants?

3. In what ways does a traditional URE in science influence non-traditional students' attitudes and behaviors regarding academic goals and professional aspirations?

Research Methodology

The qualitative research genre, which relies on thick, rich descriptions provided by those who are "making sense" of their lived experiences (Patton, 2002), seemed a natural fit for this study. After securing approval for human subject research from the University of Maine Institutional Review Board, individual perspectives were collected from the participants, using a semi-structured interview protocol mostly comprised of open-ended questions (Seidman, 2006). Each recorded interview lasted between thirty minutes and one hour, with an average length of forty-five minutes; and each was transcribed verbatim. During the course of the study, a total of thirty-four interviews were

conducted with student participants, research mentors and lab colleagues. Interviews were supplemented with field observations, surveys and analyses of relevant ancillary documents. Two of the more informative and unique sources of data for this study were the reflections of the student participants in their electronic journals (blogs) and their dialogic electronic exchanges on the group wikispace.   Not only could data sources be triangulated using this research strategy, but with the inclusion of research mentor and lab colleague interview transcripts, participant perspectives could be compared with those sharing their "lived experience." This provided the opportunity for cross-case analysis among research triads.

All of the collected data was interpreted using ®™NVivo 8, a qualitative research software program that assists in categorization and thematic development from text. Over one hundred coding categories were generated during the analysis phase of the study. Coding categories were condensed when patterns emerged using frequency-in-participant-reporting. Emergent data patterns were contrasted for differences in laboratory organizational emphasis, leadership emphasis and training emphasis. An external auditor confirmed the dependability of the data reduction strategies. The researcher's goal to allow each participant his or her own voice was realized in this study as each of the participants reflected on the activities and events that transpired in the course of the URE during face-to-face interview sessions. The opportunity to co-construct meaning from these shared experiences became reality when the participants contributed to the final analysis and conclusions of this project through a series of

electronic exchanges before the completion of the final draft. The research priority of this study was to collect data in an authentic situation so that the final interpretations might have immediacy, relevancy and transferability.

Premises

The organizational structure of a research laboratory is directly related to the organizational model and the organizational emphasis established by the research mentor. The model may be characterized as either hierarchical or egalitarian, while the emphasis reflects either a focus on the individual or a focus on the group. The organizational structure of the research laboratory contributes to the social climate. In turn, the leadership emphasis and the training emphasis of the research laboratory also contribute to the social climate. The mentor leadership approach may emphasize unilateral decision-making or a collaborative process. The training emphasis may rely on formal, structured training sessions, or these sessions may be informal and serendipitous. Acculturation of new laboratory personnel (in this study- the student participants) proceeds as three negotiation priorities are undertaken; familiarity with the learning milieu, acquisition of vocational habitus and attainment of cognitive apprentice status. For adult learners, fluency in these negotiations can be hastened by self-reflection and peer discourse.

Rationale for the Study

Gains made in the fields of science and engineering in this country in the post-Sputnik era have all but disappeared in the new millennium. As the "Graying of America" continues, with the aging of the baby-boom generation, scientists and engineers who graduated from college in the post-Sputnik era now are eligible for retirement

(Business Roundtable, 2005). The demand by business and industry for college graduates with undergraduate and advanced degrees in science and engineering continues to increase by 5% each year. The strength of global marketplaces now attracts a substantial number (33%) of international students who have acquired advanced degrees in science and engineering in the U.S. to return to their home countries (National Academies of Sciences, 2007). At the same time that science and engineering graduates are decreasing in numbers, the number of students beginning their college educations at community colleges continues to increase. Community college demographics underscore the diversity of the student population. As the established scientific community seeks to increase the number and the diversity of its members, it would seem that capable community college students might balance this deficit. Regrettably, the probability of community college students leaving school before they complete a degree or transfer to a four-year institution is greater than it is for undergraduates at four-year institutions (Schraeder & Brown, 2008). In addition, fifty percent of the incoming freshmen at all institutions of higher learning who declare an intent to major in science have changed majors by the end of their sophomore year (Seymour & Hewitt, 1997).

In contrast, traditional undergraduate students who have had the opportunity to experience "real" science through a URE report greater commitment to educational and professional goals and perseverance toward graduate school application/admission (Seymour, Hunter, Laursen & Deantoni, 2004). Perhaps the same gains might be reported by non-traditional students, if they were offered similar research experiences.

The Researcher

Access to the community college student population was acquired during the six years the researcher was employed as adjunct faculty in the Maine Community College System (MCCS). Familiarity with this student population is the result of over twenty years of teaching experience in more than ten different community colleges located throughout the U.S. It should be mentioned that two of the student participants were previous students of the researcher, but would have no further academic relationship with the researcher beyond the duration of the study. A research stipend was provided to student participants to cover the cost of housing, transportation and loss of income during the summer of 2008. The researcher acknowledges that while substantial expertise with the participant population is an advantage, it may also be construed as a potential liability. Considerable efforts have been made to safeguard against mechanistic researcher bias including triangulation of data sources, triangulation of participant reporting, inclusion of an external auditor during data analysis and member checks after the data analysis phase was complete. To safeguard against personal researcher bias critical self-reflections were recorded in a researcher journal with excerpts included in Appendix R of this study.

Significance of the Study

In this study, a demographically significant student population was recruited for participation in a novel adaptation of the traditional science URE model. It is hoped that conclusions from this research will contribute to understanding how traditional undergraduate science research experiences might be modified to optimize the

acculturation of non-traditional students. Positive acculturation experiences may result in promoting positive attitudes about graduate science study, while increasing the academic and professional science-related aspirations of non-traditional students.

Chapter 2

REVIEW OF RELATED LITERATURE

For learning to happen through experience, Dewey (1938, p.27) argues that experience must exhibit two major principles of continuity and interaction: "The principle of the continuity of experience means that every experience both takes up something from those which have gone before and modifies in some way the quality of those which come after." In other words, experiences that provide learning are never just isolated events in time. Rather learners must learn to connect what they have learned from current experiences to those in the past as well as see possible future implications… The second principle, that of interaction, posits that an "experience is always what it is because of a transaction taking place between an individual and what, at the time constitutes his environment"(Dewey, 1938, p.41, in Merriam & Caffarella, 1999).

This chapter is intended to provide a synopsis of recent influential academic publications that contributed to the framing of this study and the development of its purpose. The areas of scholarship included here are: (1) adult learning theory that focuses on contextual knowing, using a developmental-constructivist model, (2) goals of undergraduate educational reform initiatives in this country, (3) inclusion of authentic research experiences for undergraduate science majors, and (4) a model of acculturation strategies that considers the dynamic between cultural maintenance and contact participation.

The first section presents an overview of recent literature that suggests optimal adult learning occurs when the relationships between the learning context and the learning community are designed to be authentic, reflective and social (Brown, Collins & Duguid,1989; Baxter Magolda, 1993, King & Kitchener, 2004). Artificial environments, such as traditional school classrooms, are therefore not optimal learning environments for adults, because they do not simulate authentic work environments. The historical Cartesian justification for a separate, componential educational perspective on teaching

and learning has proven to be inadequate preparation for workplaces of the twenty-first century (Barab & Plucker, 2002). Recognition of the value of diversity in the workplace necessitates that employees have social and communication skills beyond those of most college undergraduates. A renewed interest in hiring employees with well-developed problem-solving skills requires that adult learners have had educational opportunities that model critical thinking and provide time for peer and self-reflection on content process outcomes (Business Roundtable, 2005). The dearth of college undergraduates with educational experiences to match these workforce criteria underpins the current undergraduate educational reform initiative.

The second area of scholarship that frames this study is an overview of the influential recommendations by numerous federal commissions, national task forces, public organizations and private foundations, beginning more than twenty years ago. Substantial financial and human resources have been dedicated to understanding what changes need to be made to the post-secondary educational system and how best to implement those suggested changes. To generalize the findings reported by each agency (National Commission on Excellence in Education, 1983; National Institute of Education, 1984; Boyer Commission, 1998) would trivialize their significant contributions; however, there are three repeating constructs from their recommendations that reinforce the purpose of this study: the importance of student-centered/student-constructed learning experiences, a renewed focus on active learning or active engagement and inquiry, rather than information, delivery.

In these reports, the target populations of undergraduates that were theorized would reap the greatest potential benefits of these instituted changes were two groups of students from opposite ends of the academic spectrum - honors students and students at-risk (Kinkead, 2003). This dissertation study focuses on a third sub-population, non-traditional students who began their post-secondary experiences at community colleges.

Because the parallels between suggested changes for undergraduate educational reforms and goals of scientific endeavor (discovery, collaboration, communication) were highlighted in many of these report summaries, certainly it is not surprising that the reform spotlight became focused on undergraduate science programming. To date, one of the defining innovations in undergraduate science curricula has been the undergraduate research experience (URE). The third section of this review includes a survey of recent empirical studies that have reported benefits for traditional students from URE participation (Kardash, 2000; Hathaway, Nagda & Gregerman, 2002; Bauer & Bennett, 2003; Lopatto, 2003, 2004; Amoussou & Cashman, 2006 and Frantz, DeHaan, Demetrikopoulos & Carruth, 2006). A comparison of program features from these traditional URE's highlights the range in duration, program goals, target populations, funding sources and institutional categories (university, private liberal arts college, etc.). Following the descriptive analysis of these traditional URE models is a critical evaluation of research methodologies and reported findings. Proceeding from analyses of these selected empirical studies is a discussion of significant implications directly related to the purpose of this study.

Two qualitative studies describing benefits of URE participation for traditional student populations have also recently been described in the literature (Hunter, Laursen & Seymour, 2007 and Hurtado, Cabrera, Lin, Arellano & Espinosa, 2009). Substantial space in this section of the chapter is devoted to the assessment of their research methods and data interpretations. Presented in the next section is a critique of the distinctions and limitations of the published research. Aspects of the reviewed studies deemed exemplary were incorporated into the design, the implementation and the interpretations of this study. An element considered essential, but not mentioned in these studies (opportunity for adult reflexivity) was integrated into the design of this study, with student participant electronic journaling and dialogical exchanges on the electronic discussion board.

This chapter closes with a description of an acculturation model (Berry, 1990; 1997) currently applied by cross-cultural psychologists interested in strategies used by members of a non-dominant culture with contact-participation in the dominant culture. Striking parallels were noted between the experiences reported by the non-traditional student participants in this study and those described by recent immigrants. This model of acculturation strategies has been adapted, and now serves as a theoretical template applied throughout the analytical phases of this study.

Adult Learning Theory: Developmental-Constructivist Model

During the early decades of the twentieth century, prominent learning theorists Lev Vygotsky, John Dewey and Paulo Freire described the interaction of the learner with other learners and with the environment as paramount to meaningful, memorable learning experiences (Vygotsky, 1978; Dewey, 1940, 1951; and Freire, 1994). These powerful educational tenets would disappear after WWII, as public education systems at all levels,

by numerical necessity, were re-directed toward an efficiency model of instructional delivery (Hansman, 2001).

> *For a good part of the twentieth century, adult learning was understood as a cognitive process, one in which the mind took in facts and information, converting it all to knowledge, which then could be observed as subsequent behavior change.* (Merriam, 2008, p. 95).

It wasn't until the 1980s that educational and behavioral psychologists would turn their attention again to the significance of the learning context and the importance of socially-constructed learning experiences (Merriam, 2008).

Marcia Baxter Magolda is a contemporary contributor to adult learning theory. Her research has provided insights into the developmental nature of meaning construction for young adult learners (Baxter Magolda, 1992, 1993, 2006). In a series of publications, spanning five years, Baxter Magolda chronicled the epistemic development of eighty undergraduate students at traditional, 4-year universities, as they moved from their freshman year to graduation and for some, through graduate/professional programs. The results from her longitudinal study suggest that, prior to graduation, only 2% of undergraduates advance to a stage of "conceptual knowing" (1992) or what King and Kitchener (2004) referred to as "reflective thinking." Conceptual knowers recognize that knowledge is tenuous, while their acceptance of presented knowledge is based on an evaluation of its situational congruence. Most of the participants in Baxter Magolda's study demonstrated an "acquisition perspective" or pre-reflective thinking (King & Kitchener, 2004) where knowledge was construed as immutable and based on historical or socio-political authoritative sources. In her conclusions, Baxter Magolda advanced several principles for promoting contextual knowing, two of which; "situating learning in

students' own experience and defining learning, as mutually constructing meaning,"

(1992, p. 5) have become the theoretical cornerstones of undergraduate research

experiences. In her continuation of the original study, using qualitative interpretation of

interview transcripts from twenty-five graduate students (of the original participant pool),

Baxter Magolda concluded that the development of young adult intellect was promoted

through learning environments that encouraged students to understand their developing

personal and professional identities during authentic academic experiences in the

presence of peers and mentors (1993).

Derived from the adult learning theoretical frameworks of the constructivist-

developmental models, educational researchers began to design and implement practical

applications for adult learners that came to be known as situated learning experiences.

Often equated as synonymous terms, there are subtle, yet significant, differences between

experiential learning and situated learning. Experiential learning places an emphasis on

active learning, where the assimilation of new learning occurs by solitary learners. In

contrast, situated learning occurs when a student participates in self-directed learning or

receives group instruction which is later practiced and/or evaluated in collaboration with

the group, while situated in the authentic environment (Hansman, 2001). Situated

learning differs from experiential learning by its requirement for learning through social

interactivity. One of the more recent interpretations of situated adult learning experiences

has provided a further distinction with the introduction of the "cognitive apprenticeship"

(Rogoff, 1990). Cognitive apprenticeships emphasize the reflective thinking component

that adult learning theorists report is necessary to achieve the highest level of intellectual

development in young adult learners (Baxter Magolda, 1993; King & Kitchener, 2004).

The target population for the current study is community college students. In 2004, Daempfle reviewed recent literature on attrition rates for college students with majors in the sciences. He included an analysis of a 1993 study by Schommer that suggested a possible correlation between community college students' epistemological beliefs and the high attrition rates of community college transfer students in the sciences. "…two-year college students were more likely to believe that knowledge is simple and certain and that learning is quick compared to university students [sic] epistemic beliefs about knowledge" (p. 46). The implication remains:

> …many community college students transfer to higher education with a wide range of invisible barriers to higher level thinking which could lead to poorer overall academic performance and a higher attrition rate among community college transferees in the SME (science, math and engineering) areas. (p.46)

In summary, the current developmental-constructivist model for adult learning theory points to the importance of learning experiences that incorporate social interactivity in authentic environments. For adult learners to progress from acquisitive knowers to contextual knowers (Baxter Magolda, 1994), occasions for reflexivity must be integrated into the learning sequence. Therefore, it seems reasonable to expect that the intellectual gains previously described by Baxter Magolda (1992) for young adult learners through situated learning experiences could be achieved with community college students if offered similar opportunities for situated learning that incorporated reflective self-analysis. These theoretical suppositions shaped the modification of the traditional URE model for this study.

Undergraduate Education Reform Initiatives

While accumulating adult learning research continues to highlight the importance of active, authentic and social learning environments that provide students opportunities for reflection on personal and communal growth, there has been growing dissatisfaction with the current instructional delivery system associated with institutions of higher education. In 1983, the National Commission on Excellence in Education (NCEE) published its final report, *A Nation at Risk*, on the state of public elementary and secondary education programs. In their final remarks, the commission drew attention to the close, dependent relationship that exists between pre-college and college programming in this country. The panel noted the influence higher education has on all levels of education, and suggested that this influence carries responsibility (National Institute of Education, 1984). One year later, the NIE published its own report, *Involvement in Learning*, which described recommendations for improving the system of higher education in America. One of the three major conclusions of the report contended that student involvement and motivation were key factors to improving student learning.

> *There is now a good deal of research evidence to suggest that the more time and effort students invest in the learning process and the more intensely they engage in their own education, the greater will be their growth and achievement, their satisfaction with their educational experiences, and their persistence in college, and the more likely they are to continue their learning." (p.17)*

In turn, the blue ribbon commission detailed seven suggestions for increasing student involvement on college campuses, one of which has had a direct impact on the evolution of undergraduate research experiences in science. Faculty were encouraged to incorporate more active modes of teaching and to include a variety of teaching methods in their interactions with students. By "involving students in faculty research projects and

…encouraging internships and other forms of carefully monitored experiential learning,"

faculty can overcome one of the "greatest challenges facing higher education – the

passive student." (p. 27)

Four years later, the Boyer Commission on Educating Undergraduates in the

Research University would publish its landmark report (1998), "*Reinventing*

Undergraduate Education: A Blueprint for America's Research Universities." Funded by

the Carnegie Foundation for the Advancement of Teaching, the report chastised research

universities for "shortchanging" their undergraduate populations (p. 5). Declaring that

research universities had excluded undergraduates from the very mission of the

university, the report continued,

> *"The ecology of the university depends on a deep and abiding understanding that inquiry, investigation and discovery are the heart of the enterprise, whether in funded research projects or in undergraduate classrooms or graduate apprenticeships. Everyone at the university should be a discoverer, a learner. The teaching responsibility of the university is to make all its students participants in the mission."* (p. 9)

The Boyer Commission report included an academic bill of rights for undergraduates that

included the right to expect interactions with senior faculty/researchers and the

opportunity to pursue research in first class facilities and laboratories (p.12). Considered

radical innovations at the time, the Boyer report went on to specify that universities must

begin reform efforts that included research-based learning, undergraduate student

involvement in the research process, and a mentor for every student. Lastly, the

commission emphasized that all these efforts should be targeted for entering freshmen,

rather than reserved for upper classmen (p. 18). The Boyer report delineated the necessity

for research universities to build communities of learners that create a "sense of place" through shared intellectual interests, shared rituals and collaboration on meaningful projects (p. 36).

Historically Significant Studies: Reaching the Tipping Point

One of the earliest and most influential science education reformers who published within the qualitative paradigm was Sheila Tobias. Her earliest notable work, "*They're Not Dumb, They're Different: Stalking the Second Tier,*" was published in 1990. Her interviews with undergraduates enrolled in physics and chemistry courses highlighted a classroom culture perceived by many of the interviewees as non-inclusive, non-collaborative and non-supportive. Her second publication, "*Revitalizing Undergraduate Science: Why Some Things Work and Most Don't*" (1992), reported findings from a two-year study using narrative cases to identify exemplary science programs and to characterize those considered mediocre. There is no doubt that her conclusions provided much of the impetus for the higher education reform initiatives chronicled in this review.

> *Scientists who undertake educational reform are still scientists and, inevitably, bring to their projects the training and the habits of doing science. But reform is not a discovery process, so it is not altogether surprising that past innovations and even large-scale curricular efforts have foundered for reasons that are systemic to the process: the resistance of practitioners to change, a dependence for funding that is at best intermittent, the difficulty for mainstreaming non-traditional approaches, and above all, the vain search for the "magic bullet" which will fix the problem once and for all.*" (Tobias, 1992b, p. 681)

Elaine Seymour is the Director of Ethnography and Evaluation Research, Bureau of Sociological Research at the University of Colorado, a position she has held since 1989. Her work toward reforms in science for higher education parallels that of Tobias.

Seymour and her research colleagues began the first of several longitudinal qualitative

studies in 1990, interviewing science, math and engineering (SME) majors on four

campuses in Colorado. Popularized by of one of the articles published after the first year

of the study, 'the problem iceberg', (1995b) called attention to the scope of the failings of

SME programming and the pedagogical disincentives for SME students. Most

significantly, these concerns were described by both students who had persisted in SME

majors [non-switchers] and those who had not [switchers] (1995a,b,c). In the second year

of the study, three more institutions were added, for a total of seven. Interviews and focus

groups on these seven campuses were conducted in 1991 and 1992. In total, over 460

students were interviewed, culminating in over 600 hours of interview data (1995a,b,c).

The study's major findings were published in "*Talking about Leaving: Why*

Undergraduates Leave the Sciences" (Seymour & Hewitt, 1995). The five contributing

factors most often described by students who switched to other non-SME majors were:

poor teaching by SME faculty (90%), reasons for the initial choice of a SME major

proved inappropriate (83%), inadequate advising or help with academic problems (75%),

a lack of interest in SME or 'turned off science' (60%) and non-SME major offers better

education/more interest (59%). Furthermore, the five concerns most often cited by all

students (switchers and non-switchers, alike) were the same as those cited by the

switchers. The only discrepancies between the two groups were the differences in

response percentages.

Table 2.1

Pedagogical Disincentives for SME Students at Four-Year Institutions

Student Concerns:	Switchers	All Students
Poor teaching by SME faculty	90%	83%
Inadequate advising or help with academic problems	75%	65%
Reasons for choice of SME major prove inappropriate	83%	63%
Lack of interest in SME or 'turned off science'	60%	49%
Non-SME major offers better education/more interest	59%	46%

The seven institutions included in the study were two large research universities (one

private, one public), two state universities, a comprehensive urban university with large

SME enrollments, and two smaller private colleges (one a commuter-based campus, the

other a residential campus). When Seymour and Hewitt (1995) analyzed their data for

reported differences among students attending different institutions they discovered:

> *"Again to our surprise, we found no major differences between institutions of different types in the nature or the frequency of problems raised by their SME students. Though there were some variations in the ranking of problems by institutional type, there was little differentiation across all seven campuses in identification of the most serious concerns by either switchers or non-switchers. Every category of problem was found on every campus, regardless of differences in size, mission, funding, selectivity or reputation."* (1995a, p.199)

However, the researchers did conclude that there was a decided difference in the

expectations for faculty engagement between male and female SME students. Female

students often used the term "discouragement," (1995a, p. 201) as they described the

resistance they perceived faculty had to establishing personal dialogue or to providing

support and encouragement in the academic environment.

> "*By far the words most often used by freshmen to describe their personal accounts with SME faculty were: "unapproachable," "cold," "unavailable," "aloof," "indifferent," and "intimidating"* (p. 201).

[Note: Excerpts from student interview transcripts of this study are included in Appendix A. Time and space constraints prevent a more complete description of the textual interpretations that led to the researchers' conclusions.]

Many of the students who persisted in SME majors described developing positive relationships with faculty as a key component to their academic commitment. For some, the encouragement and opportunity for informal dialogue with faculty, especially at pivotal academic crisis points, is all that prevented their defection to another discipline.

After the publication of *"Talking about Leaving,"* advocates of higher education reforms began to call for a renewed recognition of the "social and interactive" aspects of the learning process for adults (Ewell, 1997; Geetz, 1997). Long-time educational researchers, Pascarella and Terenzini (1991), recommended that undergraduate learning experiences be designed to encourage collaboration rather than competition. Later, Terenzini (1999) would argue that adult learning necessitates activities that foster individual and group reflexivity, rather than the current higher educational model which emphasizes, "learning that is an individual, solitary activity, best undertaken by oneself and evaluated and rewarded (graded) separately from the performance of others" (p.37). To be successful in the new millennium, adult learners needed educational environments that were "interdisciplinary, reflecting both the complexity and the multidimensionality of consequential problems" (Terenzini, p. 38). Reformists began to campaign for

undergraduate activities designed to require contemplation and cooperation amongst groups of adult learners, leading to solutions that capitalized on their previous diverse life experiences. It was under the auspices of these national higher education reform initiatives that numerous federal agencies and individual states' higher education systems were prompted to now turn their reform efforts specifically to undergraduate science, mathematics, engineering and technology (SMET) programs.

Undergraduate Research Experiences in the Sciences

Historical Context

Twenty years after the publication of *A Nation at Risk* (NCEE, 1983), there is a preponderance of evidence that suggests we are still a nation at risk for declining global competitiveness in science and technology marketplaces (McCormick, 2004). What we have become is a nation divided into "a technologically knowledgeable elite and a disadvantaged majority" (NRC, 1999, p. 1). Results published by the National Assessment of Educational Progress reported that 70% of all 4th, 8th and 12th graders tested, indeed, demonstrated a lack of proficiency on the science standards proposed by various national organizations (Vogel, 1999).

More recently, the National Academies of Sciences, the National Academy of Engineering and the Institute of Medicine, recognizing the current critical state of science education at all levels and the diminishing funding for science research in this country, published (2005), *Rising above the Gathering Storm,* a report that predicts consequences for American citizens should the U.S. "maintain, fall behind, or emerge as the leader in a few selected fields of science and technology" (p. xi). The report highlighted ten significant actions that should be undertaken in national education and economic policy

to maintain the current level of prosperity and global security for American citizens. The public attention generated from this report resulted in the passage of the America Competes Act (H.R. 2272, PL 110 – 69) which was signed into effect on August 9, 2007. Destined to have the greatest impact on innovative science curriculum reform for higher education is the allocation of over twenty-two billion dollars to the National Science Foundation (NSF) over fiscal years 2008 – 2010. Mandated by the new law are particularly strong financial investments for the increased support of programs that address the earliest stages of the STEM academic pipeline, 2-year colleges through the STEM Talent Expansion Program (STEP) (Legislative Highlights, America Competes Act, 2007).

Certainly increased financial support for science educational reforms is a pre-requisite for change, but multiple strategies must be employed by higher education policy makers, administrators, curriculum developers and faculty in science programs to recruit and retain talented and diverse undergraduate students. The focus of this study is to explore the possible adaptation of the traditional URE models of undergraduate research experiences for non-traditional students who begin their academic careers at community colleges as one means to enhance recruitment and retention.

Definition of UREs in Science

Although it is not clear exactly when or where the first institutionalized undergraduate research experiences occurred, what is known is that the first documented description appeared in the literature in 1969, founded by the late Margaret L.A.

MacVicar at the Massachusetts Institute of Technology. During the 1980s several other institutions (including Stanford, Cal Tech and the University of Delaware) initiated campus-wide undergraduate research programs (Bauer & Bennett, 2003).

A broad definition for all undergraduate research experiences (Kinkead, 2003) includes mentorship of a novice researcher by an accomplished researcher and an undertaking or project that focuses on the production of new or original work. Although independent undergraduate research experiences are offered by individual researchers at baccalaureate institutions, a majority of the national opportunities are supported by federal funds. A recent, but by no means comprehensive survey of advertised federally-supported science research experiences yielded a list of over 540 different opportunities for undergraduates (http://www.pathwaystoscience.org/SummerResearch.asp). Interestingly, only a small percentage (2%) of these listed opportunities specifically targeted under-represented minority students (Native Americans, students with disabilities, and women of recognized ethnic minority groups) who were freshmen and sophomores and none were designed specifically for non-traditional or community college students. At present there are no funding programs targeted to specifically support undergraduate research at community colleges (Cejda & Hensel, 2009).

The development of a comprehensive definition for traditional undergraduate science research experiences necessitates a brief description of the range in significant categorical program differences. Traditional undergraduate science research experiences differ by the duration and location of the experience, the target population, number of

student participants, student benefits package, program focus and the program sponsor or

revenue source. A summary of these differences is provided in Table 2.2.

Table 2.2

Common Characteristics of Traditional Undergraduate Science Research Experiences

Category:	Representation: (% of total; N = 540)
Program Focus:	
• Behavioral Sciences	1%
• Biological/Life Sciences	16%
• Chemistry	15%
• Earth Sciences	8%
• Engineering	19%
• Health Sciences	8%
• Marine Sciences	2%
• Mathematics/Computer Sciences	11%
• Physics	16%
• Planetary Sciences	3%
Duration of Experience:	
• 8 – 10 weeks	84%
• 6 months	4%
• 1 year or longer	12%
Location of Experience:	
• Pacific West	14%
• Mountain West	5%
• Southwest	9%
• Midwest	21%
• Southeast	18%
• Mid-Atlantic	14%
• Northeast	18%

Table 2.2 (continued)

Category:	Representation: (% of total; N = 540)
Number of Student Participants:	
• 1 – 5	6%
• 6 – 10	18%
• 11 – 20	16%
• 21 – 50	6%
• Undeclared	54%
Student Benefits Package:	
• Stipend	Universal
• Room/Board	98%
• Transportation	98%
Target Population	
• Competitive: Freshmen-Sophomore Standing	4%
• Competitive: Minority Freshman-Sophomore	2%
• Competitive: Junior-Senior Standing	41%
• Competitive: Minority Junior-Senior	15%
• Undeclared	38%
Funding Agency:	
• NSF	50%
• DoD	4%
• NIH	0.5%
• DOE	0.5%
• Private/Other	45%

Note. Percentages that do not equal 100% are due to an overlap in program offerings

(Retrieved from: http://pathwaystoscience.org)

Based on this analysis, the common characteristics of recently-offered undergraduate science research experiences include a focus on engineering, physics, and the biological sciences. Commonly, this competitive selection process identifies six to twenty students of junior-senior standing. The duration of the program is from eight to ten weeks, with most programs offering students a stipend, room and board, and reimbursement for transportation costs to and from the program location. The agency that supports the

majority of these summer science research experiences for undergraduates is the National Science Foundation (NSF).

This traditional URE model was modified for the purposes of this study in the following significant ways to accommodate the non-traditional participants:

- Although the duration of the URE was similar (8 – 10 weeks), significant flexibility was allowed during each weekly schedule to accommodate each individual participant's personal, family and part-time work obligations.
- The location of the research setting for each participant was within a 150-mile radius of his or her primary residence, so that each student could return home, when necessary.
- There was a single student participant at each research location.
- Five of the six student participants were provided with off-campus housing, to provide flexibility in meal preparation and room arrangements.
- Participants who requested financial assistance were provided with loss-of-summer-income compensation, room and board, and reimbursement for transportation costs.
- Participant selection was non-competitive, with a wide-range of non-traditional student demographics represented by the participant population.

<u>Comparative Analysis of Recent Quantitative and</u>

<u>Qualitative Studies</u>

The substantial financial investment in recent educational reform initiatives for post-secondary science programs has also generated interest in determining the relative

efficacy of science URE's to increase college students' retention and graduation rates (Bauer & Bennett, 2003). Evaluative efforts for a myriad of different program-types began in earnest early in 2000, and continue today. The following chapter section includes comparisons of conclusions reached in recent quantitative and qualitative studies. These studies examined the reported benefits of UREs for traditional student populations. Studies chosen for inclusion in this review represent maximum variation between URE program characteristics and different methodological approaches by the principal investigators. Comparative analyses identified notable strengths and limitations associated with these studies. Once identified, positive methodological attributes were integrated into the design of the current study. Constructs of confirmability not mentioned in the reviewed studies, but considered essential to support qualitative interpretations, were also incorporated into the design of the current study.

Comparative Methodological Analyses

Studies published as recently as 2000 are included in this section, which compares methodological approaches of researchers of both the quantitative and qualitative genres, who have been interested in assessing the benefits of traditional science URE's. An analytical summary of these results can be found in Tables 2.3, 2.4 and 2.5. In general, there have been greater numbers of empirical studies published in the last eight years, compared to the numbers of qualitative studies. In addition, during this time period, only one longitudinal study (Seymour et al., 2004; Hunter et al., 2007) has been undertaken. By far, a greater number of faculty and students have participated in quantitative studies. Four of the seven reviewed empirical studies included more than one-hundred students, while neither of the qualitative studies included more than seventy-five students. This is

no doubt influenced by the research methods employed. All the empirical researchers relied on surveys, while the qualitative researchers utilized either student participant focus groups or interviews. Certainly time and budgetary constraints are always considerations in the choice of research methods, but the absence of other means of data collection prevents any form of triangulation, which does diminish the credibility of all these studies. It is also interesting to note that, even though the quantitative studies included a greater number of students, greater inclusive diversity in the target population was not achieved. In four of the seven empirical studies, more than 50% of the participants were Caucasian. Greater racial/ethnic diversity is evident in the student population described by Hurtado et al. (2009), but, in fact, it was this racially diverse group that was specifically the focus of their research questions. Although the second qualitative research group (Seymour et al., 2004; Hunter et al., 2007) did not report participant ethnicity demographics, the disparity in gender demographics (69% males, 31% females) in this study is notable. Somewhat surprising is the inclusion of two data sources (student participant and research mentor) in two of the seven empirical studies reviewed, while the qualitative studies did not have multiple participant perspectives represented. For all studies reviewed, the apprenticeship model predominated. Due to the historical developmental parallels between situated learning theory and the apprenticeship model, this was the conceptual framework utilized by all empirical researchers. Only one research group (Hurtado et al., 2008) framed their study utilizing social-psychological developmental theory.

Table 2.3

Comparative Methodological Analysis of Quantitative and Qualitative Studies Focused on Science UREs

Category:	Quantitative Paradigm: (N = 7)	Qualitative Paradigm: (N = 2)
Participants[a]: • Junior College/Community College • Freshmen, Sophomores • Juniors, Seniors • Program Alumnae • Underrepresented Student Groups • Undergraduates and Faculty • Not reported	1 2 3 2 1 2	 1 1
Institutions: • Large University Research Setting • Smaller University Research Setting • Private College	5 1 1	1 1
Duration of URE: • Summer Experience • Two or more semesters	5 2	1 1
Methods: • Interviews • Focus groups • Surveys	 7	1 1
Model[b]: • Apprenticeship • Collaborative	7 1	1 1
Conceptual Framework: • Situated Learning Theory • Social- Psychological Developmental Theory	7	1 1

Note. [a]Some programs targeted more than one demographic category. [b] One study included both models.

Strengths and Limitations of the Empirical Studies Reviewed

Limitations. A methodological reliance on survey instruments limits possible contextual interpretations for researchers. In turn, respondents are denied opportunities to detail, clarify and enhance accounts of their unique perspectives. Certainly another concern is the biases that may be perpetuated with mailed surveys. Respondents may not be representative of the surveyed cohort. The survey return rate for the University of Michigan group (Hathaway et al., 2002) was actually quite high, with a return rate of 59%, the survey return rate for University of Delaware group (Bauer & Bennett, 2003) was notably lower at 42%. The Delaware researchers did include alpha reliability coefficients for their survey questions (ranging from 0.663 - 0.913, with a value above 0.75 considered statistically significant). Data on instrument reliability was not reported by any other groups, although six of the seven groups distributed survey instruments that were newly created. A majority of the empirical studies (Kardash, 2000; Hathaway et al., 2002, Bauer & Bennett, 2003; Frantz et al., 2006) included data on key survey items found to be statistically significant in comparing pre-survey responses to post-survey responses or comparisons between mentors' responses and those of student participants.

Strengths. The strengths of the seven empirical studies reviewed here are evident in their conclusions. During the last eight years more than 2600 student participants have reported positive benefits from their participation in traditional science UREs. The greatest gains occurred as knowledge/content gains with modest gains reported in understanding scientific processes, research proposals and research presentations. A better understanding of the graduate school application process was reported by a majority of participants (Amoussou & Cashman, 2006). Students who had participated in

a structured/formal URE reported greater increases in the ability to develop intellectual curiosity, acquire information independently, understand scientific findings, analyze literature critically and speak effectively, compared to students who had not participated in a structured URE (Bauer & Bennet, 2003).

Lopatto (2004) reported that more than 75% of 1100 student participants indicated that interpersonal interactions with laboratory personnel contributed positively to their overall satisfaction with the URE. Therefore, this important element was included in the design of the current study. Last summer, in separate interview sessions, participants and lab colleagues alike, were asked to describe these interpersonal interactions. In his previous study (2003), Lopatto concluded that there was significant divergence between faculty mentor and student responses, a dichotomy that he suggested results from the relative importance assigned by the two groups to "structure items" and "consideration items" (p. 139). Faculty mentors valued structure of the research problem and research process in a URE. Students valued consideration items, those "features of mentor behavior that contribute to the emotional and social needs of the student" (p. 140). Lopatto remarked:

> *The behavior of a mentor may affect them more than the state of the physical facility or the poster requirement as the project ends…an URE may fail to yield desired responses without a concomitant attempt to develop the art of considerate mentoring in science faculty.* (p. 41).

Recognizing that incorporation of the two participant perspectives (those of faculty mentors and those of students) provided a broader understanding of the divergence in perceived URE benefits and outcomes, this feature was also incorporated into the design of the current study for non-traditional students.

The differentiation between the structure of the two learning models

(Apprenticeship Model and Collaborative Learning Model) described by Frantz et al.

(2006) was also an important design consideration for the current study. The potential

importance of a match between participant learning style and mode of instructional

delivery in the research environment is now reflected in the first dissertation question of

this study: "What influence does the organizational structure of a research laboratory

have on the acculturation of non-traditional science students?" Lastly, Hathaway et al.,

(2002) focused on benefits and gains ascribed to URE participation by minority students.

The research questions posed in their study influenced the development of the final two

questions. Ascertaining whether or not a traditional URE model can be adapted for non-

traditional students and achieve success in promoting positive educational and

professional aspirations remains paramount to the research aims of this dissertation study.

Table 2.4

Comparative Analyses of Methodological Approaches and Reliability Constructs of Reviewed Empirical Studies

Research Design: Methodological Approaches	Kardash (2002)	Hathaway, et al. (2002)	Bauer & Bennett (2003)	Lopatto (2003)	Lopatto (2004)	Amoussou & Cashman (2006)	Frantz, et al. (2006)
Target Population:	Students: 57 students Student Demographics: Junior or Senior Standing 58% Female 42% Male 77% Caucasian 11% Asian American 9% Black 2% International Participants in HHMI or NSF-sponsored UREs Mentors: 45Research Mentors 30% Female 70% Male Duration of URE: 8 – 10 weeks; single summer	Students: 183 Alumni of Undergraduate Research Opportunity Group (UROP) 108 Alumni non-participants of UROP Student Demographics: 34% Black 31% Asian American 22% Caucasian 13% Latino/a Mentors: Independent sponsorship of participant Duration of URE: On-going	Students: 986 Alumni respondents: Alumni that participated in formal/structured UREs as undergraduates Alumni that participated in informal UREs as undergraduates Alumni that did not participate in UR Student Demographics: 44% Male 56% Female 95% Caucasian 59% Science/Engineer. Majors 41% Social Science and Humanities Majors Duration of URE: On-going	Students: 249 Students Student Demographics: None reported Mentors: 41 faculty Duration of URE: On-going	Students; 1,135 Undergraduates; recent participants in federally or other-sponsored UREs Student Demographics: 58% Female 42% Male 58% of Male Respondents were Caucasian 56% of Female Respondents were Caucasian 80% Junior or Senior Standing Duration of URE: 8 – 10 weeks; single summer	Students: 8 students Student Demographics: 5- Females 4 - Minority 3 - First Generation 4 - Attended Junior College Duration of URE: 8 – 10 weeks; single summer	Students: 42 students Student Demographics: 76% Female 24% Male 40% Black 31% Caucasian 24% Asian American 5% Latina/o Duration of URE: 8 – 10 weeks; single summer
Research Site: Institutional Categorization	Large Midwestern Research University	University of Michigan, Ann Arbor	University of Delaware	Harvey Mudd, Hope College, Grinnell College, Wellesley College	41 Institutions	Humboldt State University	Center for Behavioral Neuroscience: Metro-Atlanta Area (5 HBCU's and others)

Table 2.4 (continued)

Comparative Analyses of Methodological Approaches and Reliability Constructs of Reviewed Empirical Studies

Research Design: Methodological Approaches	Kardash (2002)	Hathaway, Nagda & Gregerman (2002)	Bauer & Bennett (2003)	Lopatto (2003)	Lopatto (2004)	Amoussou & Cashman (2006)	Frantz, DeHaan, Demetrikopoulos & Carruth (2006)
Methods	Pre-and Post-Experience Survey	Mailed Survey	Mailed Survey	Survey	On-Line Survey	Pre- and Post-Experience Survey	Pre-, Mid- and Post Surveys
Model	Apprenticeship Model	Apprenticeship Model	Apprenticeship Model	Apprenticeship Model	Apprenticeship Model	Apprentice ship Model	Apprenticeship and Collaborative Model
Conceptual Framework	Situated Learning Theory	Situated Learning Theory	Situated Learning Theory	Situated Learning Theory	Situated Learning Theory	Situated Learning Theory	Situated Learning Theory
Research Findings: Reliability Constructs							
Participant Sampling	Not Reported	3 respondent categories established by URE participation	Not reported	Not Reported	Not reported	Not reported	Competitive Selection; Criterion-referenced
Instrument Reliability	Not reported	Not reported	Alpha reliability coefficients: Perceived Benefits Questions = .665 Skills and Abilities Questions = .913	Not Reported	Not Reported	Not reported	*Attitudes Towards Science Inventory (Kaelin,2004) Student Assessment of Learning Gains (Seymour, 2006)*
Experimental Validity	Chi-square analysis between pre - and post-survey items and participant and mentor responses demonstrated statistical significance (p < .01); a significant gender effect on key survey items was noted for female participants	Chi-square analysis on key survey items demonstrated statistical significance (p < .01) between URE and non-URE participants	Probit analysis of URE alumnae conferred with doctorate degrees compared to non-URE participant demonstrated statistical significance (p < .05).	Not Reported	Means and SD's calculated for survey responses.	Results were not analyzed for statistical significance	ANOVA analysis of : Gender x Ethnicity x Program demonstrated statistical significance (p < .05) for: attitudes towards science, confidence with science skills for minority males in collaborative program

Strengths and Limitations of the Qualitative Studies Reviewed

Limitations. Qualitative research is defined by thick, rich description embedded in narratives full of contextual detail (Patton, 2002). However, neither of the qualitative studies reviewed here included contextual detail of any kind. There is no mention of research interests of the mentor, number of lab colleagues in the laboratory setting, number of URE participants in each laboratory, academic background of participants, research experience of student participants, etc. These omissions minimize the transferability of both studies.

There are serious and numerous credibility issues associated with each qualitative study reviewed. In neither study did persistent or prolonged observation of participants take place. Interviews and/or focus groups were conducted by research personnel not affiliated with the institution, nor familiar with the participants. A single data collection session lasted from forty-five minutes to ninety minutes. No triangulation of data methods occurred; the interview/focus group transcripts remained the only data source. After the audiotapes had been transcribed, participants were not offered the opportunity to check their accuracy or veracity. In the published reports, no negative cases were identified and researcher positionality statements were not included. The credibility of both publications must be seriously reconsidered.

The dependability of a qualitative study is evaluated on the transparency of data reduction strategies and description of interpretative approaches (Glesne, 2006). Both qualitative research groups (Seymour et al., 2004; Hunter et al., 2007; and Hurtado et al., 2009) failed to provide accounts of how reliability between different interviewers was

established. Data reduction strategies were not detailed, nor was an external auditor

mentioned. However, Hurtado et al. (2008) did include a measure of inter-coder

reliability; Seymour et al. did not.

Strengths. Although both studies have significant issues of confirmability, their

merit is augmented by the inclusion of detailed textual excerpts from participant

transcripts. Moreover, textual comparisons of the experimental group to non-participant

student and mentor groups bolster interpretations made in the longitudinal study

(Seymour et al., 2004; Hunter et al., 2007). In addition, their interpretations were framed

by a developmental-constructivist model of adult learning, which is one of the theoretical

constructs for this dissertation study. Of primary consideration in their analysis was the

progression of professional role identification in authentic learning environments. Their

interest in students' reported clarification and reinforcement of academic aspirations and

career goals are all areas of primary interest in this study.

Most of the participants in the Hurtado study (2008) were either Latino (60%) or

African-American (22%). A majority of these were women (62%). Students of these

underrepresented groups provided accounts of real and perceived reverse discrimination

that resulted in feelings of isolation and inadequacy. Many also commented on the

pressure of constantly being viewed by others as a "token" representative of their

minority group. The fear that individual failure would confirm negative stereotypes of

their racial/ethnic group was expressed by many participants. For many, there was the

added stigma of wanting to become a scientist. In cultures where academic achievement

is not highly valued, explaining to family and friends their academic and professional

aspirations yielded little support and, in some cases, resulted in resistance. For students of

underrepresented groups then, URE's may have an even more influential role in providing motivation and encouragement for persistence in science. The opportunity to collaborate with peers and mentors on meaningful projects increased the self-confidence of many of the participants. Increased self-confidence gained in the laboratory, for some, transferred to the classroom. Several students referred to UREs as "empowering" (p.37). Non-traditional students encounter many of the same negative stereotypes and disempowering life experiences as students from under-represented groups. Interview transcripts from this dissertation study were scrutinized for remarks relating to social stigma and science stigma. Electronic peer dialogues were contextually evaluated for nuances of familial and peer exclusion. Consequently, a model of acculturation strategies is presented in the next section.

Table 2.5

Comparative Analyses of Methodological Approaches and Confirmability Constructs of

Reviewed Qualitative Studies

Research Design: Methodological Approaches	Seymour et al., 2004; Hunter et al., 2007	Hurtado et al., 2009
Target Population	3 year longitudinal study: Students First year:"Rising Seniors"; N= 76 Second year: Graduating Seniors; N = 69 Third Year: 20 mos. After Graduation; N = 55 Comparison Group: 62 Non-URE Students Duration of URE: 8 – 10 weeks; single summer Student Demographics: 69% Male 31% Female Mentors: First year: N = 55 Comparison group: N = 16	Students Total: N = 65; from four campuses. Study participants were minority participants in federally-sponsored or institutionally-sponsored science recruitment and retention programs Duration of URE: On-going Student Demographics: 38% Male 61% Female 60% Latina/o 22% Black 5% Asian American 8% Multiracial 3% American Indian 3% Caucasian
Research Site: Institutional Categorization	4 Small, Private, Liberal Arts Colleges: Harvey Mudd College, Hope College, Grinnell College, Wellesley College	4 Large Research Universities: Massachusetts Institute of Technology, University of New Mexico, University of Texas-San Antonio, Xavier University of Louisiana
Model	Apprenticeship Model	Collaborative Model
Conceptual Framework	Situated Learning Theory	Social-Psychological Developmental Theory

Table 2.5 (continued)

Research Design: Methodological Approaches	Seymour et al., 2004; Hunter et al., 2007	Hurtado et al., 2009
Methods	First Year: Interviews (N = 56) or Focus group (N = 20) Of 60 – 90 min. Second Year: Interviews (Shorter in Duration) Third Year: Telephone Interviews	Focus Groups: 2 focus groups per site. 4 – 12 participants per session. Duration of session ranged between 45 and 90 minutes.

Research Findings: Confirmability Constructs

Transferability	- Detailed textual excerpts from participants included - Little or no contextual or background detail included	- Detailed textual excerpts from participants included - Little or no contextual or background detail included
Credibility	- Persistent and prolonged observation of participants did not occur - Triangulation of data sources did occur - Triangulation of methods and theory did not occur - Member checks did not occur - Negative cases were not presented - Researcher positionality statements were not included	- Persistent and prolonged observation of participants did not occur - Triangulation of data sources did occur - Triangulation of methods and theory did not occur - Member checks did not occur - Negative cases were not presented - Researcher positionality statements were not included
Dependability	- Inter-interviewer reliability was not described - Software Program: *The Ethnographer* - Inter-coder reliability was not described - Data reduction strategies were not described in detail - External auditor was not conscripted	- Inter-interviewer reliability was not described - Software Program: ®™*NVivo 8* - Inter-coder reliability was described; .75 - Data reduction strategies were not described in detail - External auditor was not conscripted

Adaptation of Acculturation Model

Initially, scholars of situated cognition selected the term "enculturation" to represent the assimilation that occurs as a novice makes the transition from incompetence to adequacy in the psychosocial realm of educational or vocational settings (Brown et al., 1989). Arguably, the broader meaning of enculturation implies the learning of a dominant culture by the very young of that same culture. Because all the participants in this study are adults who have already experienced enculturation, the summer undergraduate research experience can more appropriately be referenced as an acculturation – the modification of the culture of an individual or group as a result of contact with the culture of another group (Berry, 1990). Decidedly, most of the published work on acculturation strategies has focused on immigrant and refugee populations. However, the model has applicability to a greater number of groups and situations. Acculturation is the final theoretical construct that was used to frame this study. Frequently in cross-cultural psychology, a distinction is made between acculturation of a group and that of an individual, which is referred to as psychological acculturation (Berry, 1997). In this study, data collected from research triad/dyad members was contextually evaluated for psychological acculturation strategies referenced by the non-traditional student participants.

Berry's model of acculturation (1990, 1997) characterizes four recognizable behavioral shifts used when individuals of a non-dominant culture seek contact-participation with a dominant culture. Individuals who choose to maintain their original culture, yet accept and seek active participation in the dominant culture, demonstrate *Integration.* At the opposite end of the spectrum are individuals who denounce their

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original cultures but refuse to recognize norms and values of the dominant culture. These individuals, who avoid participation with others of the dominant culture, exhibit *Marginalization.* Categories between the two extremes include *Assimilation* and *Separation.* Assimilation occurs when individuals of the non-dominant culture no longer identify with their culture of origin. They seek active participation in and acceptance by members of the dominant culture. Individuals who remain strongly attached to the norms and values of their culture of origin, and exclude the possibility of contact-participation with the new culture, are separatists. How quickly an individual employs an acculturation strategy is a function of social adaption skills and "culture shedding," the unlearning of aspects of the previous culture which are no longer useful or appropriate (1997, p. 13).

> *Acculturation strategies have been shown to have substantial relationships with positive adaptation: integration is usually the most successful; marginalization the least; and assimilation and separation strategies are intermediate. This pattern has been found in virtually every study, and is present for all types of acculturating groups.* (Berry, 1997, p. 24)

In this study, Berry's model of acculturation strategies has been adapted so that comparisons between student participants' perspectives of benefits gained and contributions made to the laboratory can be contrasted with the perspectives of other laboratory members. The extent of perspective congruency between these two groups influences the experiential characterization of the URE for non-traditional students. When integration occurs, participants perceive positive benefits and laboratory personnel report substantial contributions. Separation results when participants perceive positive benefits, while laboratory personnel report no substantial contributions have been made. If a participant perceives no positive benefits, and laboratory personnel suggest substantial contributions, the participant experiences marginalization.

Summary of Literature Review

Andragogy rests on four fundamental differences between adult learners and younger learners. (1) Adult learners progress from dependent personalities to self-directed human beings. (2) Adult learners value the immediacy of learning task application. (3) Adult learners have accumulated life experiences, which results in a readiness to learn and (4) a requirement for learning task relevance. Adult learning theorists who are proponents of the developmental-constructivist model propose that young adult learners achieve maximal learning gains in environments that provide authentic cognitive exercises which rely on peer collaboration. The transformation of young adult learners from "pre-reflective knowers" to "contextual knowers" requires situated learning experiences that include reflection; these are the defining characteristics of cognitive apprenticeships.

The realization that too few educational opportunities in post-secondary institutions met the developmental cognitive needs of most young adult learners led to calls for systemic reform by numerous federal agencies, commissions and task forces in the early 1990s. Because of America's economic reliance on scientific, medical and technological innovation, it is not surprising that these same reform initiatives would soon focus on instituting changes in science curricula, programming, instructional delivery and policy. Federal and private funding agencies have now dedicated substantial financial resources to individual and collaborative efforts to recruit and retain students in SMET majors.

Based mostly on anecdotal evidence, many undergraduate institutions developed programs that would offer limited and/or extended laboratory research opportunities to undergraduate students instead of reserving them solely for graduate students. A critique of a representative sample of recent publications evaluating the efficacy of these programs for traditional undergraduate students was included in this review. However, more and more students enrolled in post-secondary institutions fail to fit the definition of "traditional" college student. As college populations become more diversified, models for inclusion of non-traditional students will need to be developed and evaluated.

The current study sought to adapt a model of undergraduate research experiences in the sciences for a non-traditional student population – community college students. Compared to previous published studies, student participants in this study have provided us a deeper understanding of their "lived experience" through their electronic journals. Collecting interpretations from each member of the research triad – the faculty mentor, the lab colleague and the student participant – provided a novel opportunity to compare the perceived gains and benefits of the URE from multiple perspectives. Qualitative insights gained from this study were evaluated against the results reported for URE participation by traditional students involved in both qualitative and quantitative studies. A conceptual framework, borrowed from cross-cultural psychology, and characterizing acculturation strategies for immigrant and refugee populations provided a new lens for understanding outcomes of URE participation.

Chapter 3

RESEARCH DESIGN AND METHODOLOGY

The best stories are those which stir people's minds, hearts and souls and by so doing give them new insights into themselves, their problems and their human condition. The challenge is to develop a human science that can more fully serve this aim. The question then is not "Is story telling science?" but "Can science learn to tell good stories?" (*Reason, 1981, p. 50,* in Seidman, 2006, p. 9)

Introduction and Overview

The purpose of this study was to determine the adaptability of the current undergraduate research model for a non-traditional student population. Responses to the following three research questions were solicited from key laboratory personnel and student participants:

1. In what ways does the organizational structure of an academic research laboratory influence acculturation for non-traditional URE participants?

2. In what ways does the social climate structure of an academic research laboratory influence acculturation for non-traditional URE participants?

3. In what ways does a traditional URE in science influence non-traditional students' attitudes and behaviors regarding academic goals and professional aspirations?

This chapter reviews each aspect of the current study with an introduction and overview provided to succinctly evaluate the methodological choices incorporated in the research design. The strategies for participant selection and site descriptions are described in the next section of the chapter. An overview of the categories of information that were necessary to address the research questions are detailed in the next section. The steps

taken during data collection and data analysis are then briefly outlined. In the next two

sections, these design elements are described in detail. A discussion of the ethical

considerations pertaining to the study is followed by an explanation of the methods used

to enhance its trustworthiness. A complete review of the limitations of this study precedes

the chapter summary.

One of the primary goals of this study is to determine the extent and type of

modifications that might be necessary for successful adaptation of the traditional URE

model for non-traditional students. For that purpose, a representative sample of

community college students had to experience the URE as a "lived" or authentic

experience. The motivation to design a study using the qualitative genre was based on a

desire to deeply understand the complexity of activities, interactions and relationships

that occurred in this authentic environment. The integration of this detailed contextual

understanding in the final chapters of this study is an essential attribute of qualitative

research design. Perspectives from multiple participants were collected to gain a holistic

appreciation of the process as non-traditional students transitioned from neophyte

scientific researchers to practiced undergraduate researchers. However, the focus of this

study remains the non-traditional students. They are, by definition, the cases (Yin, 1993).

These six students are the units of interest for this study.

> *It may be useful to try to select cases which are typical or representative of other cases, but a sample of one or a sample of just a few is unlikely to be a strong representation of others. Case study research is not sampling research. We do not study a case primarily to understand other cases. ...Our first obligation is to understand this one case/these few cases. ...our first criterion in case selection is to maximize what we can learn.* (Yin, 1993, p. 4)

In addition, this study was designed so that field observations, interviews,

documents and artifacts collected from these multiple sources might contribute to an

interpretation of the influence research laboratory organizational structures have on the acculturation of non-traditional science students. Unique to this study of the undergraduate science research experience, the student researchers were asked to reflect on their daily experiences through regular electronic journaling. Excerpts from these student journals are included to inform readers of the possible unintended and/or unrecognized consequence(s) for non-traditional students in their acculturation to academic research science.

Rationale for Qualitative Research Design

A constructivist-interpretive approach was undertaken in this study to follow the acculturation of six community college science students as they negotiated summer-long research experiences at a variety of four-year institutions of higher education in the state of Maine. The choice to frame this study in a qualitative genre was based on a desire to observe a natural process involving dynamic interactions among people in a natural setting (Opie, 2004). The opportunity to represent multiple perspectives rather than a single perspective was appealing because it offered to provide a more complete and dependable account of the events under study (Merriam, 1998; Krefting, 1991). An important priority was to represent viewpoints that to date have been under represented in the literature, the voices of non-traditional students. Finally, qualitative research is unique for the co-evolution of meaning that occurs between the participant-researcher, the participant-actor(s) and the participant-reader. This provision, which allows the reader to develop his or her own "*naturalistic generalizations*," necessitates the collection of comprehensive contextual detail, matched with significant dialogical detail (Stake, 1995, pg. 42). In addition, the transparency in data analysis and the saturation of the data record

characteristic of qualitative research ensures that the reader's interpretations can be mutualistically-derived, instead of forcefully directed (Caelli, Ray & Mill, 2003).

Rationale for Case Study Methodology

This study utilized a case study approach with cross-case data analysis. This methodological approach was chosen so that multiple human relationships might be described in similar, but not identical, academic research laboratories. In a cross-case study, it is the cases (usually the participants) which are of primary interest (Green, Camilli & Elmore, 2006). The cases in this study are the six student participants. Their perspectives provided the primary insights into acculturation for non-traditional students. However, the participant perspectives were shaped by the perspectives and the interactions with their laboratory members. Each research triad consisted of the student participant, the research mentor and the student lab colleague(s). However, two of the student participants (Catherine and Sam) were placed in laboratories with no lab colleagues. These research dyads consisted of the research mentor and the student participant. Data collected from the research dyads, serendipitously provided fruitful insights that could be compared and contrasted with the research triads. In turn, the research questions of interest were contemplated by discerning patterns in the human-human interactions and the human-environment interactions within each research collective. Once these intra-group patterns were defined, the cross-case analysis compared the commonalities and the differences that emerged between the six research groups. This design element, referred to in the literature as triangulation, is consonant with all qualitative research methodologies, but is central to the design of case studies (Yin, 1984). The contribution of numerous and varied data sources served to expand and

strengthen the credibility of the final interpretations (Yin, 1993). This study is bounded

by the duration of the UREs, which spanned eight to ten weeks, beginning in June, 2008.

Population and Sample

Student Participants

The population of interest for this study was the non-traditional college student

population in Maine, specifically, students who expressed an interest in pursuing an

academic and/or professional career in science. For this study, a non-traditional student is

defined a**s** someone who was nineteen years or older when they began their post-

secondary education. In addition, each student participant also possessed at least one of

the following demographic characteristics: had a documented physical disability, was a

racial minority, had declared financial independence from their parents, was the head of

the household, was a first-generation college student, or had never received a high school

diploma.

These demographic characteristics were chosen for inclusion in the definition of

the non-traditional student for this study, based on a compilation of information collected

by the National Center for Education Statistics (NCES) in 2008. The NCES surveyed

over 19,000 post-secondary students in 2003 and again in 2006. The demographic

analysis portrayed a traditional first-time college student starting at a four-year institution

as an individual nineteen years or younger (85% of those surveyed). In addition, 89% of

students beginning at four-year institutions were financial dependents, while only 61% of

students beginning at two-year institutions were financially dependent on their parents

(NCES, 2008). At both public and private four-year institutions, 70% of entering

freshman were Caucasian. Nationwide, 77% of the students beginning their academic

careers at four-year institutions had parents, one or both of whom had completed high school, compared to 57% of students beginning at two-year institutions (NCES, 2008). In 2003-2004, 11% of all undergraduates surveyed (NCES, 2006) reported having a disability, and of those with-self-reported disabilities, 25% were characterized as orthopedic conditions, 17% as some type of mental illness, with the remainder categorized as a chronic health impairment.

Recruitment. Student participants for this study were solicited in January, 2008, with flyers that advertised two informational sessions (Appendix B). The flyers were distributed by faculty members, academic advisers and student learning center counselors at two Maine community colleges. The informational sessions were approximately thirty minutes in length. Initially, a total of twenty-one students (six men and fifteen women) expressed interest in pursuing a summer research experience. Nine of the original students submitted application materials for federally sponsored Research Experiences for Undergraduates (National Science Foundation REU Program). Unfortunately, none of these students were offered a national research opportunity (Appendix C). However, seven students decided to pursue a local summer research opportunity. The student participants were representative of a sample of convenience. Fortunately, the diversity within the student sample reflected the diversity found within the non-traditional community college population. An example of the letter of interest that these students emailed to prospective research mentors can be found in Appendix D. Four men and three women began their internships in June, 2008. One of the male participants left the study shortly after it began. The study continued with data collected from the six remaining non-traditional college students. A summary of student participant

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demographic characteristics can be found in Table 3.1. All participant names (students,

lab colleagues and research mentors) included in this report are pseudonyms to protect

their identities and to preserve the confidentialities disclosed during the study.

Table 3.1

Student Participant Demographic Characteristics

	Age	Race	Disability	GED	First Generation College Student	Financially-Independent	Head of Household
Andrea	23	White		X		X	
Catherine	45	White	X		X	X	
Tabitha	20	Black			X	X	
Bryan	28	White	X		X		
Joshua	29	White			X	X	
Sam	32	White				X	X

Research Mentors

Beginning in April of 2008, academic program administrators at two universities,

two private colleges and one private research foundation were contacted by email to

determine if faculty at their institutions might be willing to participate in this study.

Emails were sent to the eleven faculty members who expressed an initial interest

(Appendix E). Ultimately, seven faculty members at three different post-secondary

institutions were recruited for participation. Among the original participants of the

research mentor group were two female and five male academics. In this group, all had

achieved full professorship, except one who had attained the rank of Associate Professor.

It was this research mentor who did not complete the study, since his student participant

terminated the internship at the end of the first week. The remaining research mentors

were all Caucasian, and were all fifty years old, or older. The institutions represented in

the study included one large, public, four-year institution; one smaller, public, four-year

institution; one university-affiliated remote research center; and one smaller, private,

four-year college. The research mentors and their institutional affiliations are summarized

in Table 3.2.

Table 3.2

Research Mentor Participants and Institutional Affiliations

Large Public University
Dr. David Stardusky
Dr. James Dugan
Dr. Gillian Arquette
Smaller Public University
Dr. Robert Mosconi
University-Affiliated Remote Research Center
Dr. Richard Sherwood
Private College
Dr. Angela Cook

Lab Colleague Student Participants

     The final study participants are the lab colleagues. This group included both

undergraduate and graduate students who were working during the summer of 2008, in

laboratories supervised by the research mentors previously described. The research

laboratories varied in the number of these students. Some mentors had no supervisees

other than the study participant, while other mentors supervised as many as eight other

students. A lab colleague was randomly chosen from each laboratory, to participate in a

single interview session. However, all lab colleagues at each institutional site were

invited to complete the demographic survey. Unfortunately, not all the surveys

distributed were returned. The demographic data from these surveys is compiled in Table

3.3. Certainly, the sample size is small, but an interesting contrast does exist between the

homogeneity of the lab colleagues at the small private college and the heterogeneity

evident at the larger research university. It is also noteworthy that Tabitha, the

community college student placed at the small private college, shared many of the same

demographic characteristics as her lab colleagues, while the community college students

placed in laboratories at the large research university shared fewer demographic

characteristics.

Table 3.3 [a]

Demographic Characteristics of Lab Colleagues by Institutional Site

Small Private College (N = 2)		Large Research University (N = 11)	
Rank:		Rank:	
Sophomore	2	Senior	3
		Graduate Student	8
Age:		Age:	
18 – 22 yrs. old	2	18 – 22	3
		23 – 29	6
		30 - 39	2
Gender:		Gender:	
Female	1	Female	7
Male	1	Male	4
Ethnicity:		Ethnicity:	
Caucasian	1	Caucasian	9
Hispanic	1	Hispanic	
		Am. Indian/Alaskan Native	1
		Other	1
Student at Institution:		Student at Institution:	
Yes	2	Yes	11

Table 3.3 (continued)

Demographic Characteristics of Lab Colleagues by Institutional Site

Worked in Lab:		Worked in Lab:	
0-3 Months	2	0 - 3 Months	3
		4 - 6 Months	1
		7 – 12 months	1
		1 – 2 Years	4
		3 – 5 Years	1
		6 Years or More	1
Current GPA:		Current GPA	
3.0 – 3.49	2	3.0 – 3.49	3
		3.5 or Higher	8
Laboratory Employment:		Laboratory Employment:	
Full-Time Stipend	1	Full-Time Stipend	7
Part-Time Stipend	1	Part-Time Stipend	2
		Part-Time Voluntary	2
Residence:		Residence:	
Out-of -State	2	Out-of-State	0
		In-State	10
		International	1
Physical Disability	0	Physical Disability	0

Note. [a] Not all lab colleagues returned surveys, in total there were 17 lab colleagues.

Pre-Participation Orientation Program

Prior to the initiation of this study, all six community college students participated

in a series of five orientation/training sessions that began in March 2008 and were

completed by May 2008. Each instructional session lasted approximately three hours and

was conducted at the residential campus of the community college students. The first

orientation session provided an introduction to science electronic databases and strategies

for accessing and analyzing peer-reviewed journal articles and reviews. In the first

session, students also established their electronic journals (blog accounts/websites) and

gained familiarity with the navigational system of the electronic discussion board

(wikispace). The second and third sessions were spent acquiring basic laboratory skills.

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These included: aseptic technique, micro-pipetting, preparation of common laboratory reagents and buffer solutions and agarose gel electrophoresis. The fourth session consisted of a field trip to a local university where the annual research symposium showcased undergraduate research. Students attended a poster session, several short student seminars and toured the library. The final orientation session for each participant was individually designed to review the salient skills and research literature specific to his or her future laboratory assignment. Housing arrangements and stipend disbursement schedules were finalized during this last session. All students who requested financial support were provided with a stipend that covered the costs of room and board, transportation and compensated the participants for the loss of summer income.

Summary of the Research Groups

Beginning in June, 2008, six non-traditional students participated in UREs on university and college campuses distributed throughout the state of Maine. The institutions varied by size, student enrollments, primary revenue sources and the advanced degrees awarded. Research interests of the faculty mentors at each of the institutional sites were varied. Although not exhaustive, their interests included investigations aimed at understanding: regulatory mechanisms of cardiac pacemaker cells in *Drosophila melanogaster,* molecular changes associated with soft-shell clam populations (*Mya arenaria*) exposed to red-tide zooplankton and genetic mutations in hypovirulent strains of soil fungi that may one day lead to reduced pesticide and herbicide use on economically-important food crops. Table 3.4 summarizes the personnel and the relationships for each participating research group in this study. The asterisk denotes the two graduate students that were assigned the primary training responsibilities

in the laboratory of Dr. Gillian Arquette. A unique dynamic operated in this group as

members attempted to negotiate issues of authority, expertise, life experience and gender.

These dynamics will be discussed at length in a future chapter.

Table 3.4

The Research Groups

Institution	Student Participant	Research Mentor	Lab Colleague
Large University Research Setting	Joshua	Dr. Gillian Arquette Karen Mills[a] Leslie Brown[a]	Derek
	Andrea	Dr. Michael Dugan	Tracey
	Bryan	Dr. David Stardusky	Roberta
Smaller University Research Setting	Catherine	Dr. Robert Mosconi	None
Remote-Access Research Setting	Sam	Dr. Richard Sherwood	None
Private College Research Setting	Tabitha	Dr. Angela Cook	Kristin

Note. [a] Denotes graduate student status.

Initial Researcher Responsibilities to Participants

In total, this study included eighteen participants distributed across four different

research settings. The Institutional Review Board of the University of Maine reviewed

and approved the use of human subjects prior to the initiation of this study (Appendix F).

Participants were provided with a verbal description and a written account of the

responsibilities, the potential risks, and the possible advantages associated with their

participation. Participants were provided with assurances of confidentiality, and every

effort has been made to ensure that their trust in the integrity of the researcher and this

study has been preserved. All the participants willingly signed the informed consent

letters. Blank copies are included in Appendices G, H, and I.

Rationale

A variety of documentation was collected from each participant in the study. The greatest variety of support materials was collected, with the greatest frequency, from the student participants. This design rationale rests on the supposition that, for student participants, the summer research experience would constitute a situation with a high degree of unfamiliarity and uncertainty. It was this group that was expected to experience the fastest rate of change, with the greatest magnitude. It was important to include in the research design ample opportunity for the students to reflect on their experiences and to recount them to others. Other study participants were queried less frequently than the community college students. This in no way diminished the quality of the information collected as each research mentor interview session was approximately twice as long in duration compared to the student interview sessions. The average research mentor interview lasted approximately ninety minutes, with a range in duration of one to two hours. Moreover, all interviewees shared valuable insights regarding the UREs which contributed to the final interpretations of this study.

Data Collected From Student Participants

Interviews. Each student participant was interviewed three times during the course of their research internship. Although the interview schedule was intended to be consistent for each research triad, slight deviations were made to accommodate individual participants. The first student interview occurred after completion of the first week. The questions asked during the first session were designed to solicit first impressions of the laboratory personnel and laboratory routines. Several questions focused on training

methods and communication modes between laboratory members. Final questions focused on the student's goals for the URE and challenges or obstacles that had arisen during the first week.

The second interview was conducted during or after completion of the fourth week. Questions asked in the second session encouraged students to share their perspectives on their intellectual progress and to provide an evaluation of their overall satisfaction with the URE. Students were asked to suggest factors that had contributed positively or negatively to their satisfaction rating. In addition, students were queried about the effectiveness of the academic and technical preparation they had undertaken prior to beginning the internship.

The final interview was held after the termination of the internship. In these sessions, students were essentially asked to reflect on the priority negotiations associated with acculturation; their familiarity with the learning milieu, the extent to which they had acquired a vocational habitus and an assessment of metacognitive gains. The format for all of the interview sessions used semi-structured questions that were formulated prior to the interview. The questions were designed to be mostly open-ended, soliciting detailed, descriptive, and thoughtful responses from the participants (Gubrium & Holstein, 2002). The interview sessions were recorded on audiotape and transcribed verbatim. The student participant interview questions can be referenced in Appendix J.

Field observations. A second informative source incorporated into the research design was a single field observation of the student participant in his/her research laboratory. The field observation occurred at approximately the mid-point of the internship. For all participants, this was a scheduled observation. Extensive field notes

were taken by the researcher, with a focus on noting the demonstration of laboratory skill attainment and capturing significant verbal and non-verbal exchanges between triad members. A summary was completed after each field observation, so the more relevant events might be recorded (Appendix K). The field observation provided an opportunity for the researcher to view the actual human to human interactions and human with environment interactions, rather than listening to a retroactive account of these events from the participant's perspective.

Electronic journals. Student participants were also asked to reflect on their UREs using personal and group electronic journaling. Students created personal blog sites prior to beginning their internship. In addition, students were registered and familiarized with researcher-managed wikispaces during one of the initial pre-participation training sessions. The inclusion of electronic journals was intended to provide a forum that supported student introspection. It was hoped that the dynamic and emergent aspects of the qualitative research genre would be epitomized in the personal and unsolicited comments students chose to share electronically. Although some participants posted electronic entries more frequently than others, all students utilized these electronic resources. Representative excerpts from two of the participants' blog sites are included in Appendix L and a sample exchange from the wikispaces can be found in Appendix M.

Data Collected From Research Mentors

The research mentors comprised the second participant group of interest. Corroboration of the observational data generated from this group included interview transcripts, documents and, for some mentors, field observation notes. Field notes are

included in the research record if the research mentor was involved with the student participant on the day of the scheduled observation. Inclusion of data from this group provided a deeper understanding of the differing perspectives of acculturation in an academic laboratory setting.

Interviews. Research mentors were interviewed twice during the course of the URE. Each research mentor was interviewed sometime after the student had completed the second week, and again after the student had completed the internship. Questions asked during the first interview were designed to stimulate commentary on the laboratory organizational structure and social climate (Research Questions 1 and 2). In the final interview research mentors shared their perspectives on the benefits and gains made by the non-traditional student. Additionally, mentors were asked to contextually frame the participant's achievements within the research progress of the laboratory. The research mentor interview questions can be found in Appendix N.

Artifacts. Documents collected from the research mentors included curriculum vitae, recent publications and written or electronic personal communications. These were used only with explicit permission. Due to the informative nature of these documents, direct reproduction of them would have compromised the signed confidentiality agreements of this study. Pivotal excerpts from these personal communications with all personal identifiers removed are included in Chapters Four and Five.

Data Collected From Lab Colleagues

The documentation collected from the remaining participant group, the student-lab colleague(s), included an interview (Appendix O) of a student representative from the laboratory group and a survey (Appendix P) that was distributed to all members of the

laboratory group. Field observations of the lab colleagues are included in the data record only when collaborative work between the non-traditional student and the lab colleague(s) was observed by the researcher.

Interviews. The design justification for the lab colleague interview was based on a tentative assumption that novel perspectives might be revealed that would expand the understanding of acculturation for non-traditional students by comparison to reports from "traditional" college students. Needless to say, it seemed evident that interpretations of this kind would not be possible if in-depth, semi-structured interviews were not included for this potentially revelatory group of participants.

Lab colleague survey. Basic demographic information about the composition of each research group was collected from a lab colleague survey distributed to all lab group members. These data would be important in exploring the differences in interpersonal dynamics between research triads. The lab colleague survey was distributed at the mid-point of the student internship and collected prior to the completion of the internship. These results have already been described in a previous section of this chapter and are summarized in Table 3.3, page 60.

In total, the documentation described here was collected from each research group and compared with the five other research triads/dyads. The data collection schedule offered ample opportunities for each participant group to record, report and reflect on the 2008 UREs. A summary of the documentation for this study is represented in Table 3.5.

Table 3.5

Documentation Collected From the Research Triads and Dyads

Category/Frequency	Schedule
Student Participant	
Interviews:	After First Week of Internship
3 occasions	Mid-point of Internship
	Completion of Internship
Field Observation:	Mid-point of Internship
1 occasion	
Electronic Journal	Undefined
Personal: Blog	
Collective: Wikispace	
Research Mentor	
Interviews:	After Second Week of Internship
2 occasions	Upon Completion of Internship
Field Observation:	Mid-point of Internship
1 occasion	(Not applicable for all triads)
Documents	Undefined
Lab Colleague(s)	
Interviews:	Mid-point of Internship
1 occasion	
Field Observation:	Mid-point of Internship
1 occasion	
Survey	Mid-point of Internship

Data Management and Analysis

Induction is paramount to the qualitative research genre. The analytical tasks that
were undertaken in this study after data collection had been completed, required
beginning at the beginning. In stark contrast to quantitative research, there were no
formulated hypotheses that stood to be proven or disproven. Drawn from the data
collected, subtle distinctions in the content and the context of the spoken words of the
participants directed the categorization, reorganization and reduction processes.

Open Coding Strategies

Over fifty hours of recorded audiotapes from participant interview sessions were transformed into electronic text. A qualitative data coding software program was selected to assist with the initial steps of transcript analysis. Although several different programs were considered, ®™NVivo 8, produced by QSR International was chosen. Each participant transcript was individually coded using broad, open coding categories that were created based on the interview questions asked of each participant group. At a more fundamental level, the interview questions were formulated to solicit perspectives on the three primary research questions of this study. The original open-coding categories included participant dialogue quotations referencing academic and professional aspirations, organizational structure of the laboratory and comments centered on interpersonal relations in the research setting. From these three broad categories, more specific coding categories were generated, based on similarities and dissimilarities between topical references embedded in the categorical quotations. For example, the coding category "Academic Aspirations for Student Participants," underwent the following analytical refinement sequence: Academic Aspirations→Completion of Associate's Degree→Completion of Bachelor's Degree→Completion of Graduate Degree→ Master's Degree→Doctorate Degree and/or Professional degree. In turn, every transcript from each source (participant) in each participant category (lab colleague and research mentor) was analyzed using the same set of open-coding categories. Over one hundred final open-coding categories were created. Invaluable to the analysis at this stage are the computer-tabulated source and coding category frequencies. This numerical information provides a sense of overall relevance for a particular coding category, as well

as providing information on the relevance of the coding category for individual

participants. Computer screenshots of these open categories can be viewed in

Appendix S.

Axial Coding Strategies

In the next phase of data analysis, related open categories were clustered to form

an axial coding scheme (Patton, 2002). The relation established among categories was

based on principles of researcher-interpreted convergence and divergence. The first axial

cluster that emerged from the data was based on textual comments related to laboratory

structure; organizational emphasis, training emphasis and leadership emphasis. A second

axial cluster centered on negotiation priorities between participants within the laboratory

social network. Within this cluster were coding categories related to familiarity with the

learning milieu, acquisition of vocational habitus and status as a cognitive apprentice.

Constant comparisons were made between quotations assigned to the initial open coding

categories and their re-assignment to the emerging axial categories. Confidence in the

structural relationships constructed after this phase of analysis is strengthened by these

constant comparisons. A visual representation of the previously described data

categorization, reorganization and reduction methods is included for clarification

purposes.
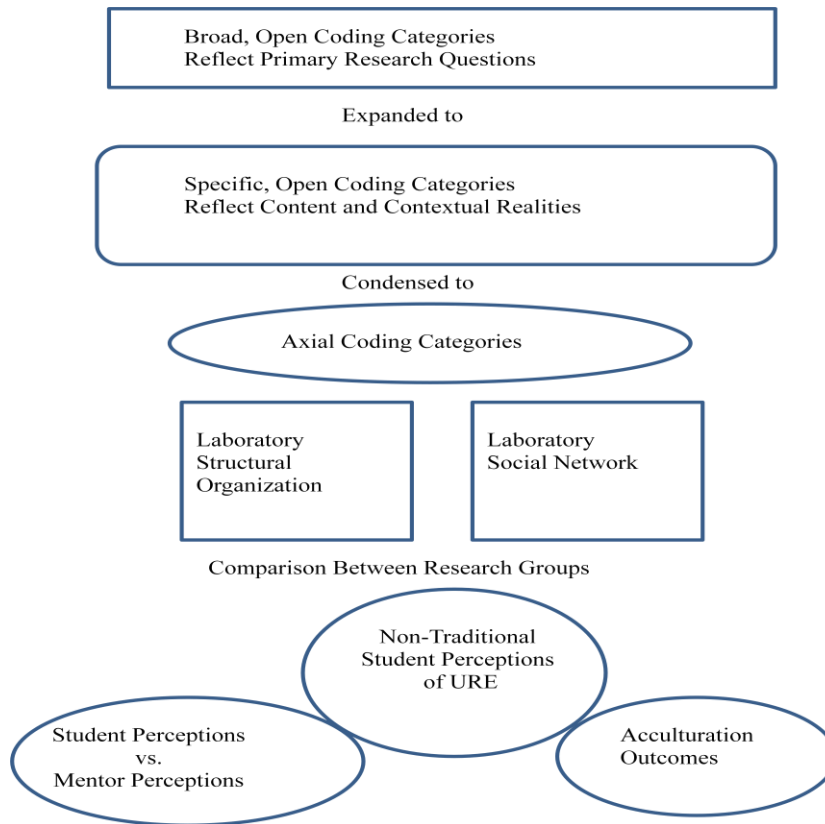
Figure 3.1

Data Analysis Strategy Using ®™NVivo 8

Cross-Case Analysis

In the final phase of analysis, frequency comparisons of content and contextual references from the two axial coding categories were made among research groups. Several thematic patterns emerged when student participant perspectives were contrasted with those of their research mentors. Organizational structure and social network assimilation did influence overall perceptions of the URE for non-traditional students. Student perspectives and research mentor perspectives were not always congruent when comparing perceived contributions to the research group and developmental gains. As cross-case analyses concluded, categories of acculturation outcomes for each student

participant emerged that are strikingly similar to acculturation outcomes described by Berry (1990, 1997) for immigrant populations. These interpretations will be elaborated in future chapters.

Trustworthiness

As described by Lee (1991) in Miles and Huberman (1994) the confirmability of qualitative research can be evaluated at three different levels. Assessed at the first level, trustworthiness relies on the accuracy of representation of the meanings and interpretations of the participants. At the second level, confirmability considerations are based on the degree of transparency included in describing the researcher's analytical reduction process. Lastly, the congruity between the research conclusions and the chosen conceptual frameworks can be evaluated, allowing the reader to determine the transferability of the findings. In essence, the trustworthiness of this study is substantiated by its "demonstrated representativeness" (Miles & Huberman, 1994, p. 263).

Participant Representativeness

The representative capacity of the student participants can be demonstrated by the diversity captured in this group. Maximum variation among the variables most likely to be significant for non-traditional students is represented by the six members of the student participant group. This diversity is reflected in the differences in their ages, ethnicities, physical capabilities, high school completion and categorization as first-generation college students. Their acculturation experiences could then be contrasted to the second, more homogeneous student participant group, the lab colleagues. In this way, acculturation was explored from multiple perspectives, and described by multiple voices.

The trusting relationships developed between the researcher and the student participants, over the course of six to twelve months prior to the beginning of the study lend credence to the honesty and the openness of the viewpoints they shared during their interviews and those they recorded in their electronic journals. To ensure accuracy and completeness in the data record, all the interview sessions were tape-recorded and transcribed verbatim from the recordings (Glesne, 2006). Each participant was e-mailed a copy of his/her completed transcript, to verify the record and provide additional opportunity for the participant to expand or clarify responses.

Triangulation of Data Sources and Participant Perspectives

Another determination of the methodological integrity of a study is the inclusion of triangulation (Patton, 2002). Triangulation analysis utilizes multiple forms of evidence and ensures that multiple perspectives from one or more participants will be captured over the course of the research project (Glesne, 2006). In this study, perspectives were collected from eighteen participants in multiple forms which included interviews, field observations, surveys, documents, artifacts and electronic journaling. The study continued for ten weeks; data were collected from all participants until saturation was achieved. All documents and artifacts have been archived; all original tape recordings and transcripts have been preserved. The original field observation notes and contact summary forms from the field observations are now included in the permanent records of this study.

Transparency of Data Reduction Strategies

An audit trail was compiled during the analysis phase of this study, so those interested in understanding the data reduction strategies used could re-trace these data

management decisions (Appendix Q). Notably, Miles and Huberman (1994) suggest that data reduction decisions occur in all phases of the qualitative research process: the preparatory design phase, the data collection phase, and the data analysis phase. Therefore, a researcher reflexivity journal was kept during this study, from its inception in September of 2007 to its completion in May, 2009. The entries in this journal provide further insight into the decisions, strategies and bias of the researcher, and provide a record of how those changed during the course of this study. Lastly, as the data analysis phase of this study ended, an external auditor was conscripted to provide additional comments on the strengths and weaknesses of the research conclusions. The auditor was a professional qualitative researcher, proficient in educational research evaluation.

Researcher Positionality

Of fundamental importance in exemplary qualitative research design is the self-reported position of the researcher (Wolcott, 2001). Researcher positionality assists the reader in understanding the influence of researcher bias in the initial design choices made and the data interpretive process that follows. The credence of the researcher's interpretations can only be strengthened by the inclusion of positionality statements (Ponterotto & Grieger, 2007). Therefore, a brief account of the history of access for this study is described below.

Account of Access: Student Participants

This study required an on-going commitment from all participants that ranged from eight to ten weeks in duration. Student participants were displaced from their personal and academic zones of familiarity to alien institutional environments and unfamiliar living arrangements. The "intensiveness and extensiveness" of this research

experience (Marshall & Rossman, 1999, p. 80), suggested it would necessitate a high

degree of negotiated trust between all participants, including the researcher. This

negotiated trust was established over a period of six to twelve months with the student

participants, some of whom (two out of the six participants) had previously been students

of the researcher. The four remaining participants had all been community college

students enrolled at institutions where the researcher worked or had worked as an adjunct

faculty. There can be no dispute that a power differential existed then, between the

student participants and the researcher. It should also be noted that none of the

participants would be students of the researcher in the future, either due to graduation,

transfer or completion of degree program prerequisite courses. Additionally, in an effort

to remain vigilant to the power disparity between the researcher and the student

participants, a researcher journal was kept, with entries focusing reflexively on this and

several other issues that emerged during the course of the study. Salient excerpts from

that journal are included in Appendix R.

Account of Access: Research Mentors

The characterization of the intensiveness and extensiveness of this research

experience for the research mentors is also included, to assist the reader in the further

assessment of the study's veracity. Solicitation of research mentors for participation was

facilitated through electronic communications. The access was not pre-negotiated; each

mentor's participation was stochastic. Their acquiescence was seemingly based on either

professional generosity or on an optimistic expectation of student productivity. The

second power differential that must be recognized then, is the one that existed between

the research mentors and the researcher. Each of the research mentors who participated in

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this study had attained the status of a full professor. Each has published extensively, and most have more than ten years of experience in the academic mentoring of undergraduate science students. As a doctoral candidate with vast undergraduate teaching experience, but no experience mentoring students in an academic research setting, I found their experience, authority, and position of influence to be serious considerations when constructing meaning from their interviews and interpreting their interactions with the student participants.

<div align="center">**<u>Limitations</u>**</div>

Every research study has limitations, and responsible qualitative researchers acknowledge those limitations (Glesne, 1999; Patton, 2002). Noticeably absent from this study, in comparison with most qualitative research designs undertaken for the partial fulfillment of the requirements of a doctoral program, is a pilot study. The significant advantages of a pilot study for a qualitative researcher include the information acquired concerning the cogency of the data collection instruments and the experience gained from an initial attempt at qualitative data analysis (Wolcott, 2001). The implausibility of conducting a pilot study prior to the beginning of this study was based on logistics and resources. Considerable investments of time, energy, and financial resources were necessary to coordinate the re-location of the six student participants. The optimal time period for this re-location was the summer months, when none of the student participants had conflicting academic or professional responsibilities. In lieu of the pilot study, the interview instruments for this study were compiled from survey questions collected from recent quantitative and qualitative research projects, investigating the efficacy of

traditional undergraduate science research programs (Kardash, 2000; Seymour et al., 2004; Bauer & Bennett, 2003).

The small sample size of the student participant population is another limitation to this study. Depth of understanding is a key factor in qualitative research, and often can be achieved only with small numbers of participants. In this study, however the low initial response was coupled with the researcher's reluctance to reject participant candidates for any reason. This sample represents a sample of convenience, which is often equated with "information-poor cases" (Patton, 2002, p.244). However, in this study it was deemed more important to reward non-traditional student interest and motivation, even if transferability to other populations might be sacrificed. Serendipitously, the student participants in this study demonstrated a high degree of representativeness along demographic dimensions of significance; age, gender, first generation college student, financial independence, student/employee and recognized physical disability.

A final limitation to this study is the absence of a crucial demographic category of non-traditional students that is not represented in this study. There were no student participants who belonged to the "female, head of household" demographic category. In addition, single parenthood is one of seven risk factors that contribute to student attrition at community colleges nation-wide (NCES, 2003). In fact, a twenty-six year-old single mother was recruited for this study. Day care arrangements were made and temporary re-location plans were negotiated with her significant other. None of the research mentors contacted for participation in this study were interested in placing this student in his/her laboratory for the summer experience.

Summary of the Research Rationale, Design and Methodology

This chapter describes the design rationale for this study. The methods used to collect and analyze the data from all participants are described, in what it is hoped is sufficient detail for the reader to understand the basis for the researcher's decisions made before, during and after the study. In the summer of 2008, a total of eighteen participants co-constructed with the researcher meanings and interpretations of a "lived" undergraduate research experience in science for non-traditional students. The information collected was mostly in the form of textual data from interviews, field observation notes, pertinent documents and artifacts, and salient excerpts from the electronic journals of the student participants. Analysis of the voluminous data was facilitated by a textual analysis software program, frequently used by qualitative researchers, ®™NVivo 8. However, the emergent patterns drawn from the textual analysis were continually compared to the situated experiences of the participants. Assessment of the credibility of the final interpretations of this study was confirmed both by the participants and an external auditor.

The purpose of this study was to evaluate the efficacy of traditional UREs for a non-traditional population – community college students. The questions that provided the conceptual framework for this study focused on the influence of laboratory organizational structure and social networks on the acculturation outcomes for non-traditional students. Understanding how these outcomes influenced non-traditional students' overall perceptions of the URE and contributed to their resolve for future graduate study and commitment to careers in science shaped the conceptual interpretations of this study.

These interpretations should be informative to the administrators of federal science funding agencies and to individuals interested in local science reform initiatives for higher education. Increasingly, more and more non-traditional students will begin their college experience at community colleges. Some will have aspirations to become scientists. As has already been described in the previous chapter, more than 50% of incoming freshmen who report they intend to major in the life sciences have changed their major by the end of their sophomore year (Seymour & Hewitt, 1997). Greater numbers of diverse students might be retained in these science majors if non-traditional students were offered greater access to undergraduate science research experiences. Inclusion of non-traditional students in traditional science UREs will require that acculturation be more thoroughly understood.

Chapter 4

FINDINGS RELATED TO ORGANIZATIONAL AND SOCIAL FACTORS

THAT INFLUENCE STUDENTS' ACCULTURATION

"...[A]n individual life cycle cannot be adequately understood apart from the social context in which it comes to fruition. Individual and society are intricately woven, dynamically interrelated in continual exchange." (Erikson, 1997, p. 114).

Introduction

This chapter is the first of two that presents findings from a 2008 study that traced acculturation of six community college students in academic research laboratories located throughout the state of Maine. The purpose of this study was to determine the efficacy of the current undergraduate research model for a non-traditional student population. The broad research question to be answered by this study is: In what ways does participation in traditional UREs influence non-traditional students' commitment to pursue advanced studies in science and to seek careers as professional scientists? The research effort undertaken to explore this fundamental question employed a qualitative design and used explanatory case study methodology. The student participants were actively engaged in biological research projects with established faculty and student lab colleagues at four different institutions: a large university, a remote-access research center affiliated with the larger university, a smaller university, and a small private college. Information was collected from participants during scheduled interviews throughout the ten-week experience. Collecting perspectives from all laboratory personnel provided a unique opportunity to juxtapose evolving viewpoints of this authentic, lived experience. In this way, multiple perspectives contributed to the resolution of the three specific research questions of this study:

1. In what ways does the organizational structure of an academic research laboratory influence acculturation for non-traditional URE participants?

2. In what ways does the social climate structure of an academic research laboratory influence acculturation for non-traditional URE participants?

3. In what ways does a traditional URE in science influence non-traditional students' attitudes and behaviors regarding academic goals and professional aspirations?

Audiotapes from all interviews were transcribed verbatim. A qualitative data analysis software program, ®™NVivo 8, was used to organize and categorize the content of each transcript. Constant comparative analysis among data sources (the participants) and across the participant population (among participants at different research sites) culminated in patterns of frequent textual references. Coupled with contextual details, these patterns coalesced into thematic interpretations which are recounted in this chapter.

This chapter begins with brief profiles of each of the six primary participants, the community college students. The subsequent section presents a composite characterization of the research mentor group and a single interview excerpt from a mentor who had himself participated in a research program as an undergraduate. His quotation is representative of this group's collective perspective of the overall benefits that can be achieved through UREs and the profound influence a positive mentor relationship can have on students' academic and professional choices. The last participants to be described are the lab colleagues. Out of the six research groups, four laboratories had staff/personnel who daily interacted with the student participants. Three of these four lab colleagues had either attended or been employed by a community

college. Representative excerpts from these interview transcripts captured their impressions of community college laboratory facilities, academic rigor and student capabilities. The implications of academic stigma and institutional stereotypes are discussed later in this chapter.

Analytical interpretation proceeds with the introduction of a theoretical model that delineates relationships between dissertation research questions, laboratory social status and acculturation outcomes for non-traditional students. Next, detailed participant commentary that referenced laboratory organizational structure and social climate is related to the theoretical model. What follows is a presentation of three realized outcomes of URE participation for non-traditional students. This chapter closes with a summary of significant findings for the first two research questions posed in this study.

Student Participant Portraitures

The six student participants in this study demonstrate demographic diversity, not unlike their classmates at community colleges nationwide. Because their different individual characteristics, no doubt, influenced their interpersonal interactions with others in the laboratory setting during their recent URE, salient demographic characteristics for student participants are summarized in Table 4.1. However, to more clearly represent each participant to the reader, an individual portraiture is also included.

Table 4.1

Detailed Demographic Characteristics of Student Participants

Student	Andrea	Catherine	Tabitha	Bryan	Joshua	Samuel
Age (years)	23	45	20	28	29	32
Race/Ethnicity	Caucasian	Caucasian	Haitian	Caucasian	Caucasian	Caucasian
Previous Academic Accomplishments	GED completed at age 20	High School Graduate	High School Graduate	High School Graduate	Associate's Degree in Audio-Engineering	High School Graduate
Student Status	Full-time	Full-time	Full-time	Full-time	Full-time	Full-time
Financially Self-Supporting	Yes	Yes	Yes	No	Yes	Yes
Employment While Attending School	Full-Time: Fall Semester Federal Financial Aid Support: Spring Semester	Full Time: Independent Small Business Owner (Catering Business)	Full Time: Retail sales	Not Employed	Tuition and Expenses From Savings	Full Time: Independent Small Business Owner (Photography Studio)
Head of Household	Yes	Yes	Yes	Yes	Yes	Yes
Number of Financial Dependents	None	None	None	None	None	Three
Documented Physical Disability	None	Numerous surgical procedures on feet; unable to stand for long periods	None	Juvenile Arthritis; Crohn's Disease		
Accumulated Community College Credit Hours (sem. hrs.)	30	55	30	60+	60+	60+
Previous Academic-Related Internships	None	None	None	Out-of-State Summer Experience	None	Out-of-State Summer Experience
Previous Relevant Life/Professional Experiences	None	None	None	None	Weekend Volunteer: Hospital Medical Laboratory	Digital Video/Image Editing

The age of study participants ranged from twenty to forty-five years old. The mean age of participants was 29.5 years, while the median age was 32.5 years. Tabitha, the youngest, was the only participant who was not Caucasian. All participants had received a high school diploma or a GED, but only Joshua had previously attended college. His first Associate's Degree, in Audio-Engineering, was awarded by an out-of-state community college. All participants attended college full-time, all characterized themselves as head of the household, and five out of six (83%) were financially self-supporting. A majority of participants (66%) worked either full-time or part-time while attending school full-time. Two participants were small business owners. Catherine operated a catering business and Sam was the sole proprietor of an independent photography studio. There were also two participants with documented physical disabilities. Catherine had recently undergone a series of four different surgical procedures to realign the bones in her feet. She was not able to stand for long periods of time, but she was ambulatory. Bryan had been diagnosed with juvenile arthritis at the age of twelve. In the year preceding his URE participation, he was also diagnosed with Crohn's disease, an autoimmune disorder associated with gastrointestinal disease.

All students had completed the equivalent of the first year of college coursework, while four of the six participants had accumulated enough, or almost enough, college credits to graduate from a community college. Bryan and Sam had both previously participated in academic-related summer internships. However, only Joshua and Sam had previous life or professional experiences that provided requisite laboratory skills specific

to their assigned research setting. In the next section of this chapter, their life histories are described in more detail, using their own words and with observational detail offered by the researcher.

Andrea

Andrea was from an extremely large and close-knit family. She had seven brothers and sisters as well as two step-siblings, acquired when her father remarried several years ago. Her parents divorced when she was young; however both parents still reside in the same small community in Maine. Andrea described her adolescence as "troubled," explaining that:

> *I've always been very much of a perfectionist, but I kind of lost that 'cause I moved out of my parents' house when I was fifteen. Due to problems at home and, you know there were so many people there that I moved into an apartment that's right next door to my dad's house. And then I had to support myself; I had to pay rent , pay bills, so my devotion to school, well, I actually, emancipated myself when I was sixteen.*

She worked at a variety of food-service related jobs until she turned twenty-one years old. At that time she enrolled in an adult education program and completed her GED. She was an intelligent young woman, who is now extremely committed to her educational goals. Her academic aspirations included completing an Associate's Degree in Nursing, followed by transfer to a prestigious liberal arts college in Maine where she planned to complete an undergraduate degree. Her long-term educational goals included medical school, with an interest in a surgical specialization. In this excerpt from the first interview, Andrea described her thoughts when her research mentor provided her with journal articles that he intended would provide background information for the work done in his laboratory:

I've read maybe two or three of them [articles]in the past, and he's handing me fifteen. I was just really overwhelmed by that. And after the first week which was a four day week, I spent the three day weekend finishing the reading. I went into the lab on Monday, and I was talking to him, and he was just, like, "Well you know, I was planning on having you finish that reading this week, like, I can't believe you did it over the weekend." Like so, apparently I was ahead of the game. Which was good to hear…but that was, that was pretty much my main concern, because he wanted to get me caught up to date on what he's done. But he's done so much…that it's like, how?? He's been working with fruit flies since before I was born, so… how can I really get caught up to date inside of a week or ten days?

This excerpt illustrates Andrea's eagerness to demonstrate her motivation and her work ethic to her research mentor and lab colleagues. It also highlights Andrea's concerns for what only she perceives to be her educational inadequacies. In addition, notable in this dialogical exchange between student participant and research mentor is a lack of clearly communicated educational objectives and realistic completion schedules. Andrea was left to make assumptions regarding the research mentor's educational intentions. Unclear and misinterpreted communications were a recurring theme in this laboratory.

Catherine

Catherine was the oldest of the student participants at age forty-five. She was a resident of a remote, rural, northern Maine community. She was single, had never been married, and had no dependents. She was the owner-operator of a small catering business that specialized in pastry and dessert items. She had recently undergone several debilitating foot surgeries, which had required extensive bed rest. At the time of the URE she was ambulatory, but unable to stand for long periods of time. Catherine had only one more college course to complete to finish her Associate's Degree in Science. Prior to beginning her URE she had expressed an interest in pursuing an undergraduate degree in

Food Science or Nutrition at one of the state universities. However, she also mentioned

the tenuousness of that decision and confided that one of her primary interests in the

summer URE was to clarify her academic goals. During the first interview session, which

took place after Catherine had completed one week of her internship, she commented:

> *A lot of science is very repetitive and very precise, exactly the same, all the time. Which I have to say, is kind of similar to like working in restaurants, in a way. You have to prepare the same meal exactly the same way, every single time. So in that way, there isn't a lot of difference between a scientist and a chef.*

Catherine's URE took place on the campus of a small state university. She was

one of two students in this study who participated in a research dyad. Although her

research mentor had previously administered an active research program in *Drosophila*

melanogaster (fruit fly) genetics, she was the only student researcher in his laboratory

last summer. Catherine was an animated and effusive conversationalist, which was

remarked upon by her research mentor during the final interview. Where a younger

student researcher might have been hesitant or uncomfortable engaging in conversation

throughout the workday, Catherine was not.

> *What I'm saying is that I actually found myself engaged in discussions with her about stuff I was doing. If I'd be scratching my head about something, and I had this little problem…and there's a sort of a practical aspect to it where it wasn't like totally, "You have to know all about this to discuss it," I'd talk to her about it, you know, and she would get interested in it. That was another thing I noticed about her, she would get interested in what I thinking about, and actually make some contributions.*

Their collegial relationship had several significant nuances which contributed to the

development of the theoretical model of this study. The dynamic between Catherine and

Dr. Mosconi will be explored in greater depth, in a future section of this chapter.

Tabitha

Tabitha was the youngest student in this study and the only participant who was not Caucasian. Her mother was Haitian and her father was Caucasian. Her parents divorced shortly after Tabitha was born. Her mother currently resides in another state, and she is not in touch with her father. Her only sibling, an older sister, resides in Maine. Tabitha received her diploma from a small, private, Christian high school and has completed the equivalent of one year of college coursework. While attending school full-time she also worked approximately thirty-five hours a week at a trendy retail boutique. She was extremely personable and, of all the participants, she was the most socially and culturally adept and adaptable. At the completion of the URE, Tabitha intended to transfer to a second community college to complete an Associate's Degree in Dental Hygiene. Prior to beginning the URE her professional aspiration was to become a dental hygienist, and she had only casually considered pursuing a graduate degree in dentistry.

> *Had I considered maybe pursuing dental school after I was done with dental hygiene? Yes and No. It seemed that all the important people around me had been telling me to go for it! They saw the potential in me…which at times I did not see. I also felt like pursuing a graduate degree would be too much work and all along I was looking only to just get a good job and make it. I definitely didn't want to pursue anything if the only drive I has was that I could potentially make more money.*

This excerpt, from her second interview, occurred at the midpoint of the internship. It is suggestive of the gains in intellectual confidence she has made and foreshadows the effect this may have in re-shaping her academic and career goals.

> *So far, it's not what I thought it would be. 'Cause I thought it would be, I don't know …I thought, way more math and all that stuff involved. And it's just like if you learn it, and someone shows you once, then you kind of pretty much know how to do it the next time. So I think in that area, it's less intimidating than I thought it would be. But we'll have to see… You have to come ask me the last week, and then I'll tell you in the end.*

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Bryan

Bryan was twenty-eight years old and a first generation college student. He lived

with his parents and depended on their financial support. He had two significant health

issues. He was diagnosed with juvenile arthritis at the age of twelve, and in the year

preceding his URE participation had been diagnosed with Crohn's disease. He had

completed four semesters of community college coursework, which included two

semesters of chemistry. However, he had not taken any biology courses. This lack of

academic preparation proved to be a serious challenge for him during his URE. His

frustrations were highlighted in this quote from his second interview:

> *I really didn't have a clue what they were doing in the lab. I wish I had done more*
> *research into the technical aspects of what they were working on, ...I didn't even*
> *know what genetics was, let alone what it was like to work in a laboratory, so that*
> *was all new and I had to start from scratch in my efforts to learn it. It was like*
> *taking a crash course in biology in a week.*

After his first year of college coursework, Bryan participated in a summer

internship program sponsored by Vassar College in New York. This on-going program

heavily recruits first generation community college students of lower socio-economic

status to explore transferring to Vassar. Numerous Maine community college students

have participated in this program, including Sam, who was also a participant in this

study.

Bryan had applied, and had been accepted to Vassar. He would start classes there

immediately following the completion of his URE. He hoped to attend a New England

medical school, specializing, perhaps, in psychiatry. He had also given some

consideration to a MD/PhD dual-degree program. Bryan's lofty academic and

professional aspirations were not supported by clear and achievable intermediate goals.

Most notable, compared to other participants, were his social immaturity and his inability to match his efforts with his lab colleague's expectations. This quote from his first interview session illustrates both his disengagement and his ingenuousness regarding laboratory responsibilities:

> *The first week wasn't very exciting to me, but one of the things that stands out in my mind was that I was in Professor SE's lab wearing a lab coat and I had the gloves and the goggles on and I was walking around saying, "I'm a scientist, I'm a scientist."…That was kind of exciting.*

Joshua

Joshua was twenty-nine years old. He was a first generation college student. He was self-supporting, and financed his first year of community college expenses from savings. He owned a home, which he attempted to sell during the summer of his URE participation. He had completed two semesters of community college coursework immediately prior to his URE participation, but he was the only participant with previous college experience. He had pursued several other vocations before deciding to return to school. During the first interview he explained:

> *And I realized that I wasn't making enough money and there were always people around that could replace me. And the employers could always use that against me by paying me less or, demanding certain things. So I decided I needed to stop doing this and go back to school. So, that's well, when I decided to go back to school. I looked at community colleges, only because the tuition was cheaper.*

Joshua's immediate educational goals included completing an Associate's Degree in Health Sciences or Applied Sciences. He was committed to completing an undergraduate degree in science, but was uncertain about a specific field of study. He sought academic and professional goal clarification during his participations in this study.

During his URE he began to explore the possibility of graduate study. Joshua readily

admitted that he was socially awkward and lacked self-confidence.

> *No, when I talk to these people in the lab, and they're going for their Master's*
> *degrees and they are younger than me. You know, we talk about the same things,*
> *we have the same questions about, you know, genes, and things, and …I feel like*
> *I'm on the same level as them, they've just had a little more experience. And I*
> *don't think that they think of me as you know someone who is, you know, less*
> *smart.*

As the internship progressed, his confidence in his technical skills and his

perceived positive contributions to the lab research efforts elevated his self-assurance. Of

all the participants, Joshua was the most prolific electronic author. He took full advantage

of the reflexivity and peer interactivity this medium offered. His gains in self-confidence

and social acumen may be partially attributed to his electronic introspection. However,

his need for peer recognition and validation did not diminish during the course of the

internship.

Samuel

Samuel (Sam) was thirty-two years old, married and the father of two children.

His daughter was fourteen and his son was eight years old. The semester preceding his

summer internship he had transferred from a community college to a large state

university. He had not declared a major at the time of the URE, but had sufficient

coursework to be considered either a physics major or an engineering student. When

asked during the first interview what advice he would offer to a community college

student preparing for a similar URE, he remarked:

> *If you, if you come, you know, you should have your own ideas about what the*
> *research is about, and take a little piece of that, and make it your own. And not*
> *just go in – because there's a lot of people at community colleges, especially*

where I went to – where it's very trade oriented, it's very "go to work". And this is a little different, and I, I'd just want, I'd probably want to make sure that they could make that distinction, and know that if they want to get out of it all that they can, they should understand that it's about the research, it's not about just doing the work.

While attending school full-time, Sam also owned and operated a successful photography studio. His previous professional experience included computer-image enhancement and video-editing for a regional newspaper. He is self-assured, self-reliant and readily accepts responsibility. His comments from the first interview reflect how significant these personal attributes were in defining his relationship with his research mentor:

And, if you let him, he can throw you off your game, if you're not confident in what you're doing, or confident in yourself. And even if you are, you still have to recognize that he can throw you off your game, and that he doesn't mean to, that's just his personality, and that's how he operates. So, somebody who's a little newer than the rest of us... might... really get taken off track.

Research Mentors: A Composite

The six research mentors who participated in this study have collectively published over one hundred peer-reviewed articles during the last nine years. Cumulatively, their institutional experience totals over one hundred and thirty years. Although all the research mentors maintained active research programs, three of the six received federal and local funding to support their research endeavors. All the research mentors had attained the status of full Professor. They received their doctorates from prestigious institutions that included Harvard University, Johns Hopkins University, Penn State University, State University of New York and New York University. Demographically they were a homogeneous group. All mentor participants were

Caucasian and all were fifty years old, or older. Two women and four men participated as research mentors in this study.

Three of the six research mentors had themselves participated in some form of research project/program as undergraduates. Overwhelmingly, they all reported positive benefits from the experience and each described the influence it had had in their personal educational and professional choices. An excerpt from Dr. Mosconi's (Catherine's research mentor) interview is representative of the experiences reported by the two other mentors. This is his response:

> *I think everybody feels that way, when they get to see, like see something done at a professional level. To stand alongside somebody, and watch them do it or to sit there and actually get a chance to do it themselves… It doesn't matter that it's a skill that you have to learn that you'll never use again. It's just the doing of it, when you've never done anything quite like it before. For me I think, for me that was the first, sensation, that first revelation of - this is what these dudes do. This is the kind of thing they do, and it's what I would do in a real research project.*

His words echo what Seymour, et al. (2003) described as two common benefits expressed by the URE participants they interviewed – acquisition of technical skills and personal identification with the professional scientist role. So it is interesting to note that research mentors in this study would report the same benefits, even after more than twenty years had passed. The influence of mentor relationships, reported by student participants in previous studies, had a pivotal influence on perceived URE outcomes. The positive influence of the mentor relationship for Dr. Mosconi is evident in his account of his URE participation. The mentor-participant relationships that existed in this study are explored in detail later in this chapter.

Lab Colleagues: A Collection of Their Impressions

A total of thirteen lab colleagues co-participated with the community college students in this study. They worked in three different laboratories on the campus of the large research university and a single laboratory at the small private college. In each setting, the number of lab colleagues ranged from two to five students. Of the thirteen students, ten were Caucasian: eight were female and five male. The majority of the student lab colleagues (60%) were twenty-three years old or more. Most of the students (62%) had worked in their respective laboratories for more than a year. Only two students participated as volunteers; the remaining lab colleagues received stipends for full-time or part-time commitments. All student lab colleagues reported a GPA of 3.0 or higher, and only one student was not an in-state resident. A single representative lab colleague from each of the four laboratories was solicited for an interview. Interestingly, of the four who volunteered to be interviewed, three had either attended a community college or had been employed by a community college. Their perspectives of community college facilities and academic rigor are based on actual, but limited, personal experience.

All the lab colleagues interviewed for this study described the community college laboratory facilities as adequate, but below the standards of the facilities at their home institutions. The laboratory equipment was characterized as "dated." All the students noted that the academic rigor of community college coursework was less challenging than courses they had taken elsewhere. Lastly, all lab colleagues, during the course of the interviews commented on the vocational focus of community colleges. Here is a short excerpt from one of these interviews:

> ***Derek,*** *lab colleague of **Joshua**: I didn't take the chemistry at my normal school so I can't really compare them directly. But, I did find it was pretty easy, I didn't*

have any trouble, and I had almost 100% in the class. And it was, compared to the school that I was going to, pretty…, I didn't have to work very hard. But I don't know. I found that it was kind of similar for a lot of people in the class, as well. It felt a lot like high school.

Tracey, *lab colleague of **Andrea**: That in general, probably the courses don't require the community college students to think as much. Range, as far as the range is concerned I don't see a huge difference in the courses that they need compared to the courses that traditional college students need. But yeah, in general, I think probably the course loads are different and in what is expected of the community college students, it's probably less.*

For the non-traditional students who participated in this study, negotiating peer acceptance and garnering peer recognition were social tasks that were at least as important as the acquisition of scientific knowledge or demonstrated proficiency in science-related technical skills. The community college perspectives described by their lab colleagues served to reinforce an implicit laboratory social structure that proved difficult to access. Barriers to establishing a presence in the social network included overcoming this stigma.

Significance of Participant Groups Diversity and Homogeneity

This study included three different groups of participants. Non-traditional community college students were the population of primary interest. The heterogeneity of their demographic and personal characteristics reflects the diversity found in the greater community college population in Maine, and the U.S. However, it is the relative demographic homogeneity of the two remaining participant groups that strengthens the credence of the cross-case analyses that follow. In this study, the demographic similarity amongst the research mentors results in demographic homogeneity in this participant group. The research mentors are similar in age, race/ethnicity, institutional rank and years of teaching and research experience. The third participant group, the lab colleagues also

demonstrate surprising demographic similarity. Lab colleagues were similar in age, race/ethnicity, in academic rank, in number of years of laboratory experience, in financial support provided by the laboratory, and in their cumulative grade point averages.

The purpose of this study was to compare differences in organizational structures and social climates in academic research laboratories and to determine to what extent these differences influenced the perceived benefits of URE participation for non-traditional students. Interpretations of these laboratory differences were rendered more meaningful because demographic variability in laboratory personnel could be eliminated as a consideration that might have influenced participants' reported outcomes.

Theoretical Model of Non-Traditional Student URE Participation

Introduction

The theoretical models for this study were developed during the data analysis phase. More than one hundred different, specific, open-coding categories were created from interview transcripts and electronic journal entries (See Appendix S). Careful examination of these coding categories yielded textual frequency patterns that, with refinement, resulted in two axial coding categories: structural organization and social organization (See Appendix Q). In this study, analysis of the collected textual data resulted in 50% of all participant references assigned to open coding categories related to organizational structure or social climate (Figure 4.1).

Open Coding Categories by Responses

Legend:
- Leadership Emphasis
- Social Climate
- Training Emphasis
- Organizational Structure
- Self-Confidence
- RQ #3
- Other
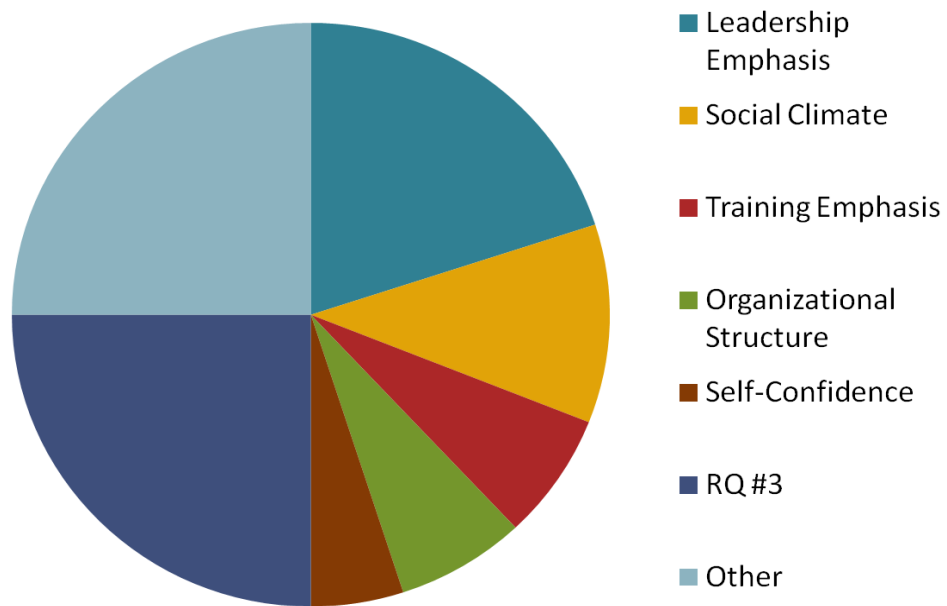
Figure 4.1

Frequency of Participant Responses Related to Laboratory Organizational Structure and Social Climate

The open coding categories related to social organization are: leadership emphasis (20%), social climate (11%), training emphasis (7%) and references to student self-confidence (5%). Textual references in participants' transcripts related to organizational structure were 7% of all references coded. Half of all comments made in interview sessions, electronic journals and from field observation notes were related to the first two research questions of this study, while another 25% of the total participant discourse referred to categories directly related to Research Question Three. These will be thoroughly described in Chapter Five. Lastly, note that, the remainder of participants' comments were placed in coding categories *not directly* related to any of this study's research questions. Examples of these open coding categories included: description of participants' housing situation, description of distractions in personal life that influenced

perceptions of URE and characterization of facilities and equipment of community colleges.

The present research questions reflect the importance participants assigned to structural organization and social networks for non-traditional student acculturation in academic science laboratories.

1. In what ways does the organizational structure of an academic research laboratory influence acculturation for non-traditional URE participants?

2. In what ways does the social climate structure of an academic research laboratory influence acculturation for non-traditional URE participants?

Definitions

Before turning attention to the proposed theoretical model for this study, relevant terminology is briefly reviewed.

Acculturation: a process that occurs for adults of a non-dominant culture who make contact and participate with a new dominant culture.

Learning milieu: the total learning environment; includes people, places and things.

Vocational habitus: a set of behaviors and attitudes that accompanies a professional/vocational identity.

Cognitive apprenticeship: expert-directed experiences that introduce the novice to intellectual strategies for navigating the complexity and ambiguity of professional responsibilities; mentor often shares his or her meta-cognitive processing with apprentice.

Theoretical Model of URE Participation Acculturation Outcomes for Non-Traditional Students

The theoretical model for this study is adapted from Berry's model (1990, 1997) of acculturation for refugee and immigrant populations. In his model, acculturation outcome categories are determined by the extent that the non-dominant population accepts or rejects cultural norms and values of the dominant culture while retaining or abandoning the cultural norms and values of the culture of origin. Berry proposes a simple 2 x 2 matrix that represents the acculturation outcomes of all possible interactions between the dominant and non-dominant culture. A representation of this matrix is presented in the table below.

Table 4.2

Berry's Model of Acculturation Outcomes

	Values and Norms of Dominant Culture: Accepted	Values and Norms of Dominant Culture: Rejected
Values and Norms of Culture of Origin: Retained	INTEGRATION	SEPARATION
Values and Norms of Culture of Origin: Abandoned	ASSIMILATION	MARGINALIZATION

For this study, the matrix is adapted to reflect the levels of social acceptance and professional competence members of the non-established culture report they have achieved, compared with levels of social acceptance and professional competence reported by members of the established culture. The adapted matrix is presented in Table 4.3 below.

Table 4.3

Model of URE Acculturation Outcomes for Non-Traditional Students

	Laboratory Members Report Social Acceptance and/or Professional Competence	Laboratory Members Report Social Alienation and/or Professional Inadequacy
Participant Reports Social Acceptance and/or Professional Competence	INTEGRATION	SEPARATION
Participant Reports Social Alienation and/or Professional Inadequacy	ASSIMILATION	MARGINALIZATION

For all participants, members of the established and non-established community alike, estimations of social acceptance and professional competence were based on perceived changes in the laboratory social climate. In turn, the social climate was directly influenced by the laboratory organizational structure and social structure. For non-traditional students, then, the laboratory organizational structure and social structure significantly influenced the perceived benefits of URE participation. Organizational and social factors that contributed positively to the warming of the social climate increased the likelihood of participant integration and laboratory productivity. Organizational and social factors that cooled the social climate diminished the likelihood that participants would report positive benefits, and resulted in diminished laboratory productivity. Inter-relationships between these sets of situational factors are represented in Figure 4.2.
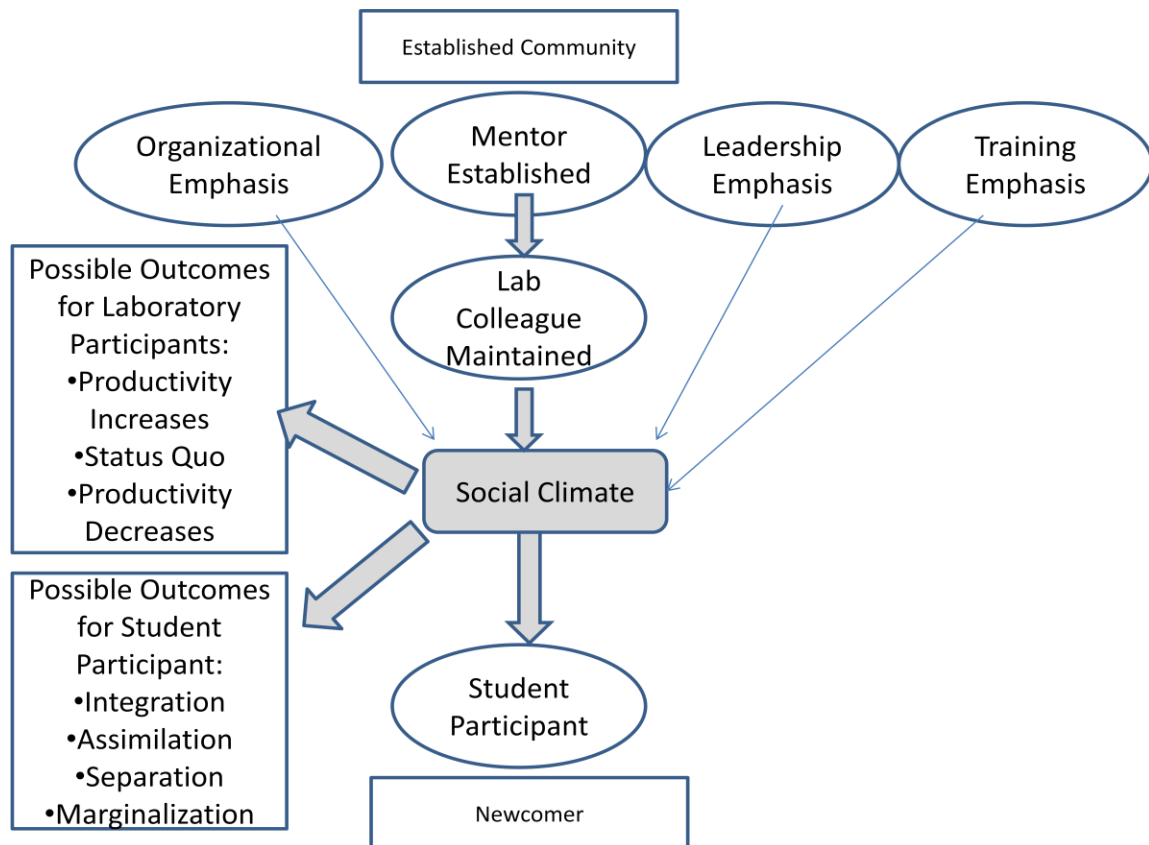
Figure 4.2

 Possible Outcomes of URE Participation for Non-traditional Students

Organizational Structure

Within the established community of the academic research laboratory, it is the

mentor who institutes the organizational structure. This organizational structure may be

maintained, or even modified by other laboratory personnel, but it is not possible for

student personnel to alter the laboratory organizational structure. The laboratory

organizational structure relies on an organizational model. In some laboratories the model

chosen is hierarchical; in others, an egalitarian model is utilized. The hierarchical model

places an emphasis on the individual. Individual merit and individual accomplishment are

recognized. In contrast, laboratories that operate under the auspices of an egalitarian

organizational model maintain a focus on group accomplishments. Collaboration among

lab colleagues is emphasized and gains made by the group are recognized. The outcome for students in laboratories employing the hierarchical model is dependence. The reference here to dependence does not imply psychological or intellectual dependence, but rather refers to scientific or experimental dependence. While the rewards for individual success maybe great in the hierarchical model, the risks for individual failure are even greater. Therefore, individuals working in this research setting often achieve experimental or protocol improvement, but rarely advance to experimental or protocol innovation without the intercession of the mentor. Students bound by the dependent category operate within a model that yields reluctance for experimental innovation, which retards their transition to cognitive apprentice.

Students working in laboratories with an emphasis on the group are able to distribute the risk of failure that accompanies innovation. Although the rewards of success are shared, individual researcher autonomy is more likely to result. Laboratory personnel who experience shared success gain researcher confidence. These students become more independent in their pursuit of innovation. Once student-researcher independence has occurred in a laboratory setting where negative consequences for experimental innovation are minimized, there is an accelerated transition to cognitive apprentice.

Leadership

A second responsibility of the research mentor is to determine whether the leadership emphasis will be unilateral, bilateral or multilateral. Unilateral leadership emphasizes singularity in decision-making. In laboratory settings where the leadership is unilateral, student life experiences are de-valued. Student self-esteem is either

unchanged, or is diminished. In academic research settings with bilateral or multilateral leadership, student(s) and research mentor share responsibility for decision-making. Student life experiences are valued and student self-esteem is either unchanged or increased. There is an increased likelihood that the transition from neophyte researcher to cognitive apprentice will occur. When multilateral leadership is found in the academic research laboratory, democratic decision-making predominates. Multilateral leadership requires a higher level of trust between laboratory personnel, and therefore, achieves the highest level of intra-group trust.

Training Emphasis

In this theoretical model, training emphasis in an academic research laboratory may be formal/structured or informal/serendipitous. The research mentor may not be the primary trainer of new laboratory personnel. In many research laboratories, training responsibilities are delegated to experienced student researchers. Nonetheless, it is the mentor who determines the model for training novice student researchers. Together, the leadership emphasis and the training emphasis define the social climates of research laboratories. Embedded within the boundaries of the social climate is the laboratory social network, where newcomers interact with research mentors and lab colleagues. Although the academic research laboratory social climate is established by the research directors, this climate is maintained and often influenced by student lab colleagues. For newcomers, negotiating status in the social network begins by gaining familiarity with the learning milieu. As familiarity expands, students begin status negotiations of intermediate priority and acquisition of vocational habitus. These two status negotiations are not necessarily mutually exclusive, therefore gaining familiarity of the learning milieu

may occur simultaneously with acquisition of vocational habitus. However, the final

negotiation priority, induction to cognitive apprenticeship, is not initiated unless some

level of demonstrated achievement of initial social network negotiations has been

accomplished. Lab colleagues may formulate stereotypes regarding community colleges

and community college students which become significant factors influencing the

perception of newcomer achievement in these social network negotiations.

Acculturation Outcomes

Student perceptions of success in these realms of social network negotiations are

either confirmed or refuted when compared to the perceptions of laboratory personnel.

When perceptions between newcomers and established community are confirmatory,

experiential congruence exists. When there is disparity in perceptions, experiential

dissonance has occurred. Newcomer integration has occurred if both the student

participant and the laboratory members are matched in their perceptions of positive gains

in social acceptance and professional competence. Their viewpoints demonstrate

experiential congruence. Students who report positive gains in social acceptance and

professional competence, not matched by the perceptions of other laboratory personnel

do not become integrated lab members and remain separate. In a situation where neither

the student nor other lab personnel report substantial gains in social acceptance or

professional competence, there is no gain in status in the social network. These students

experience marginalization during URE participation. Acculturation outcomes, as we will

see, significantly influence the reported benefits and academic aspirations of non-

traditional students. Re-evaluated academic choices re-direct professional interests and

career choices for these students.

<u>Findings Related to Research Question One</u>

In what ways does the organizational structure of an academic research laboratory influence acculturation for non-traditional URE participants?

Organizational Models

      Hierarchical and Egalitarian Models. A hierarchical academic research laboratory is characterized by well-defined roles for all laboratory personnel. These roles are based on prestige, experience and academic ranking. The research director is the faculty member responsible for directing the research efforts of the lab members. In some academic laboratories, a post-doctoral fellow oversees the daily operations of the laboratory and, in turn, has major responsibilities for the coordination of the daily research efforts of laboratory personnel. In this study, only one of the academic laboratories had a post-doctoral fellow. He was an international student, managing the lab for Dr. Stardusky, on the campus of the large research university. Bryan was the non-traditional student in this lab. In the other participating laboratories, anywhere from zero to four graduate students were employed on projects during the summer of 2008. In addition, three of the participating laboratories had at least one other undergraduate student (besides the non-traditional student). The laboratories with no other undergraduate students were: Dr. Stardusky's lab (Bryan, community college participant), Dr. Mosconi's lab (Catherine, community college participant) and Dr. Sherwood's lab (Sam, community college participant). Five of the six research laboratories were based on a hierarchical model of organizational structure.

Table 4.4

Research Laboratories Utilizing Hierarchical Model

Lab Director	Stardusky	Mosconi	Dugan	Arquette
Post-Doctoral Fellow/Lab Coordinator	1	0	0	1
Doctoral Students	0	0	1	0
Master's Degree Students	6	0	1	2
Undergraduates	0	0	1	2
Non-Traditional Student	Bryan	Catherine	Andrea	Joshua

Viewed from the perspective of the established community, one of the advantages of the hierarchical model is its efficiency.

> *Dugan: Obviously the amount of teaching warps everything. I don't have much time myself to do research during the school year. I rely on the undergrads and the grad students, but so does everyone else here. So, come summer it's the one time I can get out in the lab which I can't do the rest of the year. We are just too busy as faculty especially because I teach both semesters. I teach a 400 course. It has its advantages. It's a chance to recruit students to work in the lab. So many of them have already made commitments for the summer, but I'm back up to what I'd consider is an appropriate number of students working in the lab. I have one doctoral student, one master's degree student and one undergraduate who's doing her honors project over the summer. Graduate students require less of an investment of time than undergraduates…but it does take a while to get a student fully integrated into the lab.*

> *Stardusky: Well this summer, is a little strange actually, I have more graduate students working in the lab, than I do undergraduates. I usually have five or six graduate students and four or five undergraduates, but this summer, the community college student will be the only undergraduate. I had four undergraduates in the spring working on their capstone projects, but they have all finished and graduated. So this summer I have six graduate students and one post-doc. I am not able to spend as much time in the lab any more, sadly, I spend a great deal of my time now writing reports and writing papers. But I do try and walk through the lab a couple of times each day to check on my students and to answer any questions that they have. But everyone in the lab is so close, they help*

each other and the post-doc is very helpful in directing and helping students with their individual projects.

Communications among laboratory members can be targeted to the most appropriate individual(s), which minimizes the frequency and duration of information-sharing occasions that are necessary to maintain coordination of laboratory activities. However, for non-traditional students, these short and direct task communications were often viewed as terse and alienating. Compare the perspectives of Joshua and Leslie, the lab coordinator for Dr. Gillian Arquette.

> **Leslie:** *I usually make sure that the undergraduates are checking in with me every day when they come into the lab to get instructions and updates on what is going on in the projects they are involved with and what are the top priorities for that day. I also have them check-in with me throughout the day, if they have any questions about results or what they are doing. And I make sure that they report to me before they leave about what they accomplished that day and what is left to be done later, and any concerns that they may have.*

> **Joshua:** *Leslie is complex…sort of. She doesn't seem judgmental, but she might have a slight ego about her knowledge level. She seems to occasionally not explain the details about why we do things a certain way. I usually ask and she tells me. She likes to let everyone know how busy she is, a lot. Most of the time she delegates tasks to the undergrads or me and I guess that makes her busy. She spends a lot of time on the internet.*

The two laboratories characterized as egalitarian were coordinated by Dr. Angela Cook and Dr. Robert Sherwood. An egalitarian model of organizational structure values democratic principles. In Dr. Cook's lab, members shared responsibilities, perhaps not always equally, but certainly, equitably. Each laboratory member had loosely-defined roles and each member was recognized as equally competent. For this lab, daily morning meetings were required to coordinate the lab activities of the day, but afterwards, Dr. Cook would often find it necessary to be elsewhere on campus or at various off-campus locations. A single experimental procedure was undertaken by the group each day, with each member responsible for some aspect(s) of the protocol. Throughout the day,

students in this lab continuously communicated their progress to each other. There were

no clear experts or "specialists" in this lab. The three students by necessity had to share

information continuously in order for a procedure to move forward. As a group, they

developed more sophisticated communications, or as Tabitha remarked, "We had to

conversate with each other a lot." These verbal exchanges provided opportunities for

memorable reinforcement of important lab procedures. In short, these students facilitated

their collective transition from pre-reflective learners to contextual learners. As has been

previously mentioned, there was striking demographic homogeneity in this group of

students. All three students were undergraduates, and each had just completed his or her

freshman year.

Although characterized as egalitarian in organizational structure, Dr. Sherwood's

lab is better characterized by the social interactions that occurred in the research dyad.

This dyad consisted of the Sam, the student participant, and Sherwood. In this study the

second research dyad consisted of Catherine, the student participant, and Dr. Mosconi. In

these research dyads, there were no lab colleagues. The organizational structure was truly

defined by the relationship that existed between research director and non-traditional

student. Between the two research dyads, these relationships were very different.

Therefore, these differences will be discussed in the Findings section for Research

Question Two.

Organizational Emphasis

Focus on the Individual. In the four academic research laboratories where the

hierarchical model operated, the primary organizational emphasis remained focused on

individual effort. Students' achievements were attained and recognized as individualistic

efforts. Lack of success was also attributed to individual student researchers. If student

efforts were not recognized as group collaboration, they could not be rewarded on group

merit. Implicit pressure for individual success resulted in subtle and not-so-subtle

competition between lab colleagues in these research settings. For one non-traditional

student, pressure for success ultimately resulted in overwhelming loss of self-confidence

and self-destructive behavior near the end of the internship. For other non-traditional

participants, it sparked serious inventory of self-worth.

> *Andrea: I show up to the lab around seven am or so and that gives me at least an hour to "make home," and also that way if I want to do research of my own, I can use the equipment before the graduate and pre-med students arrive, so that I do not feel that I am in anyone else's way.*

> *Bryan: I feel like the, the lab research was already set up before I got there. And… I was just kind of an extra person …didn't really feel comfortable asking the professor if I could… do something specific. I kind of wanted to wait for him to tell me to go ahead and do it. And it seemed like everybody had, that all of their jobs were already outlined. You know what I mean? And I didn't really have a job that was outlined.*

An organizational structure that is built on an egalitarian model results in more

frequent and sophisticated intra-group communications, recognition of collaborative

efforts and diminished performance pressure for non-traditional students. Although only

two research groups permanently adopted this model, the Stardusky lab sporadically

utilized the egalitarian model when soil samples had to be retrieved from remote field test

sites. For the URE participant in this lab, this organizational shift was unexpected and

disorienting. Established hierarchical roles were displaced on those days when the entire

lab re-located. For the graduate students in this lab, the field research was a welcome and

relaxing change from the research laboratory. Their hierarchical status was easily laid

aside on those days, but for Bryan, days in the field were another proving ground, another

environment where his status had to be earned. While other students in the Stardusky lab looked forward to fieldwork, Bryan came to dread it.

Outcomes for Non-Traditional URE Participants

Selection of an organizational model by research directors is not typically a conscious decision. For most mentors, the structure of their laboratories is similar to the structure of the laboratories they worked in as undergraduates and/or graduate students. Dr. Cook is the single exception. During the final interview she confided that, "there was no way I was going to run my lab the same way my dissertation adviser had… I barely survived that experience, and I certainly didn't want to perpetuate it for the next generation of scientists." And so, laboratory structures evolve over time. What was successful or necessary when mentoring a great number of students during the supervision of an active research program at the beginning of a faculty career might not be successful or required now. The hierarchical model is adapted by most, because it is the model of academia. It is familiar.

In this study, the influence of organizational structure on acculturation outcomes for URE participants fostered either student-researcher independence or student-researcher reliance. Five of the six non-traditional students participated in labs with a hierarchical structure. They faced a work environment that emphasized individual effort and individual success, placing them in direct or indirect competition with their lab colleagues. These very same people were often responsible for their training and their performance evaluations. For all the participants, the lab colleagues were the only other peers they knew at their 'away' institution. In the hierarchically-structured laboratories, the emphasis on individual success inhibited their willingness to take risks. None of these

students chose to undertake an individual research project for the internship. All preferred to assist others in their projects or expressed interest in learning a variety of laboratory techniques. For Andrea, especially, the perceived need to help others in her research laboratory subverted her own research interests and ultimately became status threatening for at least one of her lab colleagues.

> *Dugan: So she's helped quite a bit with the other undergraduate's project (honor thesis). Andrea asked to be trained in a lot of different areas, that was really important to her, she wanted to help other students in any way that she could.*

> *Andrea: I've been practicing doing injections to bathe the heart in ionic solutions so that I can be helpful to the other students in the lab. Having the space to myself was nice because I didn't feel like my practicing was in the way of the real research.*

> *Tracey: I think she wanted - she was here a lot. You know, I think she wanted to be here in case something was going on. So she just kind of busied herself doing that. You know what I mean, waiting for something to happen, so she could be involved, yeah. Also, she was here in the lab, much more than I was, so it was just [lab colleague] and I that were, pretty much, the only grad students here throughout the summer.*

Andrea, Joshua and Bryan relied on their lab colleagues or their research mentor to select, to teach and to evaluate the science processes practiced in their laboratories. This reliance ensured their dependence. In a dependent relationship, one rarely gains self-esteem or self-confidence. Certainly, Andrea and Bryan did not. Joshua, both on the electronic discussion board and in his electronic journal referred to this reliance on others for information. He called them "information keepers."

> *There are people that withhold the extra information. You can ask a question and they'll give you a straight answer, but will not give you the surrounding information, so that you can have an understanding of the whole issue. It keeps you from coming back to them for questions - which keeps them in a position of power over you. And, ah it's important to be aware of those people.*

During the course of the internship as Andrea and Joshua gained practice and experience in the laboratory, as they negotiated the learning milieu, their reliance on others was diminished. For these two participants, reliance on others in their laboratories for training and technical direction resulted in losses of self-confidence. However, as the internship progressed, some of these confidence losses were regained, as their technical expertise increased and their experiences broadened.

> *Joshua: When I talk to these people in the lab, and they're going for their Master's degrees and they are younger than me, you know, we talk about the same things, we have the same questions about, ah, you know, genes, and things, and …I feel like I'm on the same level as them, they've just had a little more experience. And I don't think that they think of me as you know someone who is, you know, less smart.*

Tabitha, like Andrea, Joshua and Bryan, was also a member of a research triad. The organizational structure in her URE laboratory (Dr. Angela Cook) has previously been described as egalitarian. The organizational emphasis in this laboratory was on the group, and collaboration was promoted as a primary means of interpersonal interaction. Tabitha and her lab colleagues developed novice researcher independence. After initial mentor guidance, Tabitha and her lab mates designed, problem-solved and completed a series of experiments investigating correlations between changes in murine bacterial populations and mandibular bone resorption. In the last weeks of their internship, this lab group created a poster depicting their experimental results and participated in a poster presentation session at a regional conference of student scientists. Most remarkable about Tabitha and her lab colleagues' accomplishments, these three students had just completed their first year of college coursework. Their autonomous success as a collective elevated Tabitha's confidence in her ability for experimental research design to the point where she commented in the last interview:

I think I might like to collaborate on another research project. I like to be able to learn from people and have them learn from me. And from this summer I think that's what works best… when more than one person is a specialist in that particular research area. However, way in the future, I might like to design my own project, something all by myself.

Summary

Five of the six research groups in this study employed a hierarchical organizational model. Stratification was based primarily on academic rank, (freshman, sophomore, etc.) which, in most cases, also equated with students' success with increasingly demanding coursework. Status in the hierarchical model of the academic research laboratory is also determined by research experience and research accomplishments. Neophyte researchers obviously have not had previous research experience, but may have undertaken advanced coursework. The non-traditional students participating in these UREs have had neither experience nor opportunities for advanced coursework. Their status in the organizational hierarchy, then, was undefined until they could demonstrate competency in the learning milieu – a daunting task, given the ten-week time period. For student participants placed in hierarchical laboratories with lab colleagues, (Andrea, Bryan and Joshua) the focus on individual effort and individual accomplishments precipitated subtle competition and fostered subconscious mistrust towards other laboratory personnel. In these same laboratory triads, the lab colleagues interviewed all held negative stereotypes regarding community colleges and community college students. For the three student participants in these hierarchical laboratories, the implicit pressure to represent themselves and their institutions favorably was great. To minimize the risk of failure, each of these students declined the opportunity to undertake an independent research project. Two of the three students were able to master technical

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skills in the laboratory, which raised their self-esteem and reduced some of the

performance pressures. However, they remained reliant on either the research director or

a lab colleague to direct their research efforts. They did not achieve autonomy in

experimental research.

> **Bryan:** *I haven't really made many gains, as far as research skills, but I've learned a lot about like different research protocols. I didn't actually get a chance to do any myself but...*

> **Andrea:** *I would want to master more of the techniques that I learned in the lab. I am sad that the graduate student working with the frogs was absent so much because I really would have like to learn more about that. I also never got to do any dissections on the* Drosophila *pupae or work with Tracey on her research that had to do with the effects of receptors both inside and outside the* Drosophila *heart.*

> **Joshua:** *It is very important to me that I have daily instruction on the procedures I am doing and I usually need help with a procedure at least twice before I can do it on my own. If they were not helping me along I would get very frustrated. I frequently ask [lab colleagues] how some of these procedures are working and what reactions are taking place. I'll admit there are times when I don't really care what is going on in the tubes, but most of the time I am curious and I ask questions.*

Tabitha was the only student participant placed in a research laboratory that could

be characterized as having an egalitarian organizational structure. The autonomy outcome

of her URE experience is a stark contrast to those assigned to the hierarchical laboratory.

Along with her lab colleagues, she contributed to a project that produced novel

experimental results. These results were publically-shared with a larger research

community at the end of the summer URE. Being part of a peer collaborative elevated her

confidence in her own intellectual and technical skills. In this triad, all three students had

the same academic rank and similar levels of laboratory experience. The lab colleague

who was interviewed had no previous experience with, and limited knowledge of,

community colleges. It seems that any performance pressure Tabitha experienced was

also shared by her two lab colleagues. Although she did not undertake an independent

research project, she and her lab colleagues did gain experimental autonomy during the

design and implementation of their culminating summer project.

> *Tabitha: We extracted more RNA from the sample on Thursday and still nothing much happened. Our RNA did not show up as being very high when the Bioanalyzer analyzed it lol. So then we figured that it might have given us great results the first day we used it cause it was still very fresh. And the other sample was frozen, but we didn't know in what and so we decided to use a new sample that Dr. Cook had in the -80 freezer since it was frozen in RNA later- definitely. Come to find out-this Monday the other sample was only frozen in liquid nitrogen. Friday we extracted RNA from the new sample and ran it on the Bioanalyzer. To our dismay it was still reading low. Therefore, we were consistently getting low readings although we had changed different variables. However, although they were low such as 7 ng 11 ng the sample was diluted 1:10 so we were still getting okay numbers well within the range.*

In this excerpt, it is apparent that Tabitha and her lab colleagues learned to problem-solve

during the experimental process. She questioned one aspect of the experimental design,

so she and her lab colleagues attempted to reproduce their original results using a

different sample. In her final statement she concedes that their results are not optimal, but

are acceptable. She and her lab colleagues have learned to accept the ambiguity of

scientific results. And all of this they learned from each other.

Findings Related to Research Question Two

In what ways does the social climate of an academic research laboratory influence

acculturation for non-traditional URE participants?

In the second half of this chapter, characterization of the leadership and training

strategies utilized by the participating research communities, in this study, was

undertaken. Together, leadership and training emphases contributed to the social climate

of the laboratory. Potentially, there were numerous factors that also contributed to the

social climate in these laboratories, they were not, however, the focus of this study. For non-traditional participants the social climate influenced acculturation outcomes. Community college students were marginalized, separated or integrated into the established academic research community. For laboratory personnel, acculturation outcomes of the newcomers influenced the overall research productivity during the summer internships.

Leadership Emphasis

As previously mentioned, when the frequency patterns of the textual data open-coding categories were analyzed, the category that was mentioned most often in the greatest number of data sources was the "Characterization of Mentor Relationship." Over 155 references (20%) were made in 43 different data sources (10%). In this study, the mentor-participant relationships can be categorized as having a unilateral, a bilateral, or a multilateral emphasis. Relationships characterized as unilateral in their focus demonstrate singularity in decision-making. The research director alone was responsible for all decisions regarding the research effort and research productivity in the lab. Of the six research groups that participated in this study, four were categorized as having an emphasis on unilateral leadership. Of these four research laboratories, three were located on the campus of the large research university. These were the laboratories of Dr. Arquette, Dr. Stardusky and Dr. Dugan. The fourth laboratory, directed by Dr. Mosconi, was located at the smaller research university. Dr. Sherwood's laboratory had an emphasis on bilateral leadership. His laboratory is located at the remote-access research site affiliated with the large research institution. The only research group that placed an emphasis on multilateral leadership was the laboratory group supervised by Dr. Angela

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Cook and located at the small, private liberal arts college. A summary of student

participants placed in each of these laboratories is included below.

Table 4.5

Summary of Laboratory Leadership Emphases

Research Director	Student Participant	Research Site
Unilateral Leadership Emphasis		
Dugan	Andrea	Large Research University
Stardusky	Bryan	Large Research University
Arquette	Joshua	Large Research University
Mosconi	Catherine	Smaller Research University
Bilateral Leadership Emphasis		
Sherwood	Sam	Remote-Access Research Center
Multilateral Leadership Emphasis		
Cook	Tabitha	Small Liberal Arts College

Unilateral Leadership Emphasis

In a research laboratory that functions under unilateral leadership, the research

mentor/research director makes all consequential decisions, and therefore accepts all

consequential responsibility. For the non-traditional students in this study, this leadership

approach had several significant effects on student motivation and students'

developmental gains. Students placed in laboratories guided by mentors committed to

unilateral leadership strategies had few opportunities to accept professional or scientific

responsibilities in the lab setting. They were not asked to contribute substantially to

record-keeping activities, inventory of laboratory supplies, equipment maintenance,

specimen preservation or warehousing of samples. All these responsibilities are routine

assignments in a working laboratory. Exclusion from these simple laboratory tasks

amplified participants' feelings of transience and insignificance. Because non-traditional

students were not offered a stake in the decision-making processes in their laboratories,

they were not as invested as their colleagues in lab productivity. In some labs this led to perceptions of inequitability between participants and lab colleagues. Many of these non-traditional students had life and professional experiences that might have proven invaluable, had there been an opportunity for them to contribute. For student participants without extensive life experiences, opportunities to gain experience managing personnel and laboratory resources were lost. In the Mosconi lab, the restrictiveness of unilateral leadership was associated with Catherine's adherence to routine and her hesitancy for innovation.

> *Mosconi (Mentor): When I first came here, there were some students who would be a little bit too self, too assertive. In other words, it has to be clear who's boss, in your lab. It has to be very clear. But you shouldn't have to make it clear. So you know if somebody gets a little bit rowdy or rambunctious, or something, you don't want them knocking over the vials or plates, this is not a place for a party. So there have been times when I have had bad interactions with people mind you. I had to ah- sort of find a way to divest myself of them.*

> *Catherine: But one of the big things he [mentor] has said is 'You don't just do something, you ask me first...'So that's very different - even if it seems like the smallest mundane thing, I guess with collecting scientific information, you don't just pick something up and go...*

However, as was previously suggested in the discussion of organizational models - hierarchical organizational structures are chosen because they are efficient and because they are familiar. Unilateral leadership is also efficient and familiar. In university laboratory settings, singularity in decision-making is often necessary, to coordinate the research efforts of numerous individuals with very different interests, talents and commitment levels. In each of the university research settings, the mentor was deeply respected by the student participant. Non-traditional students recognized the authority as deserved and sought to gain the approval of the laboratory director.

>*Andrea: The director and man in charge never acted as though he were truly our superior even though I feel that we all believed he was whether or not he acted like it. That was probably more a matter of respect for all of his knowledge, accomplishments and devotion to his research for o-so-many years.*

Bilateral Leadership Emphasis

In this study, one research group was characterized by bilateral leadership. Mutually-derived decisions occurred through dialogical exchanges between director and participant. The research director, Dr. Sherwood, delegated consequential responsibility to the student participant, Sam, based on his previous professional and life experiences. At the time of the study, Sherwood's research project required someone with technical expertise in video-image editing, a skill set he himself did not have. Dr. Sherwood recognized and capitalized on Sam's expertise, which significantly improved the productivity of his lab. In turn, Sherwood was able to provide Sam with insights into the scientific research process and identification of fish species associated with marine reef systems.

>*Sherwood: To get Sam up to speed, I explained the general situation and then gave him "homework" to view website tutorials involving the coral reef crisis and the science related to my study. Sam was very responsible. I gave him a lab, a computer, video technology and suggested how he should move forward. He and I shuttled data back and forth via the internet, so I was with him even as I was in the field. He performed as well as any graduate student would have.*

>*Sam: Functioning independently is an absolutely critical aspect of working with him. 'Cause he wants to micromanage you while he's here, but then he doesn't want you to bother him with the details once he's gone. So, you have to, you have to absorb all that you know, and kind of, not absorb it. He's a very ... headstrong, self-involved individual. And I say that in a nice way. Someone like me... I can handle that, because I'm a very headstrong, self-involved individual. And so, you'd think we'd butt heads that way, but we knew each other's roles, and that, and that's worked out fine.*

Shared leadership responsibilities resulted in greater commitment to the project for the student participant and were reciprocated by the research mentor, as he

relinquished control over most technical aspects of the project. Assured of his status in the dyad, Sam's confidence allowed him to initiate a small, independent project related to, but separate from, the reef-project. Their plans for continuing work on the reef system project and for future collaborations highlights their established working relationship. Their relationship, where leadership responsibilities were shared between them, was seemingly more secure with greater potential for permanence, compared to the mentor-participant relationships defined by unilateral leadership.

Multilateral Leadership Emphasis

The hallmark of multilateral leadership is democratic decision-making. In this study, the laboratory located on the campus of the small private liberal arts college operated under the auspices of multilateral leadership. Led by Dr. Angela Cook, this research group included the student participant, Tabitha, and her two lab colleagues. Recall that these three neophyte researchers had all just completed their first year of college coursework. For most of the decisions made within this laboratory triad, the mentor's opinions had no more value than those of the other lab group members. Each lab member was recognized as having had unique and valuable previous life experiences. These provided unique perspectives and allowed for meaningful contributions to discussions before decisions were rendered by the group. An emphasis on multilateral leadership provided leadership opportunities for all laboratory members at different times and in different situations, during the course of the internship. Besides recognizing previous experience, multilateral leadership in this triad recognized developing expertise and newly-acquired experience. For Tabitha, the single minority student in this study, an emphasis on multilateral leadership reinforced positive peer interactions and encouraged

collaboration. These were significant factors that influenced Tabitha's perception of the benefits of her URE experience.

> *Tabitha: I think that our daily mornings and sometimes afternoon/end-of-the-day meetings are great and necessary. It is the time where we all discuss what has happened in lab or what our course of action will be for the day and sometimes to just chat about different topics. So I must say I am glad that she [mentor]has made the time to talk with all of us on a daily basis; I think it has made all the difference for me - and allowed me to really enjoy my summer experience.*

> *Tabitha's research mentor: Early on, we all agreed that we would all be learning together this summer – including me. So, that's what we did. I just enjoyed spending time with them. Watching and listening to them really make big gains in their understanding; that was so rewarding. And the fact that they did it together, made it even better for me.*

Training Emphasis

Training newcomers in any environment is an energy and time intensive endeavor. This is especially true in academic research laboratories where, oftentimes, the training of newcomers must occur within a very condensed time period – the summer months. In academic research laboratories, the compressed training schedule is complicated by the pressures for laboratory personnel who must accomplish most of the actual data collection for on-going experimental projects during this same time period.

> *Dr. Dugan (Andrea's research mentor): Just training someone in the lab is initially a major investment in time. Not everybody does that and gets it more or less right…..And for all of us still doing research in the summer with students, time is worth more than money… the summer is really when most of the science gets done. When we have undergraduates in the lab in general, it's not like you can drop everything and spend a week with them one-on-one, so it always goes slower, I'm sure, than they would like, but especially when you know that they may not be back the following semester, it's a huge concern…the investment.*

Frequency pattern analysis of the open-coding categories generated in this study suggests that training newcomers in research skills is a significant priority for both laboratory personnel and student participants. After "Characterization of Mentor

Relationship" (20%), "Training of Research Skills" was the second most frequently referenced category (14%) from all of the textual data collected.

In this study, training of student participants in research laboratories was characterized as either formal/structured or informal/serendipitous. Formal or structured training sessions are characterized by advanced planning including providing teaching materials, observation and guided practice, and scheduling future training sessions. Informal training or serendipitous training sessions lacked one or more of these elements. Further analysis resulted in categorization of training episodes as either sequenced or discrete. Sequenced training sessions demonstrated either a logical experimental/research progression or a progression in technical skill difficulty. The number of different training episodes that occurred during these internships varied for each student. Based on these descriptors, training methodology was assigned for each student participant (Table 4. 6).

Table 4.6

Summary of Training Methodology Experienced by Student Participants

Formal/Structured Training with Sequenced Episodes	Formal/Structured Training with Discrete Episodes
• Tabitha (Numerous)	• Joshua (Numerous) • Catherine (Limited)
Informal/Serendipitous with Sequenced Episodes	Informal/Serendipitous with Discrete Episodes
• Sam (Limited)	• Andrea (Numerous) • Bryan (Limited)

Formal/Structured Training

Formal or structured training sessions are characterized by advanced planning. Therefore, the need for the training session must be either anticipated by the trainer or requested by the student. These sessions provided ample opportunity for both the trainer

and the participant to prepare for the training activity. To that end, teaching materials were collected and written materials were distributed to the participant either in advance or during the training session. Sessions characterized as formal or structured were designed to include observation and guided practice for the non-traditional student. Participant questions were answered before the training session ended, and a follow-up training session that focused on either additional practice or skill assessment was scheduled. If these training sessions followed a logical progression leading to incremental mastery of skills or protocols with increased levels of difficulty, students reported positive intellectual gains and described increased researcher confidence. Tabitha, the student participant in Angela Cook's laboratory, received this type of training. Her electronic journal entries elegantly described her mastery of current cellular and molecular techniques, including microbial cell culture techniques, DNA and RNA extraction, RT-PCR, utilization of microarray technology and diagnostic flow cytometry.

In their laboratories, Joshua and Catherine both experienced formal or structured training sessions which were episodically discrete. For Joshua there were numerous, discrete structured training sessions which occurred throughout the course of this internship. For Catherine, these formal training sessions were very limited in the total number that occurred in her research setting. Her total repertoire of newly-acquired laboratory skills/techniques did not number more than five at the end of her internship. The URE training outcome for both of these students was a sense of "experimental myopia." Neither student was confident in their overall understanding of the research that was undertaken in their home laboratories. Here is an excerpt from Joshua's electronic journal:

I have noticed in all of my past jobs/internships, and volunteer work that all of this technical/computer/scientific work really doesn't require understanding, other than from the higher level of bosses/Principal Investigators, etc. The work is all done from procedures that have been setup long before you ever showed up or from the box the chemical kits came out of. Once you know how to pipette, use a centrifuge, and how to keep your work area clean, there really isn't much else you need to know to do this work. Why Antarctic Yeast? I don't exactly know. The people I work with don't exactly know either. I am sure [research mentor] knows, but even then, I believe her testing is part of a greater collective of scientists that only all together know what is truly going on.

Informal/Serendipitous Training

Informal or serendipitous training sessions are oftentimes characterized as missing one or more of the same elements that are included in formal or structured training sessions. For student participants in this study, the training sessions were seldom planned in advance; they occurred serendipitously. Although students were appreciative of the time invested by the trainer, the context or subtleties of the session often went unnoticed. Because students had no time to prepare for the learning activity, and because the contextual complexity was unrecognized, these sessions often resulted in numerous repetitions of the same learning activity. From the trainers' point of view, participants were deemed inattentive or uninterested. From the participants' point of view, training sessions were inefficient and demoralizing. For both, the outcomes were the same; frustration, feelings of inadequacy and tensions created among laboratory personnel.

***Bryan:** I was in different labs almost every day. One of them was in a government laboratory. So that was a little different. Yeah, I got juggled around a lot. So it wasn't like I was in one lab every day. I was mixing it up, plus going out into the field. So I never really knew where I was going to be, or what I was going to be doing, until I was there. And then I'd just get sent somewhere…it was really frustrating.*

Andrea, Sam and Bryan participated in laboratories where training sessions were informally structured. For Sam, training sessions in Dr. Sherwood's laboratory were

serendipitous because of his already considerable previous experience with video

technology and image-editing. His knowledge and training in this realm exceeded that of

his mentor, therefore training was unnecessary. An initial, focused, on-line series of

training tutorials acquainted Sam with coral reef fish species. Project-related training in

Sam's dyad occurred only when he had specific questions concerning new/unrecognized

fish species that appeared in the videotapes, as he edited them. His training sessions were

considered sequenced due to the fact that for the entire internship, the scope of the

training remained entirely focused on identification of fish species.

Andrea and Bryan both participated in research settings where the training was

informal and episodically discrete. In these laboratories, training sessions were

spontaneous and often relatively isolated from other, routinely-practiced, laboratory

protocols. Advance preparation for these activities did not occur, and only rarely were

they followed by a de-briefing or review activity session. Student participants commented

that these types of training sessions were extremely stressful for them, because the

learning objectives were always extremely nebulous. Participants felt they should have

gained more from the activity somehow, which left them to question their intellect or

previous educational experiences. Research directors assumed their intended learning

objectives had been clear, but did not schedule time after the activity to confirm their

expectations or to clarify those expectations with the student participant. The usual result

for the research director or trainer was unspoken uncertainty.

> **Dugan:** *I actually asked Andrea, "Where do you feel like you're lacking in preparation?" And she had said that she really didn't know how to work her way through a journal article. So I wanted to force the issue. Here's the end of the dock, that's deep water… let's see how you do, so I gave her a stack of papers at the beginning of the week and she had finished them by the next week. I don't know what she has going on in the larger sense, but she seems to have gotten*

quite a bit from them…It's like an empty field of tall grass, all you want them to do is turn it into hay…sometimes you get hay, sometimes you get wood. I think she made 'hay.'

Training by Peers

Hierarchical Organizational Structure. All the research triads in this study utilized peer training. The organizational structure of three of these laboratories has previously been characterized as hierarchical. Hierarchical research triads that utilized peer-training included Joshua's, Andrea's and Bryan's triads. Peer-training, in this study is defined as training directed by laboratory personnel of the research triad who are not faculty. Numerous disadvantages for peer-training were reported by student participants. Only a single advantage could be attributed to peer training in these research triads. It was, however, an advantage afforded to peer trainers, not to non-traditional students.

In hierarchically-structured laboratories, peer-training amplifies stratification and contributes to peer competition, unless a substantial investment has been made by the research director to, "train the trainer." Peer training, done well, is time-consuming for student-trainers. Teaching in the laboratory setting diverts their time and their focus from their own research projects. On an irregular basis, peer training responsibilities may be a welcome interlude, but on a regular basis, they were viewed as intrusions by the lab colleagues interviewed in this study. For the peer trainer, teaching responsibilities were perceived as situations where potential inadequacies or ineptitude could be revealed. Peer trainers were reluctant to accept teaching responsibilities in these circumstances. In turn, student participants perceived colleague reluctance as either an unwillingness to share information or as an unwillingness to forge friendships. The result was heightened tension among lab colleagues.

Tracey: I think that Andrea was a little, she was ... she was very eager to learn. In a way, almost too eager…she was a little over the top. But, ahm that didn't bother me, you know, and she, she wanted to be involved with the things that I was doing. You know, when I was here that was not a problem for me. It was a little bit awkward because some of the stuff I was doing I was just learning how to do it myself, so it was difficult for me to teach her at the same time.

For non-traditional students, it was difficult to separate and then re-combine the roles of peer colleague and peer trainer. Student participants, as newcomers at an away institution, were remarkably limited in the number of social contacts available to them. For most participants their lab colleagues were the only candidates for social interactions. This limitation was more problematic, when lab colleague roles included teacher and evaluator. From a posting on the electronic discussion board from Joshua:

Awkwardness:
My lab manager is 25 years old, which is very close to my age (29). I find it a little awkward talking to her especially when there is a lot of eye contact. I am not sure if it's that she is in my dating age range and I think she is fairly attractive. I don't want to seem like I am staring deeply into her eyes or anything and I guess that's what makes it awkward. I have no actual interest in dating her, it's just that she falls into a date-able category, I guess.

In this study, the benefits of peer training in a hierarchically-structured research setting are reserved for peer trainers. There is no refuting that peer teaching reinforces conceptual understanding for the trainer. Teaching can often clarify gaps in understanding for a peer-instructor. However, in a hierarchical model, there is no one to whom neophyte researchers can bequeath their newly-acquired knowledge. In this study, the benefits of peer-training did not outweigh the costs for non-traditional students.

Summary

Leadership in an academic research setting can be characterized as either unilateral, bilateral or multilateral. Unilateral leadership emphasizes singularity in

decision-making. In laboratory settings where the leadership is unilateral, student life experiences are de-valued. Student self-esteem is either unchanged, or is diminished. In academic research settings with bilateral or multilateral leadership, students and research mentors share responsibility for decision-making. Student life experiences are valued and student self-esteem is either unchanged or increased. When multilateral leadership is found in the academic research laboratory, democratic decision-making predominates. Students are full-participants as decision-makers and leaders. To lead others, students have acquired new self-confidence. As student participants' self-confidence increases so does their self-esteem. For non-traditional students this is one of the most notable benefits of a positive URE experience.

The training emphasis in an academic research laboratory may be formal/structured or informal/serendipitous. If training sessions were sequenced in a logical experimental progression, leading to mastery of new skills and techniques, students reported positive intellectual gains and described increased researcher confidence. Students who participated in laboratories where the training emphasis was unstructured often concluded that ineffectiveness of the sessions was in some way their responsibility. Lack of self-confidence and self-esteem led them to wrongly attribute trainer ineptitude to their own perceived personal or educational inadequacies. Issues of self-confidence for both student participants and lab colleagues were inflamed by peer training sessions in hierarchically-structured laboratories. Peer-training in these research settings resulted in amplified social stratification and contributed to competition among peers.

Return to the Theoretical Model

The organizational model applied in an academic research laboratory directs the leadership emphasis and the training methodology. Together, the training emphasis and the leadership emphasis determine the social climate of research laboratories. Influences of laboratory organizational structure and laboratory social climate on URE outcomes for non-traditional students are represented in Figure 4.3.

		HIERARCHICAL MODEL	EGALITARIAN MODEL		
Training		Unilateral Leadership	Bilateral Leadership	Multilateral Leadership	Training
FORMAL				• Tabitha	Sequenced
		• Joshua • Catherine			Discrete
INFORMAL		• Andrea	• Sam		Sequenced
		• Bryan			Discrete

(Vertical axis: Increased Self-Esteem; Horizontal axis: Increased Autonomy)
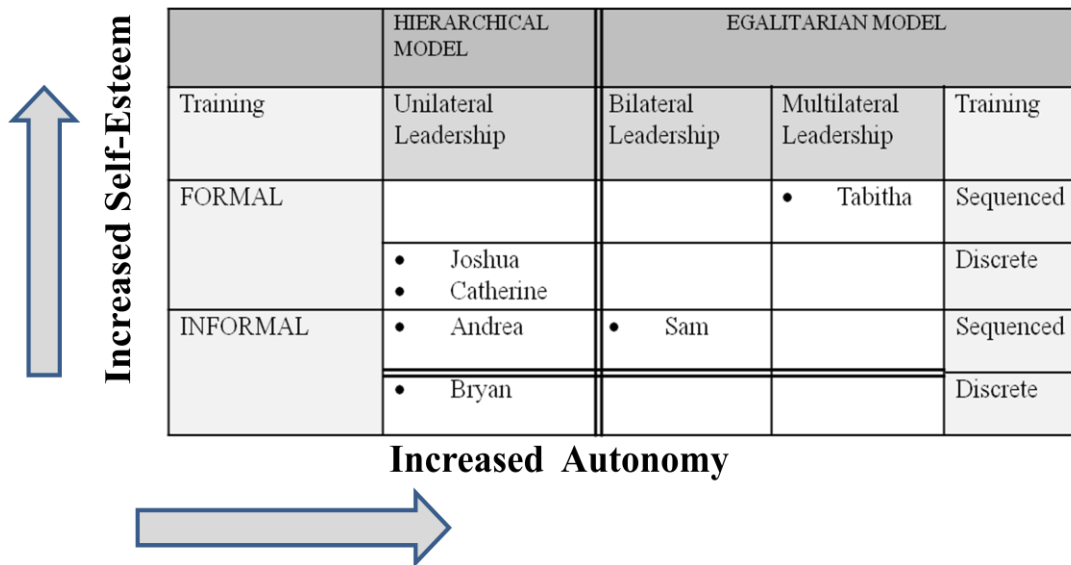
Figure 4.3

Influence of Organizational Structure and Social Climate on Developmental Gains Made by Non-Traditional Students during URE Participation

The organizational model that operates in the research setting may be hierarchical or egalitarian. Hierarchical organizational models rely on unilateral leadership to promote efficiency in research efforts and coordination of laboratory personnel. In this study, four of the six research groups utilized organizational models that were philosophically based on efficiency. Furthermore, the leadership emphasis and the training emphasis

contributed to the social climate in these four research laboratories. With unilateral leadership, the social climate was characterized as socially stratified, with subtle competition among peers. Nonetheless, student participants in laboratories with unilateral leadership that received formal or informal *sequenced episodic* training reported positive benefits from URE participation. The three non-traditional students in these laboratories (Joshua, Catherine and Andrea) made substantial gains in self-confidence, which bolstered their self-esteem. However, in these hierarchically-structured laboratories, gains made in neophyte-researcher autonomy were negligible. The student (Bryan) who participated in a laboratory that operated under a hierarchical organizational model with unilateral leadership and informal, *discrete episodic* training sessions did not report positive benefits from URE participation.

Student participants Tabitha and Sam reported positive URE benefits. Assigned to laboratory settings directed by mentors who employed bilateral or multilateral leadership frameworks, participants gained independence and self-reliance. These non-traditional students reported positive URE benefits in research settings where training methodologies were structured and sequenced. Participants' self-confidence increased in these settings. Increased self-confidence led to increased self-esteem. As we shall see in the next chapter, significant gains in autonomy and self-esteem elevated students' academic aspirations and shifted professional goals towards research-based science.

In this study, five of the six students enthusiastically endorsed the positive benefits of their URE. In fact, Bryan also reported positive benefits from his URE experience, but these were overshadowed by the negative consequences he recounted of his URE participation. However, to fully understand the complexity of participation

outcomes, the perspectives of the established laboratory communities must be considered. Three perspectives of non-traditional student participation in academic research settings emerged from analysis and interpretation of transcripts of interviews with laboratory personnel. The first was characterized by benefits to the organizational structure and social climate. Organizational benefits included greater division in personnel workloads and the contributions from participants' previously acquired life and professional skills. Benefits to the social climate were increased numbers of leadership candidates and decision-makers. In addition to these positive benefits, laboratory personnel reported greater overall lab productivity with URE student participation. A second possible laboratory outcome derived from research personnel transcripts was interaction with a URE student participant afforded no substantial benefit, but was not detrimental to laboratory structure, social climate or overall productivity. And finally, for one laboratory, participation in this study resulted in disruption of the laboratory structure, with both the social climate and laboratory productivity negatively affected.

When student participant perspectives were compared to perspectives of the established laboratory community, four possible acculturation outcomes emerged. These outcomes were represented in Figure 4.2, and are reviewed again in the next section.
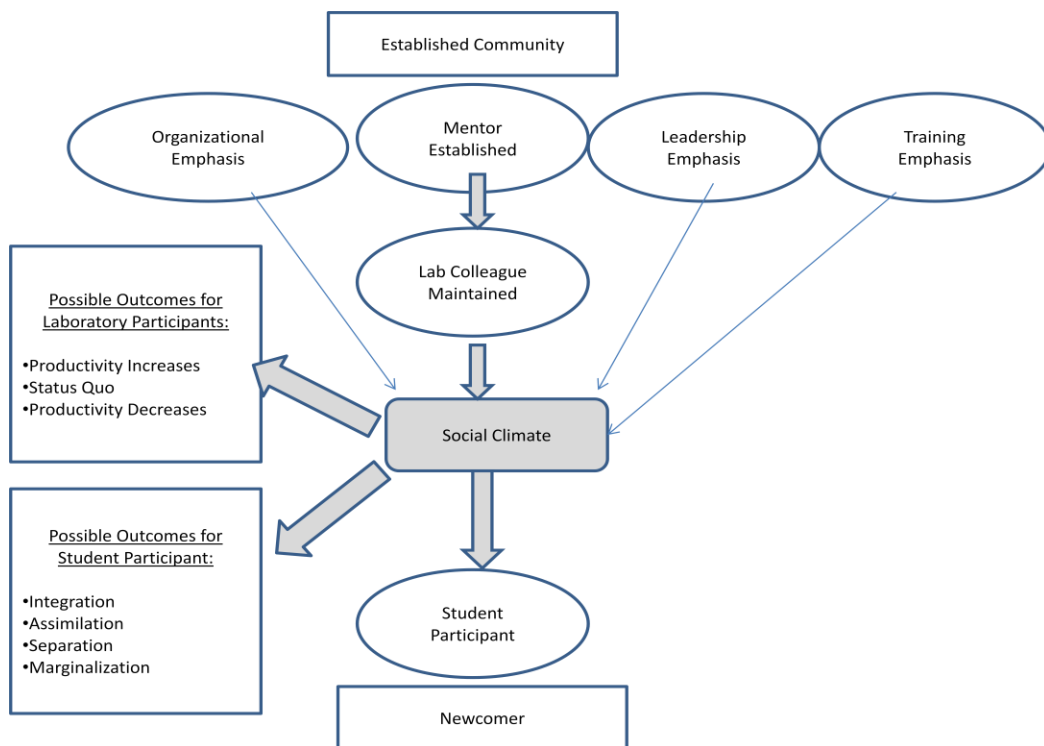
Figure 4.4

Possible Outcomes of URE Participation

The student participants in this study who achieved **Integration** into the

established laboratory community were Tabitha and Sam. In turn, personnel in their

laboratories reported positive benefits to the organizational structure and social climate,

and claimed substantial increases in research productivity. Representative excerpts from

the Tabitha/Cook triad are included here. Transcripts from the Sam/Sherwood dyad

reflected similar sentiments.

> **Tabitha:** *As of now, with two weeks left of my URE, I would definitely say that it has been very positive. And although the first week was a little hard because I was the only one not from this college, and [lab colleagues] had already known each other from the previous summer it only got better not worse. They have come to accept me as another resource and help to them in the lab even if I haven't taken all the physics and chemistry classes that they have-there are other things that I bring to the "lab". Such as my ability to be well organized, goal orientated and focused…I think my age has also helped make this a positive experience. Although I know I have some stresses in my life, I don't have a household to run*

and kids to bring to school/daycare etc. all of my energy and attention is focused on just research.

Dr. Cook: *Tabitha has made substantial gains in her understanding of basic techniques, but more than that she has made fundamental leaps in her understanding of the process of science. She was never content to just follow protocol directions and she really wanted to understand the how and why things worked the way that they did. She definitely was a role model for the other two students in the lab, she was definitely the strongest personality, and she was their leader in most things.*

Separation from the established laboratory community occurred for Joshua, Andrea and Catherine. The students' perspectives of their contributions to the laboratory and their perceived individual developmental gains did not match those reported by laboratory personnel. In comparison, students overestimated their gains and contributions to the research efforts of their home institution. Laboratory personnel suggested that at best, nothing was lost, but nothing was gained by the presence of the non-traditional student.

Representative excerpts from the Andrea/Dugan triad are included here. Transcripts from the other two research groups reflected similar sentiments.

Andrea: *This summer I have gained skills in working in groups; communicating with my fellow lab partners and asking as many questions as I could. Aside from that I have gained dexterity– managing injections and EKG on* Drosophila *pupae – and some knowledge aside from that on the heart structure of the* Drosophila. *I did not manage to learn to sex them efficiently but aside from that I "mastered" most every other skill. I still have some of my data left to analyze but at least this science geek has something to look forward to.*

Dugan: *When I look at the summer, are we in a different place because Andrea was in our lab? You know, not really. I look at it as we just broke even. We didn't gain anything, but we didn't really lose any ground either. She wasn't really like an extra pair of hands that I could count on as making a contribution.*

Marginalization was the participation outcome for a single student in this study, Bryan. His presence in the laboratory disrupted the hierarchical organizational structure.

In this laboratory there were no other undergraduates, except for the student participant. For these graduate students, who had all completed advanced coursework and had substantial laboratory experience, Bryan's inexperience was a nuisance and his simpler questions were trivial. Prior to his arrival, in many ways, this laboratory functioned as egalitarian, only because there existed a single stratum – graduate students. Bryan's presence re-introduced stratification. Peer trainers for Bryan were those graduate students who now occupied the lowest graduate student stratum those with the least experience. This led to (as previously described) heightened perceptions of inadequacy and resentment for the peer trainer(s) and was demoralizing for Bryan. As his internship progressed, Bryan became more reluctant to participate in daily lab activities, explaining to his lab mentor that his absenteeism was related to his numerous diagnosed illnesses. By the end of his internship, significant tension existed in the laboratory whenever he was present. Laboratory productivity on those days was affected. A behavioral positive feedback loop was initiated in this laboratory setting that once initiated, was not interrupted. Representative excerpts from the Bryan/Stardusky triad are included here.

> **Bryan:** *I have other people that have been educating me along side [lab mentor] as well and these people deserve some attention. Two PhD students, [lab colleagues], have taught me lab protocols and genetic theory. Some of the lab procedures I have been working with are PCR (Polymerase Chain Reactions), laying and labeling plates, data entry, and electrophoresis. These lab techniques are valuable tools. Consequently, these tools make me a valuable laboratory technician and I am indebted to [lab colleagues] for sharing their knowledge. If I could change one thing about my experience it would be the amount of time that I am able to spend at the lab. I have not been putting the time that I would like into the lab work that I want. I am juggling five doctors on top of everything. This translates to a lot of study, communication time, and appointments. I wish I had my medical condition under control before the research experience started.*

> **Stardusky:** *Bryan, in a lot of ways, is very socially unwise. He is very abrupt with the other individuals in the lab. I am sure he does not realize this himself; he just seems not to have acquired these necessary social skills. It had been very*

unsettling, for the, ahm, this was very disconcerting for the graduate students to have someone who was an undergrad who they saw only rarely, be so abrupt in the way that he asked questions, or in the way that he interacted with them.

Summary of Findings from Research Questions One and Two

The organizational structure of an academic research laboratory is the framework used to coordinate long-term and more immediate research activities. Two models, hierarchical and egalitarian, are available to research directors for administrative frameworks. In this study, the selection of an organizational model had two significant consequences for non-traditional students. Indirectly, the adoption of either the hierarchical model or egalitarian model directs further administrative choices regarding leadership and training models. In combination, the training emphasis and leadership emphasis contribute to the social context of the research laboratory. This contextual framework is realized for non-traditional students as the laboratory social climate. Directly, the laboratory organizational structure represents the boundaries of scientific autonomy achievable for non-traditional students. Both non-traditional and traditional students who participated in laboratories guided by an egalitarian framework made greater gains as independent novice researchers than those in hierarchical research settings. Both student participants and research mentors appreciated and valued these developmental gains. For non-traditional students, gains in laboratory self-reliance translated to gains in self confidence. Research mentors valued gains in laboratory autonomy for its indirect benefits: minimizing supervisory responsibilities, while increasing lab productivity.

Non-traditional students experienced the contextual framework of the research laboratory through leadership and training activities. When student participants were

afforded active leadership roles with meaningful decision-making authority, students assumed more responsibility in the research setting. Greater researcher responsibility led to greater investment in the research efforts of their home institutions. For non-traditional students, gains in laboratory responsibility resulted in increased self-confidence and greater self-esteem. Not surprisingly, research mentors also valued gains in laboratory responsibility. As equitability in workloads became more realistic, research efforts were maximized and laboratory productivity improved.

In this study, non-traditional students reported perceived benefits and gains from URE participation. For students, developmental gains included gains in researcher autonomy and gains in self confidence. Established research communities also reported perceived benefits and gains from their participation. Gains reported included increased laboratory productivity and benefits in organizational structure and social climate. Based on comparisons between gains reported by newcomers and those reported by established research communities, acculturation patterns emerged. Two of the six students in this study, Tabitha and Sam, experienced full integration into established research communities. Separation occurred for three of the six students: Joshua, Catherine and Andrea. These students perceived their efforts as substantial and their contributions to their research communities as notable. However, their established research communities did not reach the same conclusions. Marginalization occurred for one student participant. Bryan himself reported minimal positive benefits from his URE and the established research community at his home institution concurred.

Non-traditional students interacted with the established community within the arena of the laboratory social network. These interpersonal interactions were, in turn,

influenced by the social climate. Notable in this study, was the disparity in perspectives that existed between reported URE benefits and gains when student participant accounts were compared to those of the established laboratory community. This dissonance occurred in three of the six research groups (50%). Those groups reporting a mismatch in perspectives were research groups utilizing the hierarchical organizational model. Additionally, these were the same research groups where non-traditional student acculturation resulted in separation.

Chapter 5

PROFESSIONAL AND ACADEMIC SELF-CONCEPTUALIZATIONS:

RE-EVALUATION, RESOLUTION, AND RECONSTRUCTION

The long-term psychological consequences of this process of acculturation are highly variable, depending on social and personal variables that reside in the society of origin, the society of settlement, and phenomena that both exist prior to, and arise during, the course of acculturation. (Berry, 1997, p. 5)

Findings Related to Research Question Three

The final research question of this study sought to reveal factors, processes and relationships that develop during URE participation and influence non-traditional students' academic and professional self-conceptualizations.

Research Question Three: *In what ways does a traditional URE in science influence non-traditional students' attitudes and behaviors regarding academic goals and professional aspirations?*

Introduction

This is the second of two findings chapters presented in this study. The previous chapter presented characterizations of two different organizational structures. In turn, the influences of the hierarchical model and the egalitarian model on shaping social climate were discussed. Both the newcomers' perspectives of their own social acceptance and the perspectives of laboratory personnel regarding the newcomers' social acceptance were modified by the organizational structure and the social climate of the established research community. Certainly, social acceptance is an important aspect in the determination of acculturation outcomes for non-traditional students, but as Table 4.3, (reproduced here as

Table 5.1) illustrated, acquisition of professional competence is a second important factor contributing to these outcomes.

Table 5.1

Model of URE Acculturation Outcomes for Non-Traditional Students

	Laboratory Members Report Social Acceptance and/or Professional Competence	Laboratory Members Report Social Alienation and/or Professional Inadequacy
Participant Reports Social Acceptance and/or Professional Competence	INTEGRATION	SEPARATION
Participant Reports Social Alienation and/or Professional Inadequacy	ASSIMILATION	MARGINALIZATION

This chapter presents findings that chronicle the progressive development of professional competence for URE participants. As we shall see, these developmental gains in professional competence shaped the academic and professional self-conceptualizations of the student participants in this study.

Before representing these interpretations of professional competence, the first section of this chapter includes a brief explanation of relevant textual coding category frequencies that emerged during data analysis. This information is followed by descriptions of the transitions each participant made as they negotiated with laboratory personnel of the established research community for progressive gains in professional competence. The accumulated data will detail the student participants' laboratory experiences which specifically highlight relationships between social acceptance and acquisition of professional competence in an academic research setting. Afterwards,

student acculturation outcomes resulting from unique relational combinations between social acceptance and professional competence will be discussed. In addition, the phenomena of acculturative stress will be presented. Transcript and observational data indicative of student acculturative stress levels will be shared. Lastly, space will be devoted to a comparison of acculturation outcomes, acculturation stress levels, and ensuing changes in student participants' academic aspirations and professional goals.

Recall that, in Chapter Four, a detailed description was provided of the open coding categories derived from textual analysis of participants' transcripts. Approximately one half of all coded categories were directly related to research Questions One and Two, while approximately another quarter were related to Research Question Three (Figure 4.1.). Specifically, the categorization of these textual references coded to Research Question Three resulted in the following division of participants' commentary: 10% were related to academic goals, 7% were related to gains made in familiarity with learning milieu and another 7% were related to progress made in the acquisition of vocational habitus. However, only 2% of all textual references were coded as directly related to professional goals. These coding category frequencies are represented in Figure 5.1

Open Coding Categories by Responses

Legend:
- Academic Goals
- Learning Milieu
- Vocational Habitus
- Professional Goals
- RQ #1 and #2
- Other
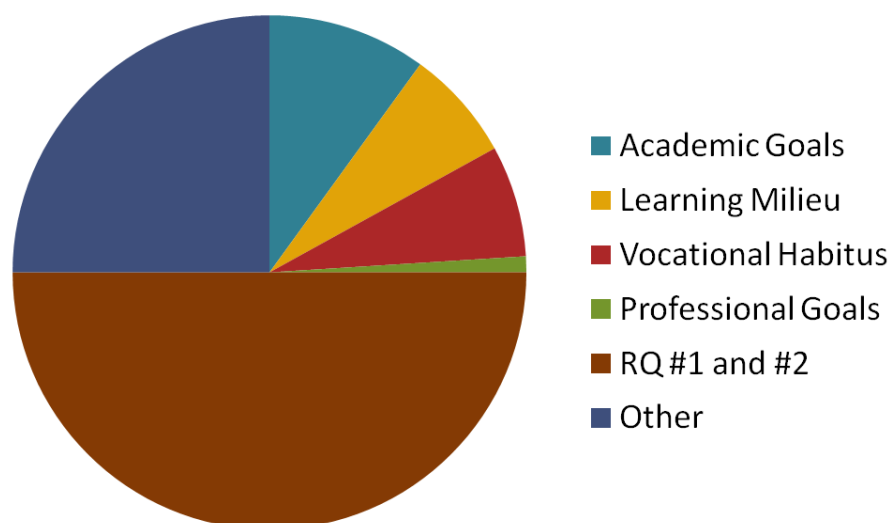
Figure 5.1

Frequency of Participant Responses Related to Professional Competence and Academic and Professional Goals

Student Participants' Gains in Professional Competence

Learning Milieu

The learning milieu represents the total learning environment. In the science URE context, it includes the knowledge necessary to perform work in an academic research laboratory and at designated field research sites (if applicable). In this study, all student participants reported at least minimal gains in familiarity with their respective learning milieus. They gained understanding of the techniques, protocols, instruments and animal models that characterized the research done in their assigned labs. This excerpt from Joshua's second interview characterizes the opinions expressed by most participants on the intensiveness and extensiveness of their internship gains in familiarity with the learning milieu:

Joshua: I feel like the amount of stuff I've been exposed to in just this two weeks in the lab is probably more than the amount of lab experience, you know, that I'll get in the whole next semester of classes. It's gonna be a little bit annoying, to be back in the classroom lab. And you know, you gotta wear the goggles, and you gotta go through this long procedure just so you can pour some hydrogen peroxide or something. And it just takes so much time to learn, you know, such a small amount, whereas in the lab now, I'm mixing all these chemicals all at once, and I'm doing a bunch of things all at once.

Andrea's quote demonstrates how she and most of the other student participants began to understand the correlation between the animal research model utilized in their laboratories and the research questions that were investigated.

Andrea: As I said the Drosophila *have three larval stages in which they are burrowing through the media in the containers that they have been laid in. The transition from third instar larvae to P1[first pupae stage] is of the most importance to me for the time being, since that is when injections and temperature gradients are to be done. There are a few factors that can be employed to age them. As described by my research guide [Dugan], third instar stage lavae look like the Michelin man under the microscope; that is to say that they have a clearly segmented body and are opaque.*

These testimonies can then be compared to Bryan's description of the progress he made in gaining familiarity with the learning milieu of his assigned research laboratory. This excerpt is from his second interview of the internship, which occurred at approximately week five.

Bryan: Yesterday I was in [SE's] Lab. I washed a lot of dishes and also did some data entry.

What is clear is that not all non-traditional students achieved the same level of familiarity with the learning milieu. Certainly Bryan, during the course of his internship, did not make substantial learning gains in his assigned laboratory. Although there are multiple factors that, no doubt, influenced the degree of learning for each student participant, this study focused on social interactions, training, and acculturation

outcomes. As social interactions and training have previously been discussed, the emphasis of acculturation outcomes will be discussed later in this chapter.

A second student in this study who did not achieve significant gains in familiarity with the learning milieu was Catherine. Her repertoire of learned laboratory protocols was less than five at the end of her internship. However, the factors that influenced her lack of substantial learning gains are strikingly different from those that minimized Bryan's learning. What can be said is that both of these students, lacking breadth in their laboratory training, failed to make noticeable gains in their acquisition of vocational habitus. What this suggests is that a continuum exists for non-traditional students transitioning from neophyte researcher to competent professional, and that familiarity with the learning milieu is requisite to acquisition of vocational habitus.

Acquisition of Vocational habitus

After the initial negotiations between newcomer and established community members for access to, and familiarity with the learning milieu were underway, negotiations proceeded to acquisition of vocational habitus. The use of the term "negotiations" here is meant to imply that non-traditional students in this study were not guaranteed premium training opportunities; these instead were offered by laboratory personnel of the established community. As such, social status (in the hierarchical organizations), levels of social acceptance newcomers had achieved, and the extent of familiarity with laboratory procedures all influenced these negotiations. In this study, acquisition of vocational habitus was equivalent to gains in understanding of the science process and habits of mind necessary to be a professional scientist. For student participants, vocational habitus was frequently observed during training activities, but

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was not explicit to the training objectives. Vocational habitus was observed in activities

led by both peer colleagues and research mentors. Student participants also observed

vocational habitus demonstrated by research personnel in the daily activities of the

laboratory. Other qualitative researchers interested in the reported benefits of traditional

science research experiences for undergraduates have characterized these qualities (those

which, are referred to collectively as vocational habitus) that their participants reported in

their interview sessions as, "feeling like a scientist" (Bauer & Bennett, 2003; Hunter et

al., 2006). Their characterizations of these reported habits of a scientist included

perseverance, diligence, attention to detail, acceptance of ambiguity, tolerance of the

mundane, objectivity, and ethicality. As was previously mentioned, as students acquired

vocational habitus, laboratory personnel became more appreciative of the participants'

progress and were more likely to provide greater and greater social support for their

research efforts. These two excerpts from the interview transcripts of the Andrea/Dugan

laboratory triad are characteristic of vocational habitus relational reinforcement that

occurred in four of the study's research groups.

> **Andrea:** *Patience in science, right. I was raised being told that if you can't manage the little things how are you ever going to accomplish the big ones; a factor that I keep in mind whenever I am frustrated by something that seems mundane. It holds true for the most part and in research taking the time beforehand to make sure that everything is in line is o-so-important because that way you can be sure that the data you get is as accurate as possible.*

> **Dugan:** *I think the main thing is that over the course of the summer she's come to understand what research means in the real world. You know it's just not a pie in the sky cure for AIDS you know and stuff like that. And what it is, it's a day to day slog you know and what you do in a given day is, is hard work. And it isn't you know you come in, in a white suit, spray some stuff and get some great results. Actually, you know, a lot of what you do is just prep work. And she, she's come to realize that. I think that at the end of the day she understands that that's good.*

Notable in this study was the apparent relationship between variability in learning milieu exposures and scope of acquired vocational habitus. Non-traditional students who participated in a variety of different laboratory procedures experienced greater gains in vocational habitus. Students who participated in a limited number of laboratory procedures did not make as many substantial gains in vocational habitus. In all, a total of fifty-five textual references were categorized as germane to "Behaviors of a Professional Scientist," an open-coding category created to capture participant-reported acquisition of vocational habitus. Four of the six participants made ten or more references to acquisition of vocational habitus: Andrea (12:55), Joshua (16:55), Sam (12:55) and Tabitha (10:55). Catherine and Bryan, during the course of their ten-week internships were trained on fewer different laboratory techniques. Transcripts from Catherine's interviews produced four references to gains in vocational habitus, while analysis of Bryan's transcripts produced one reference to vocational habitus. Gains in vocational habitus for these two non-traditional students were limited to recognition of the repetitiveness of certain scientific tasks and to the diligence required for extended periods of focused attention to detail.

> **Catherine:** *The gains I have made in research skills have been very exciting. The boring tedious aspect of science work was something I truly relished. I worked measuring the wings of larva fruit flies while they were under the affects of CO_2. I was told that many students did not like doing that particular task for more than two hours but I truly enjoyed it… There is a joy I get in looking at tiny things.*

> **Mosconi:** *And, it wasn't; she just didn't learn a lot of, of transferable skills here. She learned some basic ones. But it was, the whole experience, a lot of it was just doing some repetitive thing that she had already learned. So, contributing to me, but not continuing to gains in her learning experience, but just doing laboratory stuff. That's the monotonous part of it.*

Changes in Professional Competence through Reflexivity

Unique to this qualitative study on science URE participation was the inclusion of a reflexivity requirement for student participants. Students were asked to reflect on their URE experiences and record their impressions using electronic journals – personal blog sites. Student participants were also asked to share with each other significant issues/experiences that occurred during the URE internship, using an electronic discussion board – private wikispace. Four of the six participants posted at least weekly journal entries to their blog sites. The total number of electronic entries for each participant is represented in Table 5.2.

Table 5.2

Student Participant Electronic Journal and Discussion Board Entries

Participant	Blog Postings	Wiki Postings	Wiki Replies
Joshua	31	14	18
Andrea	18	16	21
Tabitha	11	5	10
Bryan	8	3	8
Sam	5	0	0
Catherine	1	0	1

Several benefits to undergraduates have been attributed to learner reflexivity by other researchers (Baxter Magolda, 1993, 2006; King & Kitchener, 2004). In these previous studies, undergraduates who routinely incorporated learner reflexivity made more substantial gains in critical thinking skills and experienced the transition to "contextual knower" sooner than those who did not routinely incorporate reflexivity in their learning strategies. For non-traditional student participants in this study who routinely utilized electronic reflexivity, three positive outcomes resulted. First, student

participants, as cohorts, were able to provide each other with social support. Second, enhanced positive social support validated the students' perspectives of their changing perspectives of professional competence. Third, this validation was significant in minimizing student participants' acculturative stress. Acculturative stress is defined as stress that occurs during the process of acculturation and can often include anxiety, depression, and feelings of marginality, heightened psychosomatic symptoms and identity confusion (Williams & Berry, 1991).

An excerpt from one of the electronic discussions (between Joshua and Andrea) that demonstrated cohort social support is included here:

> *Joshua: I have worked in the technical realm for years (mostly computers) and I have noticed that there often is a certain type of person that I encounter in the technical fields. I call them the Information Keepers. These people hold information and use it like it was power. They don't like to clearly answer questions because they are afraid if you understand it, you will gain some of their power. I think it's some sort of insecure social dysfunction and can be harmful in a work environment. I am just wondering if any of you know what I am talking about and if you have any of these people in your labs.*
> *Posted Jul 22, 2008 3:21 pm*
>
> *Andrea: re: Information Keepers*
> *I do know what you mean... I think... people who try to hold some sort of extended knowledge over your head do so, so that they can feel empowered. Luckily I have no one like such in my lab, but I have definitely encountered the type in other work environments. They aren't usually pleasant people; their arrogance seems to place everything out of balance and gives them an air of anger. In general I have found that arrogance is really a mask for insecurity if that makes you feel any better.*
> *Posted Jul 24, 2008 8:55 am*

A second significant outcome associated with electronic reflexivity in this study, and a corollary to validation of students' changing perspectives of professional competence, is clarification of professional and personal role responsibilities. Joshua, single, at age twenty-nine, questioned the personal sacrifices that might be necessary to

be successful as an academic researcher. He posted this entry on his blog site, with a

similar question posted to the electronic discussion board. (That dialogical exchange,

although fascinating, has been included in Appendix T).

> ***Joshua:*** *Anyway, I would be willing to bet that many successful researchers are single or don't have a standard family. Is it that family brings people down/slows them down so that they can't reach the same level of success? Is it that family is so fulfilling that there is no need to overachieve in research? Or maybe it's about dividing up time. Children require time and spouses require time. I think this is something to consider when thinking about how far you want to go in research and how much you are willing to sacrifice.*

Induction to Cognitive Apprenticeship

A third beneficial outcome of electronic reflexivity for at least two of the student

participants was facilitation of the transition to cognitive apprenticeships. Previously,

several investigators interested in characterizing URE participation benefits (Kardash,

2000; Hunter, et al., 2006) have concluded that traditional URE participants often fail to

make substantial gains in critical thinking skills, nor do they attain competence as

autonomous science researchers. In this study, electronic reports posted by Tabitha, Sam

and Joshua suggest their transition to independent critical analysis of science process and

reflections on social network interactions within their respective laboratories had begun.

Transitions to cognitive apprenticeships occurred for both Tabitha and Sam in their

research environments, as well. Apparent in this excerpt from Sam's second interview is

his newly-described understanding that, in science, data collection is necessarily followed

by data analysis. His comments also indicated his realization that biological systems may

have inherently more complexity than mechanical systems, and that this additional

complexity requires greater sophistication in data analysis.

> ***Sam:*** *It was a matter of just learning what research science was all about. Because I ah, I really didn't have an idea of exactly how all that went down. I*

would think my biggest gain would just be understanding the process of how, of how, research science works and ah how gathering data fits in with the whole process. In physics it's awful easy to see what, in an experiment what would constitute a change in data. What's the word I'm looking for um, when you have a set of data and you have things that can sway it one way or the other… Relevant error! It's awfully easy in physics to see what that percent error is. Going into something like marine biology, figuring out where that error is, where there might be shifts in the data, that is completely different.

In his research dyad, Sam was solely responsible for data extraction and data analysis on the coral reef fish project.

Tabitha's excerpt is from one of her blog postings chronicling a series of experiments she and her lab colleagues undertook to determine if known periodontal bacterial species were correlated with severe mandibular bone loss in processed murine samples. Notable is her mention of the importance of reproducibility of results, attribution of earlier ambiguous results to specific alterations in standard protocol variables and an expectation of results based on the initial experimental hypothesis.

> **Tabitha:** *Prof. Cook wanted us to run a gel so we could look and see if there really was any DNA. We were hesitant and nervous cause if you remember last time we did it nothing showed up. We did come to the conclusion that it probably was the fact that we had a marker that was to be used with bigger [DNA] fragments.. and also our polymerase -Taq man.. (lol) had not come and we used a different polymerase from an entire diff. protocol. Our nervous/anxiousness made us mess up our buffer the first time oopps but, we finally got it done. Went to lunch and went to view the gel under the U.V. light located in the lab in the floor above us. Suddenly the "nose game" was enacted and I was the one who had to put on the purple gloves and carry the gel which was in EtBr. upstairs. We placed it on the manual U.V. light and I saw something very faint but, I was sure I saw something. [Lab colleagues] didn't seem as excited at first but, that would change. Then we went to go take a pic. of it and sure enough there were bands!! At the approximate size they were suppose to show up at.*

Acculturation Outcomes and Changes in Professional Goals and Academic Aspirations

In previously reported studies, student participants reported positive benefits from science URE participation. Student reported outcomes did not vary when different methodologies (interviews, surveys, focus groups) were utilized to collect student opinions (Kardash, 2000; Hathaway, et al., 2002; Bauer & Bennett, 2003; Lopatto, 2003, 2004; Amoussou & Cashman, 2006; Franz, et al., 2006; Hunter, et al., 2006; Hurtado, et al., 2009). In this study, as well, every non-traditional student reported positive benefits from URE participation. What was potentially more telling was comparing the students' perspectives of described URE benefits to the changes in laboratory productivity and social climate reported by participating research communities. When these acculturation outcomes for non-traditional student participants were compared to reported and observed changes in professional and academic self-concepts, a clearer pattern of changes in professional goals and academic aspirations emerged. These changes in career and academic plans for each participant are summarized in Table 5.3 and described in greater detail in the remainder of the chapter.

Table 5.3

Changes in Student Participants' Academic Goals and Professional Aspirations

Associated With URE Participation

Participant	Academic Goals Prior to URE Participation	Academic Goals After URE Participation	Professional Goals Prior to URE Participation	Professional Goals After URE Participation
Bryan	Undergraduate Degree from Out-of-State University Medical School	Undergraduate Degree from Out-of-State University	Psychiatrist Partner in Private Medical Practice Hospital Affiliation for Clinical Research	Uncertain
Andrea	A.A.S. Nursing from Local Community College Undergraduate Degree from Local Liberal Arts College Medical School	Re-evaluated	Surgeon	Re-evaluated
Catherine	A.A.S. degree Undergraduate Degree in Food Science or Nutrition	Completion of A.A.S. degree Transfer to Research University Currently Pursuing Degree in Cytology and Microscopy	Registered Dietician or Nutrition-related Career	Cytologist
Joshua	Undergraduate Degree in Health-Related Major	Enrolled in Pre-Pharmacy Doctoral program	Uncertain	Pharmaceutical Research
Sam	Undergraduate Degree in Engineering	Master's Degree in Marine Architecture	Engineer	Research-Emphasis: Marine Engineering
Tabitha	A.A.S. in Dental Hygiene	Undergraduate Degree in Dental Hygiene Graduate School for Dentistry (DMD)	Dental Hygienist	Research Emphasis: Dentist/Oral Surgeon

Marginalization: Bryan

In this study, the student participant whose acculturation outcome was best characterized as marginalized was Bryan. The positive benefits he reported from URE participation included the opportunity to become acquainted with several research professors and positive gains in both his research skills and his understanding of genetics. [The following quote is taken directly from Bryan's blog site. No grammatical changes were made.]

> *Bryan: I have had many extraordinary intellectual gains from this summer research experience so far this summer. I have received a crash course in biological theory, learned details about the levels of degrees in academia, professorship, laboratory protocols, and real world applicable concepts in the fields of politics, economics, psychology and philosophy. The two most significant intellectual advancements that I have had this summer is my understanding of Genetics and libratory procedures. I never knew what genetics were and now I have many tools in my mind, fostering my understanding of it. The introduction to the science of genetics has influenced my understanding of the world and will, without a doubt, change the course of my life. The laboratory protocols I have learned have reshaped my ideas about my work life. Most of my friends have never even thought about doing lab work for a living and I never saw myself working in a scientific lab either. I have really enjoyed doing laboratory work and envision myself doing more for a living in the future.*

In the final interview, Stardusky (Bryan's research mentor) related that he had, on several different occasions, mentioned to Bryan that he had been offered an amazing research opportunity. However, he felt that Bryan was not taking full advantage of the learning experience. Bryan's absenteeism and his social abruptness increasingly became an issue for this research community.

And so it seems clear, that Bryan made minimal gains in social acceptance in this new learning environment, due to his social immaturity. Recall that Bryan, at twenty-eight years old, was the only student participant who was not self-supporting. Prior to his summer internship, he lived with his parents. His social ineptitude and lack of social

skills may have been partially responsible for his abruptness in interpersonal interactions

in the laboratory environment. However it seems possible, that his dismissive behavior

may also have been an outward sign of accumulating acculturative stress. A second factor

that distorted both the social dynamics and the productivity in this laboratory was

Bryan's absenteeism. Superficially, this would seem to indicate Bryan's irresponsibility

and disengagement with activities in the academic research setting. However, when

viewed through a lens of accumulating acculturative stress, may be attributable to

inadequate coping strategies.

In truth, Bryan gained only minimal familiarity with the learning milieu of his

assigned laboratory. He was not able to progress to acquisition of vocational habitus; to

do so would have required greater familiarity with the science practiced in Stardusky's

laboratory. Bryan could not acquire the habits of a scientist without a fundamental

understanding of the science.

> *Stardusky: People are just people and I don't, I don't, ahm, have any doubts that Bryan is unique as a person and I wouldn't expect that all community college students have the same issues that this particular student had. I'd be very willing to consider taking another community college student into my lab next summer. I actually learned a lot from this experience. We learn best sometimes when things don't go perfectly. I learned a lot about how things are functioning in my lab and how a new student, how that affects the functionality of the lab.*

Bryan's academic self-concept was not dramatically altered through his URE

participation. Recall that Bryan had participated in an out-of-state academic internship in

the summer prior to this study. He had already gained substantial familiarity with the

institutional milieu of higher education, including residential living and the rigors of

academic coursework. He had been relatively successful in both the coursework he

attempted at the community college and the coursework he undertook during the

academic summer internship. Prior to his URE participation, he had already acquired the habits of an academic. His science URE participation reinforced his commitment to his previously formulated academic aspirations. An excerpt from his final interview:

> *Bryan: It* [URE participation] *hasn't really affected my plans to continue my undergraduate education, because I already had plans for my undergraduate education. I was already going to Vassar College; I'm still going to Vassar College.*

During his final interview, Bryan discussed his professional goals, which included attaining an MD/PhD in psychiatry. After medical school, he hoped to join a private group of practitioners and had planned to establish research affiliations with a hospital. One year later, in a telephone interview, Bryan reported that his professional goals are unclear. The college coursework he recently completed as a transfer student at Vassar College included: Latin, Philosophy of Mind, Philosophy of Science, Neo-Confucianism Buddhism, General Chemistry, Fencing and Tennis.

Separation: Catherine, Andrea and Joshua

Catherine. Catherine participated in a science URE dyad. She had no lab colleagues; her daily social interactions were those that occurred between herself and her research mentor, Dr. Mosconi. Catherine reported positive gains in her research skills and perceived that she had made positive research contributions, which increased productivity in her assigned laboratory. Her research mentor did not report similar gains in laboratory productivity. Catherine's acculturation outcome is best characterized as separation.

> *Catherine: Ah, he's said quite a few times how he's glad that I'm here because he has a lot of research going on. And he doesn't have a grant going on right now, so a lot of research, a lot of data is being collected. If this was, maybe if this was a job and I was getting paid, you know, if this was just going to be a job for a year or something I don't know but I …I, I don't feel like I'm doing any less because I'm not getting paid by him.*

> *Mosconi: So I just learned ok, check up on her every couple of minutes. And make sure things are moving along. Because she would get it wrong, she would do the wrong thing. I mean, ahm, I, you know, it didn't, it didn't ever get to the point where I was throwing my hands in the air and screaming or anything like that, but it was something I learned. She's not good at, at just instantaneously ahm, absorbing and holding onto this whole routine. And partly it could be because all the elements of what she was doing were brand new stuff, even though they seem probably seem simple to me. Ahm, it probably all seemed at a much more unfamiliar level to her and then to remember the sequence of things. She just didn't seem to get sequences, so she would often omit some essential step. And I think I could say I don't think she is quite up to the ahm, this would be a problem if she goes to get this kind of a job anywhere.*

During the course of her URE, Catherine became very proficient at a limited number of laboratory-specific skills. These skills were not only very specific to the laboratory that she was assigned, but they were skills with well-established protocols, which eliminated opportunities for protocol improvement or innovation.

> *Mosconi: I really regretted actually, that I didn't get a chance to teach her more. I thought that I would have been able to spread her around into a little, a few more niches. But it's just like the summer seemed to go by so fast and there was so much wing measuring to do, and bristle counting and slide making, we never really ahm, progressed that far, in different things that she could have learned to do.*

Due to Catherine's limited negotiation of the initial professional competence priority – gaining familiarity with the learning milieu, she received limited social supports (training and leadership opportunities) from her research mentor. Failure to make significant gains in familiarity with the learning milieu limited her acquisition of vocational habitus. Undoubtedly, for Catherine, the most significant gain in vocational habitus was the realization that her physical handicap did not limit her laboratory stamina or professional performance. This single realization elevated her self-confidence and not only changed her professional or academic self-conceptualization, but fundamentally transformed her core self-view.

It was probably the most surprising that I was walking to work! Which is difficult for me with my foot problems, ahm, but I think that was probably the hardest part… was getting used to acclimating my body to walking and probably standing a little bit more, but he's [research mentor] very accommodating… Before doing the internship I was apprehensive of the work world having been through some surgeries of the foot and being anxious of my physical stamina. After the internship I realized how much I enjoyed being in an environment where the thought process was employed all the time and the seeking of knowledge was such an everyday occurrence.

Catherine experienced minimal acculturative stress with her URE participation. She had no student research colleagues who might have provided a more competitive or collaborative social climate. The social climate was entirely shaped by the interactions between the dyad members. Dr. Mosconi directed his laboratory using unilateral leadership. His training emphasis utilized limited formal, discrete activities. Therefore, Catherine made no substantial gains in autonomy as a novice researcher. Her reliance on his mentorship was a function of his leadership and his training emphasis. The social dynamic that existed in this dyad is characterized by this excerpt from the final interview with Dr. Mosconi.

***Mosconi**: I miss having her around now. It's been like a big letdown since she left, because it was always, ah, somebody there, who was always interested in all this stuff that was going on. And this summer, she was the only person here, besides myself. And ahm, you know, you can imagine there'd be so many people who would just not form any kind of comfortable fit, in this lab. But that wasn't true of her, it just seemed like it really clicked with her. And she said when she left, she said, "I really had a good time". You know, I know she did, it didn't surprise me that she said that.*

Catherine, like most of the student participants in this study, had academic aspirations strongly connected to her professional goals. Prior to her URE participation, Catherine had completed almost all the coursework necessary to obtain an Associate's Degree in Applied Sciences from her local community college. She lacked a single

course to graduate, and had made tentative plans to complete this last requirement in the fall semester following the summer internship. Catherine's academic aspirations were clearly focused on transfer to a four-year institution and completion of a Bachelor's Degree. She was, however, undecided in her choice of an academic program. Her previous experience as owner/operator of a small specialty catering service had provided some decisional influence toward a food science/nutrition undergraduate degree program. During her URE, Catherine discovered that she enjoyed and was technically adept at microscopy. Coupled with her new self-confidence that her physical handicap would impose no limits on her academic or professional goals, she transferred to a four-year institution last spring. She successfully completed her first semester in an academic program in Microscopy and Cytology. Her URE participation clarified her academic aspirations.

Catherine's future educational goals seem to be more tenuous than her professional goals. In her very first interview, she expressed a desire to continue her education. During the summer internship, although Dr. Mosconi provided social support for Catherine's undergraduate educational aspirations, he did not offer support for her graduate school ambitions. Once again, a comparison between the perspectives of these two dyad members is revelatory.

> *Mosconi: Because with her it's like the question's still whether she should complete a ahm, a, bachelor's degree. But I did, we did talk about the uses or lack thereof - of a bachelor's degree with a major in biology. And ahm, we had discussions that were appropriate to the point she's at, in her thinking about what her possibilities are. I think... I don't think she's ever going to go and get a master's degree. I think that's very unlikely. But it's possible that she might get a bachelor's degree. And we did discuss that.*

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Catherine: I would be interested in graduate school. I keep thinking, if I won the Megabucks, I'd just go to school. I wouldn't have any desire to go on any trips or anything. I would just want to go to school.

It seems apparent, that frank discussions regarding academic aspirations did not occur between these dyad members. However, this was also true, to a greater or lesser extent, in each of the mentor-mentee pairings of this study. Over eight hundred transcript references were coded during the data analysis phase of this study and only a single reference was made to academic guidance provided during the URE internship. The community college students in this study attended two-year institutions where the academic counselor-to-student ratio is approximately 1/1500. A ratio, that is currently, not all that uncommon at most U.S. community colleges (Rosenbaum, 2007). Recommendations for increased efforts in academic counseling during science UREs are detailed in the final chapter of this dissertation.

Andrea. Andrea reported positive benefits from her URE participation. She perceived that she had made significant gains in her laboratory skills, and that her contributions to the research efforts of her assigned laboratory were substantial. Her laboratory colleagues and research director did not share her perspective. The organizational structure in her assigned laboratory was hierarchical, with unilateral leadership. A telling indication of the subtle perpetuation of the hierarchical organization in this laboratory was the fact that Andrea rarely referred to laboratory personnel in her electronic postings without a reference to their academic status. In this research setting, her individual status was the lowest of all laboratory personnel. Although there was another undergraduate working in this laboratory, her status was greater than Andrea's, based on her more advanced academic rank (senior) and the research progress she had

already made on her capstone project. Andrea's acculturation outcome, then, is best

characterized as separation. She was perceived as separate from the established

laboratory community. During the course of the internship, Andrea's social acceptance

was advanced by gains she made in professional competence, but she did not become

integrated into the established laboratory community.

> *Andrea: Tomorrow I plan to go in early once again and Dugan is going to set me up with my own account on the ECG recording computer so that I can re-teach Tracey (PhD Student) on how to do injections. [Lab colleague] says that I should teach her as opposed to him since he kept mutilating pupae last week and I seem to have the steady hand for injections. I'm not letting it go to my head or anything but I do appreciate the vote of confidence!*

> *Dugan: Ahm, I think it was a lot for her to, you know, to be figuring out … you know all the things that she needed to do to just kind of survive. You know, her living situation and stuff like that. I mean, you know, to be moving away from home and living with strangers and then having to commute back home over the weekend. And stuff like that, was probably a lot. But she certainly made every effort to figure out how to do all this stuff, you know, there's stuff that she didn't learn right away.*

Prior to her URE participation, Andrea had been accepted into the nursing

program at her local community college. She had applied for and been awarded a full-

tuition scholarship for the academic year that preceded her summer internship. Her

academic aspirations included transfer to a prestigious liberal arts college after

completion of the first year of the nursing program. She dreamed of completing an

undergraduate degree in science, with plans to continue to medical school.

> *Andrea: Well, from what I've heard, in ten years I'm going to be doing an internship at a hospital…after either becoming a general surgeon or something like it. Initially, I had gone back to school to be an RN. That's the program I'm enrolled in right now at the community college, … so I'm planning on being either a general surgeon or a specialized surgeon, so, I' m going to do one more year at the community college then do the exploring transfer program hopefully, that the community college offers, where you get six credits in six weeks at Vassar College. And I'm planning on applying this coming March to [liberal arts college] to get into their pre-medical program, which offers a grant, ahm, for pre-*

medical students that will pretty much pay your way. I talked to them yesterday, and they offer that mostly to first year, and transfer students after, but they told me they don't have early admissions for transfers. I'd really like to go to [liberal arts college] just because I have so much family in [nearby] and it's the name school. And I can get there from my house pretty easily.

Andrea never shared her academic aspirations with her research mentor, nor did she ask for academic guidance from any of her laboratory colleagues. When Dugan learned of her aspirations during the final interview he remarked:

> **Dugan***: …maybe she just didn't think that I knew what I needed to know to help her individually, because I, I'm dealing with four-year college students who come in and say, "You know, I want to be" – whatever… Physician's assistant or a dentist, something like that, and I can say, "OK you're here for four years, you get a four year degree and you'll be able to go into these programs if you do the following. I have no idea how to be able to help bridge the gap for students in her situation. None - whatsoever. I really don't know what her program looks like, or how well it would be valued, as let's say, the first two of four years… by a veterinary school or medical school, no idea at all.*

The dearth of academic counseling dialogues between mentor-mentee pairings was mentioned in the previous section of this chapter. It seems important to note here, that not only student participants, but also research mentors, seemed under-informed and therefore, more hesitant to disseminate academic counseling advice. Again, this was an important participant need that went unmet in this study.

Andrea began the nursing program at her local community college in the fall semester following her URE summer internship. She stopped attending classes after the first three weeks of the semester. She did not return to school in the spring semester. Her current whereabouts are unknown. Clearly, she re-evaluated her professional goals and her academic aspirations after her URE participation, despite having made substantial gains in familiarity with the learning milieu and acquisition of vocational habitus. What prevented "warming" of the social climate in her research setting? That remains unclear.

What is more apparent is that her diminished status in this hierarchical research setting did not change over time. Acculturative stress levels for Andrea equaled or surpassed those experienced by Bryan. Unlike Bryan's her coping mechanisms did not involve absenteeism or abrupt social behavior. Instead it seems she was simply ill-equipped, with coping mechanisms that were insufficient for the task.

Joshua. Joshua reported positive benefits from his URE participation. He perceived that he had made substantial gains in his laboratory technical skills, and that his contributions to the research efforts of his assigned laboratory had been important. He perceived that he had minimally disrupted the hierarchical laboratory structure, and had not perturbed the laboratory social climate. Laboratory personnel perceived his URE participation differently. Joshua's acculturation outcome is best described as separation. He was not fully integrated into the established laboratory community. He was not always treated as an academic or science-process equal, but he did make significant progress in being accepted as a social equal.

> *Joshua: I wouldn't say that l have made major intellectual gains, but I have become more comfortable around the people in my lab and around my [research director]. They are all very "down to earth" people and I like that. The only real difference between me and the people I see in my lab every day is that they went to school for biology and I went to school for something else.*

> *Leslie: He's definitely more independent. He, at the beginning, if anything went wrong, or didn't happen exactly as the protocol or the picture in the protocol said, he would sort of like absolutely not know what to do. And come right up to you and go "what do I do, what do I do?" like it was a big problem and it's not, because nothing ever happens right in science. Now he still comes to you and he's like "This looks different, but I think it's just because of ... he actually has an idea of why it doesn't end up the right way, where before he was kind of like "What did I do wrong, what did I do wrong?"*

His gains in professional competence substantially elevated his own professional and academic self-conceptualizations. In turn, these same gains earned him greater status recognition and esteem from his laboratory colleagues, and this reinforced and regenerated the social supports they provided him. Increased responsibility in the laboratory and in field sample collection provided more opportunities for leadership and for training, which again elevated his status, enhanced his social acceptance and professional competence.

> *Joshua: Yeah I'm definitely more comfortable with what they do here. I mean, the clam project is something that most of it makes sense to me, and I would be able to basically do my own planting and measuring and understanding of what's going on. Some of the more complicated projects, like the yeast project, I don't have a real clear understanding of how I could turn that into my own project. But I'm definitely closer to a point where I could do something like that.*

> *Leslie: I would say he's definitely gotten more confidence. Initially, he kind of came across as very quiet, shy and not really wanting to jump into things, like* [lab colleague] *was saying before. But I mean he's still fairly timid. And you still have to really kind of, you know, push him to do the next step or whatever, to keep going. To reassure him that he's doing the right thing, even though he knows in his mind that he knows how. I think he just feels more comfortable in general in the lab. He's not scared of us.*

As has been previously mentioned, Joshua was the student participant who utilized electronic journaling to the greatest extent. By his own volition, he chronicled his gains in professional competence. He utilized his blog postings and his wiki discussions to analyze the laboratory hierarchical structure and to determine social alliances within the social network. From his wiki postings:

> *I have only talked to her* [Principal Investigator] *briefly and she seemed nice, but didn't seem like she wanted to waste any time. She looks like she is in a hurry constantly. I have heard from the members of the lab that she comes across as cold and short, but she actually is very nice and does take the time to explain things when in a good mood. She invited me on the clamming trip and was joking a little when we were digging in the mud so I can't complain. She does make me a little nervous though. Maybe it's just the level of power she holds over the lab that*

makes me feel that way. I want to impress her with my work ethic, but don't want to be assigned anything I don't know how to do.
Posted Jun 15, 2008 6:30 am

The other day [lab colleagues] were talking about how Leslie doesn't treat the undergrads very well and she tells them to do things they might not really know how to do and she has very little patience with them. I heard that she feels the undergrads should be able to figure it out with minimal instruction. I wonder if this is really how she feels or if it's a technique to make herself feel more intelligent than them.
Posted Aug 4, 2008 2:06 pm

His own internally-driven critical thinking about the established community of his new environment facilitated his *personal understanding* of acculturation. Joshua used electronic reflexivity for his own ends. He negotiated his own cognitive apprenticeship. Gains in understanding his new environment led to gains in understanding changes in himself. From his last blog posting:

[Principal Investigator] told me she would gladly write me any letters of recommendation I might need and she also said I would be more than welcome back into the lab if I ever wanted to come back. I feel like I "networked", but in a way that I prefer. I proved myself through hard work that will be remembered rather than networking with conversation alone. So I am back in school now at [community college] and I can feel a difference in myself. My internship has changed me just enough for me to notice. I feel like my level of understanding of science and my confidence in my ability to learn has increased a great deal.

Joshua successfully completed his final year at his local community college. He applied for and was accepted into a Pre-Pharmacy Ph.D. program. A focus of this academic program is pharmaceutical research and development. He will begin his new academic venture this fall. His URE participation provided him with the self-assurance to pursue more ambitious academic and professional goals.

Integration: Sam and Tabitha

     Sam. Sam reported positive benefits from his URE participation. He perceived

that he had made gains in his research skills and that his contributions to Dr. Sherwood's

research efforts were significant. Dr. Sherwood concurred with Sam's evaluations of his

developmental gains and the importance of the work he accomplished during his summer

internship. Sam was fully integrated into the established community of his assigned

research setting.

> *Sam: Intellectual gains, ah well, they would be along the lines of exploring a new side of science that I normally don't get to explore. I usually stay away from anything biological, so being immersed in that has allowed me to see some new things that I would never see in my degree program. As for advice to other undergrads considering this I would explain to them that , if they...are, if they have problems working on their own with things, then maybe this is not the right place for them. Or at least maybe* [Dr. Sherwood] *isn't the right... person to do it under, because he expects you to do a lot of it on your own. And I think, just from what I've been able to see, most undergrad students need a little bit of guidance. And he, he's treating me a lot more like a grad student, in those regards, than an undergrad. And, he can do that with me.*

> *Sherwood: Sam analyzed video tapes that show how fish graze and mow the seaweed around our coral settlement plates where baby corals live. Sam picked up what I needed very quickly and he analyzed the tapes perfectly. Sam was very mature. I gave him a lab, a computer, video technology and suggested how he should move forward. He and I shuttled data back and forth via the internet, so I was with him even as I was in the field. He performed as well as any graduate student would have.*

     Sam's familiarity with the learning milieu in his research setting was mostly

established prior to the actual start of his URE. From previous life experiences, he had

gained proficiency with video-editing and computer-imaging. His research mentor

provided the initial training for identification of coral reef fish species. Sam's greatest

gains during his URE occurred in acquisition of vocational habitus. Prior to his URE,

Sam had no experience with research science, and no experience with complex biological

systems. As his internship progressed, he gained a new appreciation for research science

and the appeal of biological discovery.

> *Sam: But I think this has really opened my eyes to research science, and what that's all about and what to expect for that, and I think I like that idea a little more than I did before. I always kind of, I kind of go back & forth, straight into engineering or straight into something else? But I think ah, yeah, I'm thinking…I'm thinking research science.*

As his accomplishments accumulated in the realms of familiarity with the

learning milieu and acquisition of vocational habitus, his confidence increased and he

earned the respect and trust of his research mentor. The social climate warmed as he

made gains in social acceptance and professional competence. With greater professional

and social acceptance, Sam was offered more responsibility and more autonomy in the

research setting. His elevated status within the established laboratory community was

secure, which allowed Sam latitude in accepting greater research risks. He undertook his

own independent project with the encouragement and support of Dr. Sherwood.

> *Sam: Sherwood and I are – he gave me a little pet project to work on for myself – and he's agreed to keep in contact with me.*

> *Sam's wife interjects, "He didn't just give you a pet project, he walked in on you working on something and went "OMG, I don't think anyone's doing this, you need to work on this".*

> *Sam: Well yeah, he, it has to do with marine optics, and reef work. And I think we talked about that, he's very supportive of me doing something like that. He said that there's – nobody doing that right now. So actually, I'd be very smart to look into it more. And he asked that I take his, he's got a reef course that he's teaching next spring. And he, he wanted me to take that. They do a trip down to, I think its Bonaire at the end of it. And they dive down there, and he wanted me to go down there, and if I took the course, we could go down, and he said we could come up with some light meters and put them at the bottom of the experiments. So it would be a huge opportunity for me to pursue something like that.*

> *Sherwood: I noticed that Sam was sketching equations on my whiteboard that pursued an offhand comment that I had made about how light scatters on coral reefs. He and I discussed the possibility of pursuing this should he go on to*

graduate school…We discussed graduate school. I think he's getting to see a bit of what the academic life is like.

Sam earned his status as a cognitive apprentice. He utilized previous technical skills in a novel application in his URE laboratory. He was responsible for trouble-shooting technical malfunctions, systematic data capture, and data interpretation. His critical observation skills identified a novel anomaly in the video footage which he pursued on his own, using an experimental approach. His professional self-concept was altered during his URE. His professional identity shifted to include research scientist. He began to consider more ambitious academic and professional goals that incorporated research science.

> **Sam***: It* [URE participation] *has affected mostly, more the plans for my graduate work. Because, I was leaning more towards the engineering side of my degree and this kind of made me think that I might like to go more into research science.*

Sam will graduate next spring with an undergraduate degree in mechanical engineering. He and his family will be travelling to Scotland, where he has been offered a full tuition scholarship to pursue graduate studies in marine engineering. A significant factor in his graduate school scholarship offer was the proposal he submitted for coral reef marine optics, the corollary research project that he had begun during his URE. These research efforts will be one aspect of a more extensive collaborative project, coordinated by his new research mentor.

> **Tabitha.** *I think that I will always be able to look back on my URE and be glad that I was given such an amazing opportunity that my other friends in non-community colleges wished they could have had.*

Tabitha reported positive benefits from her URE participation. She was the only student who participated in an established research community that was characterized as egalitarian. In her laboratory there was an emphasis on multilateral leadership. The

training emphasis was formal/structured and sequenced. Her two laboratory colleagues were both undergraduates and were both "rising" freshmen, like Tabitha. Daily group meetings occurred in this laboratory every morning and, frequently, a second meeting was held before everyone left for the day. Tabitha and her lab colleagues made an oral presentation on their work and the previous work of their research mentor, Dr. Cook, at approximately the midpoint of the internship. During the final week of the internship, the laboratory group presented a poster of their experimental results at a regional science conference for undergraduate researchers. Tabitha reported substantial gains from her URE participation, and perceived that she had made a substantial contribution to the research efforts of the Dr. Cook's laboratory. Dr. Cook affirmed Tabitha's assessment of the developmental gains she had made and the positive contributions she had made to the laboratory. Tabitha was fully integrated into the established research community of her URE laboratory.

> *Tabitha: I must say that working in the lab itself has most definitely broadened my knowledge in the area of science and what sort of tools, etc. are used in science research. I have learned how to properly run different types of equipment; all different sizes of centrifuges, the autoclave, the laminar flow hood, the Vispec, the Flow Cytometry machine and the Bioanalyzer. And now I know how to set a pipettor…I have also learned a lot about P. gingivalis and before this summer I would not have known that it was one of the bacteria that causes Periodontal D and how else it affects the body causing a systemic reaction contributing to low birth weight babies, cardiovascular disease, etc.*

> *Dr. Cook: Out of the three undergraduate students this summer, Tabitha is the one who was never satisfied just learning how to do something, she was always insistent that she understand how and why some technique or protocol worked. She also had the most forceful personality in the group. She truly was their leader when the situation called for leadership.*

Tabitha and her lab colleagues made gains in professional competence during the summer internship. Tabitha was initially at a disadvantage, since both her lab

colleagues had worked together the summer before in the same laboratory, as part of
an eight-week introductory program for incoming freshman. However, she quickly
attained their level of competence in most basic laboratory techniques. (Neither of her
undergraduate colleagues had done laboratory work during the academic school
year.) Tabitha also gained vocational habitus during her URE, through the training
sessions and daily discussion sessions that Dr. Cook required.

Tabitha: I really do like talking to Angela (she doesn't mind if we call her by her first name) she has seen and done a lot in her life and I think she has tons of knowledge to pass on. Even if she isn't necessarily talking about anything we are working on I still like to converse with her…she makes jokes sometimes. Lol. She is just a very sweet/cool individual. I think another reason why I like her so much is the fact that she is very patient or at least that is how her demeanor is. I know that some people would not have been as patient with us and although she has been doing this type of work for years she still understands that we haven't and that we are learning so she tries to explain every process to us even if it is something that she could do in her sleep.

Tabitha came to realize that experimental science often provides ambiguous, or
worse, contradictory results and she came to realize that, while science is often slow,
meaningful reproducible results cannot be rushed.

Tabitha: If I could change one thing about this summer, I think I would change how finicky science was lol. How some days you get the answers you are looking for and some days you are left asking what went wrong, cause you did everything exactly the same…It has been a really enjoyable time learning and meeting new people. But I don't know with less than 2 weeks to go, if it will be enough time to finish up the research that we are doing. And that is due to the fact that science can be very touchy.

Tabitha and her lab colleagues became cognitive apprentices. They collaborated
on the design of an experimental project. They selected their research model, and
matched   appropriate laboratory techniques to an initial research question. They learned
to eliminate variables one at a time when trouble-shooting. Toward the end of their
internship, they had the opportunity to communicate their experimental results to a group

of their intellectual peers. All this was accomplished as a collaborative team. There was

never any indication of competition between lab colleagues. Tabitha, in this new

environment, experienced minimal acculturative stress.

> *Tabitha: Having Angela as my mentor was excellent. She was a perfect match. She was not stressful and that allowed me to have fun with what I was doing instead of wishing and hoping the 8 weeks was over. I also enjoyed that she would teach us stuff at the beginning of a new procedure, but that it was just* [lab colleagues] *and I working in the lab that made it more fun and less stressful. Just a few days ago* [lab colleague] *mentioned that she was glad all of us were nice and not mean to each other, and I agree. It has made this whole experience a lot better to go into the lab knowing that I will have a great day hanging out and doing research with two really great, friendly people.*

Tabitha had initially started at a local community college, with aspirations to

become a dental hygienist. She completed her first year of college coursework, and had

been placed on the candidate waiting list for the Dental Hygiene Program just prior to her

URE experience. Based on her first and second semester grades, she made the Dean's

List of Academic Achievement. However, her long-term future academic and

professional goals were unclear.

> *Tabitha: But, after those 8 weeks at [institution name], I feel like maybe pursuing a graduate degree is something I should look more seriously at. I never in a million years would have pictured myself doing summer research or research in general, but I did and I really enjoyed it. I saw that it does take a lot of hard work, but the fulfillment of learning something and others telling how good you did is sooo worth it. Having Angela and other professors tell you how impressed and proud of you they are makes all the hard work and stressing worth it. I had never pictured myself doing research. I didn't believe that I could do it, but I did it!! And I am so glad that I didn't pass up such an amazing experience. If the door and the possibility of me going to dental school made itself present I think I should definitely go for it. I know I believe in myself that much more when it comes to doing things that I have never done, things that look impossible and that's all because of one experience. So why not take on another endeavor that I would never have pictured myself doing-Dental School.*

Tabitha's professional and academic self-view were changed through her URE

participation. She gained self-assurance, and became more confident in selecting more

ambitious professional and academic goals. Tabitha was accepted into the Dental

Hygiene program at a local college last fall. She finished at the top of her class. This

summer, she has worked as a summer intern in a local dental clinic. She was a teaching

assistant for an introductory college microbiology course this summer. She will complete

her Associate's degree in Dental Hygiene this coming spring. She has made plans to

transfer to an institution that offers an undergraduate transfer degree program for Dental

Hygiene. She has already begun studying for the Dental Admission Test. When asked

how she thought she had changed, she answered:

> *Tabitha: I find that I ask more questions…I always have asked a lot of questions, but sometimes I used to feel that the questions were dumb or just really obvious. But Professor Cook stressed to me this summer that no question is dumb and that one can really only learn, if they are continually asking questions. Questions show people that you are curious and interested in what you are learning…and that can only be a good thing…I also believe that I will go into this school year not just hoping, but knowing that I can do it and I will get through it and learn and have fun with it…research was fun and it was learning…so I am hoping to apply that same outlook to my school year.*

Summary

The findings from the third research question indicate that, for non-traditional students,

URE participation may have a pivotal influence on academic persistence and professional

aspirations. For one-half of the students in this study, URE participation motivated

students to reconstruct their current academic aspirations, replacing them with more

ambitious goals. And for two students in this study, Bryan and Andrea, URE participation

resulted in significant re-evaluation of their professional goals. Seemingly, for the

participants in this study, two highly significant factors related to aspirational

modifications were acculturation outcomes and acculturative stress. Recall, from the

previous findings chapter, that factors important in the determination of students'

acculturation outcomes were the levels of social acceptance each newcomer achieved in

his or her established research community. And as contemplated in this findings chapter,

progressive transitions to professional competence also contributed to acculturation

outcomes. These factors are represented for each URE participant in Table 5.4.

Table 5.4

Factors Associated with URE Participation that Influence Non-Traditional Students'

Academic and Professional Goals

Student	Social Status	Professional Status	Acculturation Outcome	Stress	Academic and Professional Goals
Bryan	Alienation	Inadequacy	Marginalized	High	Re-evaluation
Andrea	Alienation	Competency	Separation	High	Re-evaluation
Catherine	Acceptance	Inadequacy	Separation	Low	Undergraduate Degree Program
Joshua	Acceptance	Inadequacy	Separation	Low	Graduate Degree Program
Sam	Acceptance	Competency	Integration	Low	Graduate Program
Tabitha	Acceptance	Competency	Integration	Low	Graduate Program

From the organization of this table, it seems clear that the gains made in the social

environment and gains made in professional status determine acculturation outcomes.

Student participants' gains in professional status, categorized in the table as either

professional inadequacy or professional competency, are made as students progress along

a continuum from gains in familiarity with the learning milieu to gains made in

acquisition of vocational habitus to induction to cognitive apprenticeships. In the table,

characterization of professional status gains as inadequate are based on students who

attained only minimal gains in familiarity with the learning environment, with few gains in vocational habitus.

The two students, characterized as inadequate in professional status during this study, were Catherine and Bryan. It is important to note that Bryan did not gain social acceptance within his assigned research community, while Catherine did within hers. Bryan was marginalized as a URE participant, and during his internship experienced elevated levels of acculturative stress. Bryan's elevated acculturative stress levels materialized as abruptness in his social interactions in the laboratory and in his excessive absenteeism throughout the duration of the internship. Bryan seemingly did not have adequate coping strategies to reduce his levels of stress. This does not suggest that his reactions should be trivialized, but only highlights that, more than any other factor represented in Table 5.2, perception and management of acculturative stress are individually variable. Together, Bryan's acculturation experience and associated levels of acculturative stress, contributed to his re-evaluation of his professional aspirations one year after his URE participation. It remains to be seen whether Bryan will re-evaluate his academic goals, as well. It would appear from his recent course work that he is not currently on schedule to submit applications to medical schools.

The second student who also experienced elevated levels of acculturative stress during her URE internship was Andrea. Despite her social alienation from the established research community, Andrea made substantial gains in her acquisition of vocational habitus. Therefore, her acculturation outcome is characterized as separation. Like Bryan, she too, had inadequate coping strategies, which prevented a reduction in her elevated acculturative stress levels. Shortly after her URE participation was completed, Andrea

dramatically altered her academic and professional goals. Although she returned to her local community college to begin the fall semester as a first year nursing student, she did not complete the fall semester and did not return to the community college for the spring semester.

Certainly, the number of participants in this study was extremely small, however, the re-evaluation outcomes that ensued from URE participation for two of the six participants (Bryan and Andrea), must be considered in the assessment of this study's findings. Both a marginalization outcome coupled with elevated acculturative stress and a separation outcome coupled with elevated acculturative stress resulted in a non-traditional student's re-evaluation of academic and professional goals. However, comparing the results represented in Table 5.2, it appears that both Andrea and Joshua have similar patterns of social acceptance and professional competence, and both experienced separation as an acculturation outcome of URE participation. Joshua, in contrast to Andrea, did not experience acculturative stress during his URE internship. In fact, these two participants experienced very different professional and academic participation outcomes. Joshua has reconstructed his academic and professional goals. One year after his URE internship, he has chosen more ambitious academic goals, including a graduate degree in science. Andrea is no longer attending school. For now, no further interpretations can be made regarding which of the two acculturation factors might have had greater primacy in re-evaluation decisions, acculturation outcomes or acculturative stress.

A single student participant in this study was characterized with an outcome of resolution of professional and academic goals. For Catherine, URE participation

crystallized her commitment to an undergraduate degree that capitalized on skills she developed during her URE participation. Her acculturative stress was characterized as low during her summer internship. At least one environmental factor that may have contributed to Catherine's reduced acculturative stress levels was the fact that she had no lab colleagues to interact with during her internship. As has already been suggested, Catherine's resolution to her newly clarified academic goals may also be attributed to a personal factor – her elevated self-confidence. Catherine experienced substantial gains in self-confidence based on the realization that her physical handicaps were not impediments to her performance in an academic research laboratory. Based on the small numbers of non-traditional students in this study, it remains to be seen whether significant gains in self-esteem frequently result in academic and professional goal clarification for non-traditional science students. However, recently published qualitative research directed at evaluating the benefits of science UREs for a more traditional student population has reported goal clarification as the most common outcome for modifications in students' academic and professional goals (Seymour, et al., 2004; Hunter, et al., 2007).

Remarkably, half of the non-traditional students in this study reconstructed their academic and career goals after URE participation. Each of these participants selected more ambitious academic goals which included definitive commitments to graduate degree programs in science. For one participant, those plans include a shift to research-based science from previous academic plans that focused on applied sciences. Returning to Table 5.2, a discernable pattern emerged from the characterization of these three participants' gains in social acceptance, professional competence and acculturative stress levels. Most obvious are the identical characterization patterns seen between the

participation outcomes for Sam and Tabitha. Both participants gained social acceptance from their established research communities. These two non-traditional students negotiated substantial gains along the professional competence continuum, transitioning from gains in familiarity with the learning milieu to gains in acquisition of vocational habitus, and culminated in their induction to cognitive apprenticeships. Their acculturation outcomes were identical – they were both fully integrated into their respective established research communities. Sam and Tabitha both experienced minimal acculturative stress during their summer internships. Based on these findings, the following tentative interpretations can be made, for non-traditional students in this study:

- Social acceptance and substantial gains in professional competence led to full integration as an acculturation outcome.

- Integration reduced acculturative stress during science URE participation.

- Positive reconstruction of academic and professional goals in the months that followed URE participation, for these two students, resulted in steadfast commitments to science graduate degree programs.

Lastly, characteristic patterns that emerged in participation outcomes for Joshua are described. Joshua made substantial gains in social acceptance from the laboratory personnel in his assigned research setting. His gains in professional competence certainly included important gains in familiarity with the learning milieu; however, he made only modest gains in acquisition of vocational habitus. In his research setting, these modest gains were perceived by his laboratory director and laboratory colleagues as admirable, but still insufficient. His acculturative stress, by his own report and by researcher observation, was minimal during his summer internship. His pattern of participation

outcomes is identical to Catherine's, and yet their modifications in academic and professional goal commitments are noticeably different. Joshua selected more ambitious goals, including a commitment to a graduate science degree program, while Catherine's goals remained resolutely focused on commitment to an undergraduate science degree program.

No doubt there are multiple explanations for these differences, but one factor that was noticeably different between these two non-traditional students' approaches to directing their own personal gains in professional competence was Joshua's utilization of electronic reflexivity. As has already mentioned, Joshua was prolific in both his electronic journaling and his posts to the electronic discussion board. In contrast, Catherine was the most infrequent user of electronic journaling compared to the other student participants. But comparing these students' utilization of electronic journaling certainly requires more than a cursory examination of their frequency postings. Joshua certainly utilized electronic reflexivity to more deeply understand the social dynamics of his laboratory community, however, compared to Catherine, Joshua was able to make substantial gains in "virtual" acquisition of vocational habitus *through* electronic reflexivity. The participant who remained resolute in her previously determined academic and professional goals gained little in the acquisition of vocational habitus, either in the laboratory or with electronic reflexivity. The other participant selected more ambitious academic and professional goals, having made moderate gains in vocational habitus, some of which were gained through electronic reflexivity.

A final observation related to electronic reflexivity patterns emerged when comparisons were made between the two participants who utilized electronic reflexivity to the greatest extent – Andrea and Joshua. Both students had separation as their URE acculturation outcome; however, their patterns of social acceptance and professional competence were opposite. Andrea was socially alienated, while Joshua gained social acceptance. Andrea made substantial gains in vocational habitus, while Joshua acquired only moderate gains. Interestingly, Joshua utilized electronic journaling to bolster his gains in vocational habitus, which Andrea did, as well. A majority of her electronic journal entries (fourteen of eighteen) and her electronic discussion board postings (twelve of sixteen) referenced aspects of laboratory science. Significantly fewer references were made to laboratory social dynamics. The possibility exists that, had she explored the social dynamics of the laboratory environment with her fellow participants, she might have come to better understand them. A plausible interpretation suggests this might have been a strategy she could have employed to reduce acculturative stress and to negotiate greater gains in social acceptance. Specific recommendations for electronic journaling for non-traditional students' during science UREs are included in the next chapter.

Chapter 6

CONCLUSIONS AND IMPLICATIONS

The core idea in situated learning is that learning is inherently social in nature. The nature of the interactions among learners, the tools they use within these interactions, the activity itself, and the social context in which the activity takes place shape learning. (Hansman, 2006, p. 45)

<u>Introduction</u>

In this introductory section of the chapter, the design of this study will be briefly reviewed. The participant groups and the methodologies are detailed. Next the potential significance of this study is outlined, highlighting the novel design elements that were incorporated. Comparisons between this study's conclusions and conclusions presented in other relevant and recently-published journals are discussed. Limitations to this study are detailed next. Described in the final section of the introduction are the design elements that were included to strengthen the credibility of this study's findings.

The purpose of this study was to examine the efficacy of the traditional undergraduate research model for a non-traditional student population. The broader research question for this study was: In what ways were undergraduate research experiences (UREs) effective in promoting positive attitudes about graduate science study, while increasing academic aspirations and professional goals in the sciences for non-traditional students? More specifically, the three research questions explored in this study were:

1. In what ways does the organizational structure of an academic research laboratory influence acculturation for non-traditional URE participants?

2. In what ways does the social climate of an academic research laboratory influence acculturation for non-traditional URE participants?

3. In what ways does a traditional URE in science influence non-traditional students' attitudes and behaviors regarding academic goals and professional aspirations?

Design of the Study - Reviewed

Participants

Six non-traditional students from two community colleges in the MCC system were recruited for participation in this study. There were three men and three women who collectively, reflected the demographic diversity present in the Maine community college student population. In addition, six academic researchers were recruited as co-participants in this study. Their research laboratories were located throughout the state of Maine. Four of the six research laboratories had additional laboratory personnel that included undergraduate students, graduate students and post-doctoral students. Two of the research groups during the summer of 2008 were comprised of only the research mentor and the community college participant.

Methodologies

During the course of the summer internship, all participant groups were interviewed. The interview protocol followed in this study for all interview sessions involved semi-structured questions that were formulated prior to the interview. Student participants were interviewed more frequently than other participant groups. Three interviews were conducted and a single laboratory/field observation was made of student participants. The interview sessions were recorded on audiotape and transcribed verbatim. During the course of the internship, students were also asked to record their thoughts and reflections of their URE experiences in electronic journals (personal blog

sites) and to post questions, comments and suggestions from their laboratory experiences

to an electronic discussion board (wikispace). All collected textual data were categorized

using ®™NVivo 8. Interpretive patterns that emerged during this analytical phase of the

study led to the adaptation of an acculturation model widely applied in cross-cultural

psychology studies of refugee populations (Berry, 1990, 1997; Williams & Berry; 1991).

Potential Significance of the Study

The results from this study will be informative to both traditional and non-

traditional undergraduate students who are considering participation in institutionally-

sponsored science research activities. Undergraduate and graduate science faculty and

administrators will find the results from the study instructive when evaluating current and

proposed undergraduate research programming. Administrators and policymakers

affiliated with federal and local science research agencies will find the conclusions

reached in this study useful when decisions for resource allocations are requested.

Finally, other qualitative and quantitative researchers interested in pursuing science URE

investigations may find the conclusions reached in this study encourage new and future

directions for prospective research.

Contributions made by this study can be divided into two categories: novelty

incorporated in the design of the study and findings that confirmed or challenged the

results of the current published literature.

Novelty Incorporated in the Design of the Study

In total, five novel elements were incorporated in the design of this study. A new

student population was provided access to a traditional model of undergraduate science

research experiences. A comprehensive review of the science URE literature did not

return any studies focused solely on this population of participants. Secondly, the inclusion of peer colleagues' perspectives in this study was deemed unique, and necessary for the research questions crafted for this study. The influence their actions and perspectives had on shaping the social dynamics in the research setting had not been previously explored. In the recent literature review conducted prior to this study, no examples of research efforts incorporating field observations of URE participants could be identified. Other URE researchers to date have relied on surveys, interviews and focus groups to collect data. It was considered important, for the credibility of this study, to include at least one field observation of non-traditional students at work in their laboratories. The intent was to corroborate or to refute the reported perspectives of the other participant groups in this study. Granted, a single field observation is not necessarily optimal to triangulate other data sources, but it appears to have been at least sufficient, when compared to previously published studies. Another novel design methodology included in this study was the utilization of electronic reflexivity by the student participants. It would seem that, for those participants who regularly reflected on the laboratory social dynamics and their own progression to professional competence, positive participation outcomes resulted. The adaptation of an acculturation model (Berry, 1990, 1997) currently used in cross-cultural psychology was the final innovative element added to this study's design.

Conclusions that Confirmed or Challenged the Results of Previous Studies

Non-traditional students in this study reported positive benefits from URE participation. For four of the six student participants, their URE experiences either reaffirmed existing academic and career plans or led to new commitments for more

ambitious academic and professional goals. This has been the most common participation outcome reported by traditional undergraduates in the published literature reviewed (Amoussou & Cashman, 2006; Bauer & Bennett, 2003; Franz, et al., 2006; Hathaway, et al., 2002; Hunter, et al., 2006; Hurtado, et al., 2009; Kardash, 2000; Lopatto, 2003, 2004).

However, two of the six non-traditional students in this study altered or re-evaluated their academic and/or professional goals in the ten months following their summer internship.   Both, Seymour, *et al*. (2004) and Lopatto (2001) reported only a 5% change in academic and/or professional goals for the more than one thousand upper-class undergraduate URE participants they surveyed. Seymour, *et al.,* (2004) suggested these decisions be viewed as positive outcomes for the students, because URE participation had assisted them in academic and professional goal clarification. Certainly, students should question early academic and career choices, especially decisions made without previous vocational experiences. What remains unclear is whether the *students* in either study, or for that matter, in this study, ultimately viewed these results as positive outcomes of URE participation.

Limitations of the Study

Small Sample Size

A significant consideration, when scrutinizing the authenticity of qualitative studies, including this one, is the limited number of participants (Bloomberg & Volpe, 2008). The deeper understandings provided by a small number of individuals located in a specific place and time must be contrasted with the issues of transferability evoked by qualitative studies. In this study, care has been taken to provide detailed descriptions of

all participants. Supportive primary testimony has been included whenever possible, to increase the reader's confidence in the researcher's interpretations. Although the student participants in this study comprised a sample of convenience (for reasons described in Chapter 3), it should be noted that, by some measures, this study's student-participant population might better be characterized as a criterion-based sample (Bloomberg & Volpe, 2008). Participants in this study were currently enrolled in, or had recently completed two or more semesters of coursework at, a community college in the MCCS. Among requirements for participation was interest in a science degree program and future educational aspirations that included an undergraduate degree in a science-related major. Therefore, these criteria ensure this study has greater credibility than one based strictly on convenience sampling. Nevertheless, any student meeting these minimal criteria was offered the opportunity to participate. Serendipitously, a great deal of demographic variation existed amongst the student participants. Demographic variation in the participant sample reflected the diversity of the larger community college student population. However, a significant demographic sub-group not represented in this study was single parents. In community colleges across America, 17% of enrolled students are single parents. In fact, one single-parent student participant was recruited for this study, but none of the participating research mentors offered her an internship. In this study, multiple perspectives were represented, but certainly, not all perspectives.

Omission of a Pilot Study

Another limitation to this research was the absence of a pilot study. For purely logistical reasons, a pilot study was not possible prior to the initiation of the current investigation. The time and resources necessary to re-locate the six student participants

prior to their summer internship could not be invested by either the participants or the researcher until just prior to the beginning of the study. Instead, interview questions for all participants and the lab colleague survey were composed from similar, recently published, peer-reviewed quantitative and qualitative studies of UREs.

Researcher-Participant Status Differences

Finally, in this study, the existing power differential between the student participants and the thesis- researcher was neither overlooked nor forgotten. In interactions between the two, constant attention was devoted to recognizing and minimizing this power disparity. Similarly, in interactions between the researcher and research mentors this power disparity also existed. In the reflexivity journal maintained during the study, the researcher took care to note instances when the power differential might have influenced either these interactions or the interpretations of them. Excerpts from this journal are included in Appendix R.

Design Elements Intended to Enhance the Study's Credibility, Dependability and Transferability

This section of the chapter describes the measures taken to strengthen this study's credibility. Incorporated into the study's design is triangulation of both data sources and data methodologies. Triangulation of data sources includes the six individual participants -- the cases in this case study. Their individual perspectives were compared and contrasted across four different institutional locations. Their perspectives were confirmed or re-represented by their research mentors and lab colleagues. Triangulation of data methodologies in this study included interviews of all participants, a single field observation, electronic journals, electronic discussion boards, participant artifacts and a

demographic survey administered to all lab colleagues. Repeated and prolonged involvement with the student participants occurred during the course of this ten-week study. A researcher journal was kept to reflect on issues that surfaced before and during this study and after its completion. After the student participant interviews had been transcribed, each student was provided with an opportunity to read and provide comments on his or her transcripts.

The interpretations of this study have enhanced dependability because of the efforts of the external evaluator, who compared researcher-assigned analytical coding categories and coding frequencies with the data sources. The transferability of the conclusions, which are presented in the next section, should be based on the rich and detailed descriptions provided for each participant and extracted from each textual data source.

Conclusions

In this section of the chapter, this study's broader conclusions will be described, including the modifications made to the traditional URE model for this study. This is followed by comparisons of student reported URE benefits described by undergraduate participants in previous published studies, to the benefits reported by participants in this study. Conclusions related to the importance of laboratory organizational structure for student acculturation outcomes are detailed in the next section. Conclusions regarding hierarchically-structured and egalitarian-structured laboratories are discussed. In a similar manner, the next section will describe the conclusions reached for Research Question Two, relating laboratory social structures to participant acculturation outcomes. Conclusions regarding leadership strategies and laboratory training methods are included.

Next, conclusions related to the final research question, acculturation outcomes of URE participation for this novel student population are outlined. For student participants in this study, these outcomes included: marginalization, separation, and integration. The implications of this study's conclusions for URE programming directors and mentors, as well as, agency administrators and policy-makers are presented in the final sections.

Adaptation of the Traditional URE Model

Perhaps it seems unnecessary to call attention to the more obvious general conclusions of this study; however, a cursory mention of them here establishes the foundation for the more specific conclusions that follow. The traditional URE model was successfully adapted to include non-traditional students from community colleges in Maine. Minimal modifications were necessary to permit non-traditional students' inclusion in traditional URE programming. Modifications for student participants included:

- Flexible weekly/daily work schedules

- Off-campus housing

- Proximity to home locale

- Single non-traditional URE student per laboratory

- Non-selective/non-competitive participation

- Freshman and sophomores were target group

- Electronic reflexivity required

Comparisons of the Reported Benefits of URE Participation by Non-Traditional

Students and Traditional Undergraduates

Non-traditional students in this study reported positive benefits and developmental gains from their URE participation. Those benefits reported by non-traditional students did not differ significantly from those reported by traditional students, except that a greater percentage of non-traditional students chose more ambitious academic aspirations and   professional goals after their URE participation. A more comprehensive comparison of benefits and gains reported between the two student groups is presented in Table 6.1.

A compilation of reported results from two recently published qualitative and quantitative studies (Lopatto, 2004; Seymour, 2004) was used to represent the traditional student population. Table 6.1 represents a total number of 1190 traditional student responses collected by survey or interviews. The majority of traditional respondents were Caucasian males, who were juniors or seniors. Regrettably, the only other qualitative study published in the last ten years and focused on the reported benefits of URE participation by an under-represented student population, did not include numeric data of any kind (Hurtado, et al., 2009). So, although comparisons of reported benefits between traditional and non-traditional participant groups was deemed necessary at this juncture in these summative remarks, no other data are available (except from this study) to compile for non-traditional statistics. For comparison purposes, the descriptors most (100% - 75%), some (74% - 25%) and few (0 – 24%) are the quartile percentage ranges.

Returning to Table 6.1, what was notable in this comparison was the similarity in reported benefits between the two student populations. Similar to the non-traditional

student's responses, most traditional students reported gains in science-related skills, referred to in this study as gains in familiarity with the learning milieu. Some students in both populations reported gains in acquisition of vocational habitus and again, only some students reported acquisition of higher-level cognitive skills.

Several other important observations can be made from the data represented in Table 6.1. Few students have gained experience evaluating peer-reviewed journal articles during their URE participation; only some students reported the development of positive relations with their peer colleagues and mentors, and for only some, URE participation elevated self-esteem. Of course, for all of these variables, what is not known is whether these parameters were already internalized prior to URE participation. If so, students are not likely to have reported previously acquired skills or characteristics as gains or benefits *from* URE participation. More importantly, the lack of comprehensive data on the benefits associated with URE participation for either traditional or non-traditional students is obvious, and certainly suggests that additional investigations are necessary.

Table 6.1

Reported and Observed Benefits of URE Participation for Non-Traditional Students

Compared to Benefits Reported by Traditional Students

Status Negotiations:	Reported and Observed Benefits:	Non-Traditional URE Participants[a] (N= 6)	Traditional URE Participants (N = 1190)
Familiarity with the Learning Milieu	Competence in Laboratory Techniques and Skills	Most	Most
	Familiarity with Research-Specific Instruments and Equipment	Most	Most
Acquisition of Vocational habitus	Understanding the Research Process/Experimental Design	Some	Some
	Tolerance of Ambiguity	Some	Some
	Perseverance/Diligence	Some	Some
	Acceptance of Routine and Repetition	Some	Some
	Enhanced Oral and Written Communication Skills	Few	Few
	Enhanced Analytical Evaluation of Peer-Reviewed Publications	Few	Few
Induction to Cognitive Apprenticeship	Ability to Design Novel Experiment	Some	Some
	Ability to Collect and Analyze Data	Some	Some
	Ability to Represent and Discuss Results with Intellectual Peers	Some	Some
Changes in Professional and Academic Self-concept	Elevation in Self-Esteem	Some	Some
	Develop Positive Relationships with Lab Colleagues and Research Mentor	Some	Some
	Academic and Professional Goal Clarification	Most	Most
	Selection of More Ambitious Academic and Professional Goals	Some	Few

Note. [a] Most = 100% - 75%, Some = 74% - 26%, Few = 0 - 25%

Comparisons between the Two Structural Models

In this study, two different organizational models, a hierarchical organizational model and an egalitarian organizational model were employed by the six academic research laboratories. The selection of one model or the other philosophically established for that community what was intrinsically valued. In the egalitarian model, all individuals were valued equally; therefore, all individuals had equal levels of prestige or status in the context of the research setting. In the hierarchical model, some individuals were valued more than others; therefore, some individuals had more prestige or status than others. In a hierarchy, neophyte researchers were not valued, because they were inexperienced. As de-valued individuals in the hierarchy, they were not automatically afforded the social acceptance as others in the laboratory. However, neophytes depended on those with more research experience to deliver timely and appropriate training, which often was related to the level of social acceptance the neophyte had achieved. Therefore, newcomers were limited in their research efforts by their reliance on others. Without some degree of researcher independence, experimental innovation rarely materialized in neophyte research. In the hierarchical model, individuals were valued, but valued unequally. Individual valuing placed a premium on individual success and failure. For neophyte researchers the risk of further diminished prestige in the hierarchy and the possible negative consequences for social acceptance inhibited non-traditional students' motivation to take experimental risks. None of the student participants in hierarchically-structured laboratories elected to undertake an individual experimental project of their

own design. Dependence on others, in turn, diminished their self-esteem. For student participants in hierarchically-structured laboratories, URE participation was to a greater or lesser extent, a disempowering experience.

Hierarchical Model

Four of the six student participants were placed in laboratories where the organizational structure was characterized as hierarchical. For these four students (Bryan, Andrea, Joshua and Catherine), their individual status within the hierarchy was the lowest in the research setting, based on lack of research experience and academic rank. In three of the four laboratory communities, student participants encountered lab colleagues who held negative perspectives of community colleges and community college students. (Recall that in the fourth laboratory, Catherine's research laboratory, there were no lab colleagues.) The social dynamics of each hierarchically-structured laboratory was influenced by its leadership style and training methodology. As we have seen, the acculturation outcomes for students in these laboratories were either marginalization or separation. They were not fully integrated into the established research community. In these laboratories, student participants attempted to elevate their individual status within the hierarchy through gains in professional competence. Status gains were progressive and reinforcing because these gains were related to gains in professional competence. Gains in professional competence, as described in the previous chapter, followed an instructional progression from gains in familiarity with the learning environment to acquisition of vocational habitus to induction to cognitive apprenticeships. As a non-traditional student's professional competence increased, social acceptance increased and the student's prestige was elevated in the hierarchy. If the neophyte researchers continued

to make gains in professional competence the established research community provided

greater support for additional training and leadership opportunities, expanding the

possibility for additional gains in professional competence. The interplay between gains

in professional competence and gains in social acceptance were cyclically reinforced. If a

student participant made minimal gains in social acceptance, the likelihood of making

substantial gains in professional competence were reduced. These relationships are
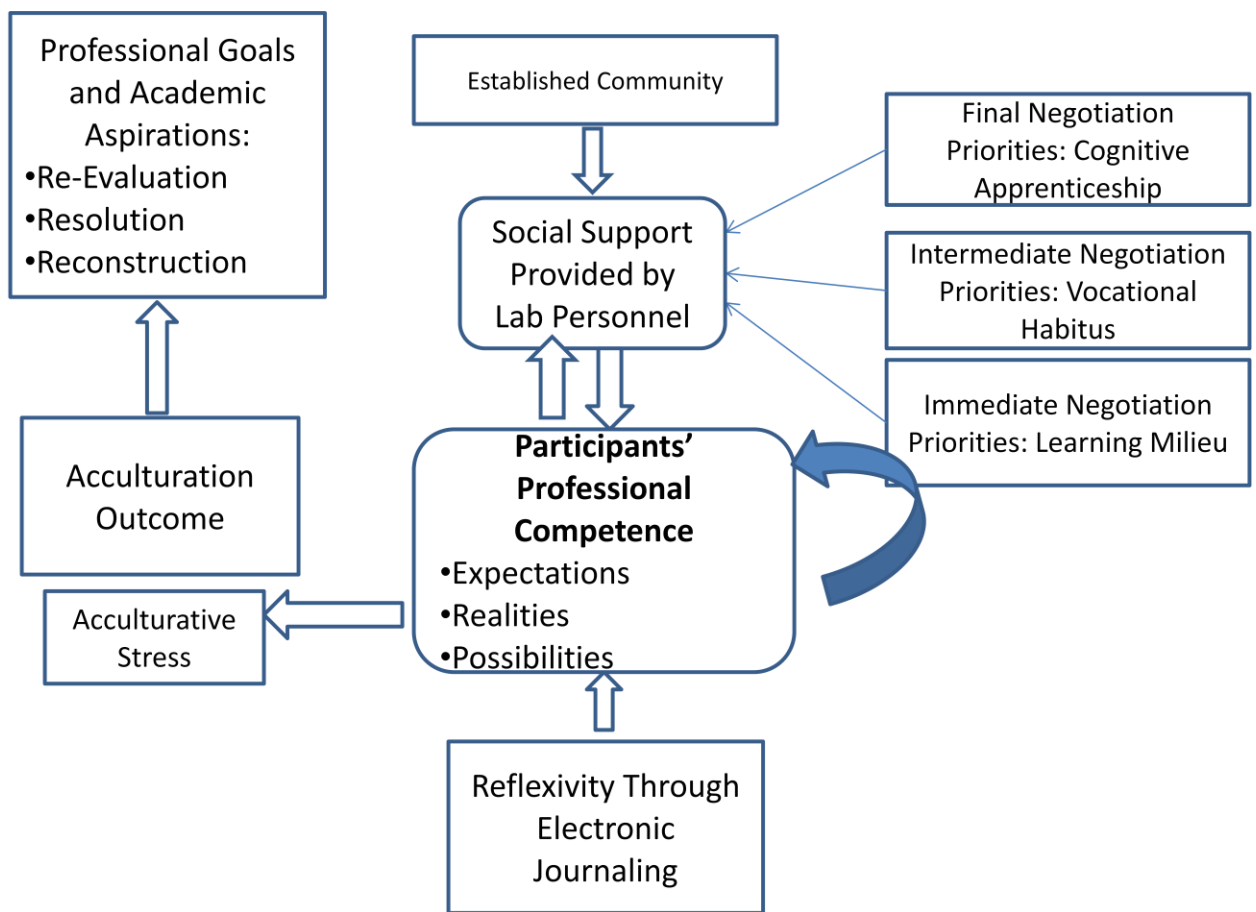
illustrated in Figure 6.1

Figure 6.1

Relationships between Gains in Professional Competence, Social Acceptance,

Acculturation Outcomes and Changes in Academic and Professional Goals

Egalitarian Model

Research communities that embraced the egalitarian model valued all individuals and their contributions to the research effort. Valuation of all individuals promoted group effort and group success. Student participants in these laboratories experienced a culture where risk of failure was minimized. For non-traditional students, an egalitarian culture fostered experimental innovation and self-reliance in their work. In turn, their self-reliance elevated their professional self-concept and reinforced their social acceptance. They collaborated with their lab colleagues and/or their research mentors, thereby enhancing lab productivity. It seems ironic that, often, hierarchically-structured organizations are recognized for their efficiency and yet, at least in this study, the collaborative organizational model proved to be more productive.

A significant distinction was identified between the two laboratory organizational structures. Status for student participants in egalitarian laboratories was not initially as jeopardized as it was for students placed in hierarchically-structured laboratories. A prevailing democratic social climate accelerated participants' accrual of gains in professional competence. Social supports offered by the established community for access and exposure to expanded training and leadership responsibilities occurred earlier in the internship and were more frequent. This also means these social supports became more reinforcing and regenerative earlier in the internship. In this study, Tabitha and Sam reported greater satisfaction and greater benefits from URE participation than the others.

In egalitarian research environments, student participants were not assigned the lowest status in the system. Their opinions and life experiences were valued and recognized. Social supports from their lab colleagues and research mentors were not so

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much earned as they were offered. The non-traditional students in these laboratories perceived that these social supports were neither transitory nor merit-based. Instead, they were secure, which allowed students in these laboratories to perceive that they could take greater research risks. Tabitha and Sam were more experimentally innovative than their peers who were placed in hierarchically-structured research laboratories, because Tabitha and Sam could risk failure without significant social acceptance repercussions. Relieved of these pressures, they found collaboration with their lab colleagues and/or their research mentor a more viable and more productive approach for research progress. The realization that experimental innovation required assimilation of standard laboratory techniques and that standard "habits of mind" could be applied in novel ways or to novel situations became the motivation for these two students to quickly familiarize themselves with the learning milieu in their respective research settings. Rapid gains in technical expertise led to reinforcing gains in vocational habitus. However, to become experimental innovators in their laboratory communities, student participants had to become cognitive apprentices. Sam and Tabitha both utilized critical thinking and creative thinking skills to design, conduct, and conclude their own experimental projects.

Social Structures That Frame Student-Participants' Professional Self-Concepts in Research Settings

The established laboratory community determined social climate through mentor choices made regarding organizational structure, leadership emphasis and training emphasis. Laboratory social climate was maintained by other significant laboratory personnel, including student lab colleagues. Laboratory social climate for non-traditional students was influenced by the perceptions lab colleagues held of both community

colleges and community college students. In hierarchically-structured laboratories, these novice researchers occupied the positions of lowest status. In a new and unfamiliar environment, the student participant's previous academic and professional self-concept was subject to change. In this study, changes in the non-traditional student's self-concept were attributed to gains in social acceptance and professional competency, i.e., acculturation outcomes. Therefore, factors reported by participants to have influenced perceptions of their acculturative experiences are significant for the understanding of non-traditional students' changes in professional self-concept and changes in academic and professional science goals. Non-traditional students who reported positive changes in their professional self-concepts described more positive outcomes from their URE participation. Factors that diminished newcomers' status in the social network served to lower social support from the established community. Without this support, students' status in the social network remained unchanged. In this new and unfamiliar environment then, their de-valued status in the hierarchical structure influenced the formation of their new demoted professional self-concept. Factors that were identified in this study that influenced the social climate were the same factors that contributed to alterations in professional self-concept for non-traditional students: leadership emphasis and training strategies of the established research community.

Unilateral Leadership

In this study, laboratory organizational structure narrowed the choice of leadership style utilized by key laboratory personnel. Leadership emphasis contributed to the social climate in the participating academic research laboratories. Neophyte researchers in hierarchically-structured communities experienced unilateral leadership,

characterized by singularity in decision-making. In these research communities, few opportunities existed for the newcomer to accept professional or scientific responsibility. Unilateral leadership amplified students' feelings of transience and insignificance. With minimal responsibility afforded them, participants' "investment" in the laboratory community was diminished, as were their own expectations of autonomy and professional competence. In a hierarchical organization, the individual with the greatest status and the greatest freedoms, the research director, is afforded singularity in decision-making responsibilities. Decision-making by one limits the decision-making responsibilities of others in the community. Devoid of responsibility, participants/community members are not invested in the efforts of the community. In this study, Bryan was not assigned substantial research responsibilities, as he suggested in one of his earlier transcript excerpts, he spent much of his internship washing dishes and preparing media. It would seem there was a relationship between his lack of substantial laboratory responsibilities and his numerous laboratory absences. It may be that he felt his absences could be justified, because he had no major responsibilities.

Bilateral Leadership

In this study, one non-traditional student co-participated with a research mentor in shared decision-making responsibilities. In this bilateral leadership arrangement, substantial responsibility was delegated to the participant based on his previous life experiences. His work was valued and, as he progressively demonstrated greater responsibility in his work, he was delegated more responsibility for decision-making in the research project. Presented with greater autonomy, he gained experimental independence on the initial project. His developmental gains in professional competence

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promoted more experimental risk-taking/innovation. As this bilateral leadership relationship became more secure during the course of the internship, the potential for future project responsibilities with similar collaboration became a reality in this research dyad.

Multilateral Leadership

Multilateral leadership can only exist in an egalitarian-structured laboratory, and it was only operational in a single research community in this study. In this research community every student's previous life experiences were valued, and every student experienced the same research autonomy. With autonomy came individual and group responsibilities and individual and group accountability for research progress. Responsibilities that were delegated to individual lab members demonstrated recognition of these students' developing expertise and newly-acquired experience. In this research community, every lab member had decision-making responsibilities, which promoted each lab member's investment in lab productivity. Their shared responsibilities reinforced positive peer interactions and led to collaboration. In Tabitha's research group very early in the summer internship, individual group members demonstrated different levels of proficiencies in performing diverse laboratory techniques. Tabitha became adept with cell culture methods. Her developing skills were recognized by her lab colleagues, and as their summer project progressed, they requested her assistance whenever cell culture was necessary.

Student-Participant Training

Issues of social acceptance were embedded in issues of training and education. Newcomers had to garner social acceptance from the trainers of the established

community to enable their progress towards professional competence. At the same time, in a hierarchically-structured organization, the newcomers' training needs were in competition with the needs of all other community members. The newcomer, diminished in social status relied on the good will of others with greater status and greater professional competence to provide appropriate training by appropriate methods. In an egalitarian organization, the training needs of all community members were similar; their status in the organization was similar; and therefore, laboratory members were not in direct competition with each other for training opportunities.

Informal Training Sessions. In this study, the training emphasis of each participating laboratory was characterized as either formal/structured or informal/serendipitous. Further distinctions in training emphasis were made between laboratories that utilized sequenced training sessions or episodic sessions. From the non-traditional students' perspectives, training issues arose with informal teaching activities. Student participants expected that training sessions would lead to enhanced understanding of laboratory techniques and protocols. Students expected that mastery through training would be achieved. In turn, laboratory trainers had expectations that students would observe and remember significant detail and nuance after limited, and often passive, laboratory learning activities. Informal training activities in these laboratories often led to repeat training sessions. Students reported feelings of inadequacy, and characterized these sessions as inefficient and demoralizing. Trainers conveyed feelings of frustration, and intimated that student participants were either uninterested or inattentive. Expectations for either group were not realized.

Formal Training Sessions. In training sessions that were formal/structured, sessions were scheduled in advance. Training materials were provided to student participants, and observation and guided practice were included in the learning activity. Formal training sessions reinforced more active learning processes and resulted in greater retention by trainees. With appropriate sequencing of training sessions, student participants in these laboratories mastered specific techniques. Their expectations for increased understanding with training materialized. Students' professional competence in the established culture was recognized. However, if formal training sessions were not appropriately sequenced, non-traditional students in this study perceived that their pursuit of professional competence was periodically displaced. For one student participant (Joshua), interruptions in the training progression were perceived as personal and purposive. He referred to his trainers in these instances as "information keepers."

The Peer Trainers

In hierarchically-structured laboratories, where students' social and professional status was unequal, inequities existed for low-status graduate students, as well as neophyte researchers. Low-status graduate students were often assigned training responsibilities in these laboratories.   Peer-trainers in hierarchically-structured laboratories frequently disavowed inadequate preparation or training, or their lack of experience, to prevent loss of status in the laboratory hierarchy. Peer-trainers in these laboratories were often ineffectual in their training responsibilities. In this study, several disadvantages were associated with peer-training. It amplified social stratification, diverted time from the trainers' research assignments, and increased time and performance pressures for them. For some peer trainers, it highlighted their own feelings

of ineptitude and, consequently, exacerbated student participants' perceptions of inadequacy. And because peer trainers were also members of the limited social network available to student participants, it diminished the number of peers in the laboratory who were available for true "low stakes" social interaction. In this study, peer-training of neophyte researchers in hierarchically-structured laboratories, hampered learning opportunities.

In this study, simultaneous comparative analysis of leadership emphasis and training emphasis resulted in the formulation of a contextual construct -- the laboratory social climate. The social climate was a product of laboratory organizational structure. From the perspectives of participating laboratory personnel, interactions with URE students either positively affected organizational structure and social climate, leading to increased productivity, or afforded no benefit, but were not detrimental. For a single laboratory in this study, URE participation negatively affected organizational structure and social climate and resulted in decreased research progress. These substantial influences of laboratory organizational structure and social climate for both student participants and laboratory personnel led to characteristic acculturation outcomes for non-traditional students: marginalization; separation and integration. Although all students reported positive benefits from URE participation, these acculturation outcomes had significant influence on students' own estimation of professional and academic self-concepts after the summer internship concluded.

Acculturation Outcomes Frame Student-Participants' Academic Goals and

Professional Aspirations

The first two research questions of this study sought to interpret multiple

participant perspectives of the influences of laboratory organizational structure and social

climate on acculturation outcomes. The third research question sought to connect non-

traditional students' acculturation outcomes from URE participations with changes in

their academic goals and professional aspirations.

Psychological Acculturation

Williams and Berry (1991) identified several phenomena that influence

psychological acculturation. The most important phenomena they describe related to the

findings of this study, is the extent of existing acceptance and understanding for the

acculturating group by the established community. More positive acculturation outcomes

resulted for newcomers when the acculturating group was not viewed as the minority

group that must be changed -- when their previous cultures and experiences were valued,

rather than de-valued. Indeed, research groups that recognized student participants'

previous life experiences as valuable were those that were egalitarian in structure and had

mentors who demonstrated bilateral or multilateral leadership strategies. The two

students (Tabitha and Sam) assigned to these laboratories, reformulated their previous

academic and professional goals to more ambitious aspirations. Secondly, Williams and

Berry (1991) suggested that acculturating phenomena result from the *interaction between*

the two groups in contact, rather than residing solely in the acculturating group. The

findings of the two previous research questions underscored the significance of these

interactions for both student participants and laboratory personnel. Thirdly, psychological

acculturation outcomes for different individuals are variable because of what are

perceived as differences even in similar acculturative experiences.

Factors that influenced student participants' perceptions of their acculturative

experience were also factors that influenced their status within the social structure and

their progress towards   professional competence in the research laboratory. However,

gains in social acceptance were of primary importance because training and leadership

opportunities were not forthcoming for non-traditional students that did not make gains in

the social network. In addition, students that were not socially accepted by the established

research community experienced higher levels of acculturative stress compared to their

cohorts that were socially accepted. Student's that were socially accepted and

experienced low levels of acculturative stress reported greater interest in and commitment

to careers that required science research skills. Participants who experienced minimal

accomplishments in these same social arenas re-directed or reformulated their

professional self-concept. For these participants, science-research was no longer an

appealing career option. These results are summarized in Table 6.2.

Table 6.2

Relationships between Social Status, Acculturative Stress and Changes in Academic and Professional Goals

Student	Social Status	Professional Status	Acculturation Outcome	Stress	Academic and Professional Goals
Bryan	Alienation	Inadequacy	Marginalized	High	Re-evaluation
Andrea	Alienation	Competency	Separation	High	Re-evaluation
Catherine	Acceptance	Inadequacy	Separation	Low	Undergraduate Degree Program
Joshua	Acceptance	Inadequacy	Separation	Low	Graduate Degree Program
Sam	Acceptance	Competency	Integration	Low	Graduate Program
Tabitha	Acceptance	Competency	Integration	Low	Graduate Program

Acculturation Outcomes

Marginalization. In this study, a single student participant's acculturation outcome was characterized as marginalization. In this community, the introduction of a newcomer disrupted the organizational and the social structures. In an environment of re-introduced stratification, training opportunities provided by peer trainers were infrequent and often were sub-optimal learning experiences. Social acceptance was not enhanced through his training sessions; therefore, additional training opportunities did not materialize. The student participant gained limited familiarity with the specific learning milieu of his assigned research community. Limited protocol familiarity prevented this novice from negotiating notable gains in professional competence. In this laboratory, the non-traditional student was unable to negotiate greater gains in research autonomy or

laboratory responsibilities. In this environment, both the student participant and the laboratory personnel perceived negative consequences from his URE participation. His acculturation outcome was participant marginalization. His professional self-concept was, apparently, negatively affected and his progress towards a research science career was deferred. One year after URE participation, this student is in the process of re-evaluating his professional science goals. (Recall, Bryan had originally intended to attend medical school with professional aspirations that included psychiatry and clinical research.) He is resolute in his commitment to the completion of an undergraduate degree, however, his choice of an academic degree program has not been finalized.

Separation. In this study, newcomers experienced separation from the established research community, because they were afforded limited autonomy in a hierarchically-structured organization. The significant point is that no matter how great the gains in familiarity with the learning milieu, or the gains in acquisition of vocational habitus, the hierarchical organization prevented total acceptance of the newcomer to the established community. Non-traditional students did not achieve full integration into these hierarchical organizations, because limited gains in professional competence in their new environment ensured their dependence on others, who may or may not have been fully-invested in these newcomers' progress. Separation was the acculturation outcome for Andrea, Catherine and Joshua. During their internships, these non-traditional students were not fully integrated into the research community. In two of these laboratories, there was a focus on individual research efforts and individual recognition. Subtle and not so subtle competition existed between lab colleagues. Both of these

hierarchically-structured laboratories also had at least one lab colleague who reported

negative impressions of community colleges and community college students.

Joshua, Catherine and Andrea's status as newcomers in the laboratory hierarchy

were the lowest of all members of the research community. To elevate their status within

the social network required gains in familiarity with the learning milieu. For Joshua and

Catherine, their gains were viewed by their research community as admirable, but,

nevertheless, inadequate. Andrea was able to make substantial gains in professional

competence, however, she was unable to make substantial gains in social acceptance

from her laboratory peers, presumably due to the limited number of lab colleagues she

had regular contact with and the negative perceptions of community college students

expressed by the one of these lab colleagues. It would seem that, in this laboratory

environment, neophyte assistance was viewed as either inconsequential or threatening (or

both) to the status of other laboratory personnel. This limited the social supports lab

colleagues were willing to extend to the newcomer. Whether research mentors were

aware of these hierarchical limitations for social support is not clear.

> *Dugan: I mean there were no surprises... you know ahm, we essentially I mean I
> brought her in and I told everyone what was happening that she was there to help
> and so forth. And everybody kind of just kind went along. I didn't think there was
> anything odd or unusual about it. I think they were pretty well-prepared and I
> think it kind of went the way we expected it. I explained to each person who had
> any reason to be in contact with her, that she's here to help out, and ah, you know
> if you have nothing for her to do, don't try to manufacture something for her to
> do. But if she can help you, I'll be training her in these techniques, and she'd
> really like to be able to work with each of you at some point or another, on what
> you're doing. And they seemed OK with that. One of my students, Tracey, was a
> little bit puzzled, like "How do I…"and I said don't worry about it, I mean, she
> had the option of not doing anything.*

> *Andrea: I just felt that I couldn't finish anything in the time period I had and that
> would be more disappointing than helping out the others in the lab, which I hope I
> did. So I'd much rather participate in somebody else's work…*

Tracey: Oh then- well, besides the fact that she was, you know, wanting to constantly be in the lab, and that you know she was always wanting someone to teach her, that's all I knew about…

Andrea's status in the hierarchy was elevated by her gains in familiarity of the learning milieu and acquisition of vocational habitus. These same gains seemingly heightened hierarchical competitive tensions and elevated mistrust amongst her lab colleagues. During her URE, Andrea experienced significant challenges to her developing professional and academic self-concepts. Her previous life experiences had already contributed to a diminished self-view. Taken together, these were all factors that exacerbated her acculturative stress. Andrea re-evaluated her professional goals and academic aspirations after her URE participation.

For Joshua, electronic reflexivity, through his discussion board postings and his blog postings, seemingly supplanted a laboratory-based cognitive apprenticeship with a virtual cognitive apprenticeship. Electronically, he was able to objectively analyze social interactions of laboratory personnel in the hierarchical organization of his research community. He was also able to question data interpretations and data presentation and often provided answers to his own questions regarding research/protocol designs.

Joshua elevated his status in the laboratory hierarchy through his individual efforts to gain familiarity with the learning milieu. His efforts gained him social supports that led to increased training and leadership opportunities, ultimately resulting in gains in acquisition of vocational habitus. By his individual efforts involving electronic reflexivity, he secured a cognitive apprenticeship of his own making. Joshua elevated his status in the hierarchy considerably with the gains in social acceptance he made, which restored his self-confidence and self-esteem. He selected more ambitious academic and

professional goals after his summer internship. The results of these relationships between

social acceptance, acculturative stress and changes in academic and professional goals are

represented in Table 6.3.

Table 6.3

Relationships between Social Status, Professional Status, Acculturative Stress and

Changes in Academic and Professional Goals

Student	Social Status	Professional Status	Acculturation Outcome	Stress	Academic and Professional Goals
Bryan	Alienation	Inadequacy	Marginalized	High	Re-evaluation
Andrea	Alienation	Competency	Separation	High	Re-evaluation
Catherine	Acceptance	Inadequacy	Separation	Low	Undergraduate Degree Program ⭐
Joshua	Acceptance	Inadequacy Electronic Reflexivity	Separation	Low	Graduate Degree Program ⭐
Sam	Acceptance	Competency	Integration	Low	Graduate Program
Tabitha	Acceptance	Competency	Integration	Low	Graduate Program

Cognitive Apprenticeships and Integration. In this study, egalitarian research

settings fostered gains in professional competence for neophyte researchers. Collegial

social climates prevailed which enhanced positive interpersonal interactions. In these

laboratories, non-traditional students, lab colleagues and research mentors promoted lab

productivity through their collaborative research efforts. Shared gains in professional

competence resulted in increased training opportunities for all members of the research

group and accelerated their familiarity with the learning milieu. These rapid gains in

familiarity with the learning milieu broadened the opportunities for acquisition of

vocational habitus. As gains were made in vocational habitus, community members were increasingly offered more responsibility which, in turn, afforded increased opportunities to demonstrate responsibility. Gains in social acceptance elevated self-reliance and self-esteem but, just as important, also set standards for group accountability and group productivity. In these research settings, student participants became cognitive apprentices. These cognitive apprenticeships provided non-traditional students with opportunities for experimental innovation which required novel creative and analytical strategies to overcome experimental obstacles. Accomplishments in this type of safe, secure, risk-free learning environment led to dramatic and lasting positive changes in student participants' professional self-concepts. In this study, students who negotiated cognitive apprenticeships achieved full integration into the established research community. It was these students that selected more ambitious academic and professional goals. These conclusions are summarized in Table 6. 4

Table 6.4

Relationships between Integration as an Acculturation Outcome and Changes in

Academic and Professional Goals

Student	Social Status	Professional Status	Acculturation Outcome	Stress	Academic and Professional Goals
Bryan	Alienation	Inadequacy	Marginalized	High	Re-evaluation
Andrea	Alienation	Competency	Separation	High	Re-evaluation
Catherine	Acceptance	Inadequacy	Separation	Low	Undergraduate Degree Program
Joshua	Acceptance	Inadequacy	Separation	Low	Graduate Degree Program
Sam	Acceptance	Competency	Integration	Low	Graduate Program
Tabitha	Acceptance	Competency	Integration	Low	Graduate Program

Implications

The elucidations presented in this final chapter are situated in the accounts

reported by the three participant groups in this study; the six non-traditional students, the

six research mentors, and the four lab colleagues. Interactions between these participant

groups were detailed, with as much description as was possible, in order to authentically

represent these significant social dynamics. As with any qualitative study, neither the

conclusions reached in this chapter nor the implications detailed in the next section are

meant to be dogmatic. They are offered merely as interpretations, with the hope that their

genuineness resonates with readers.

Implications for Science URE Programming Directors and Mentors

> *Joshua* (from his last interview): *Yeah, basically, I'd say that no matter where you go, in the lab, or anywhere, that it's always kindergarten. You have to remember that. You're always going to have your social... groups and your people that complain about everything, and the people that, ah, you know, there's a little bit of backstabbing and a little bit of this and that... and that's everywhere.*

Transition to Egalitarian Organizational Structure. Non-traditional students, in this study, experienced the greatest developmental gains when placed in academic research laboratories with egalitarian organizational structures. In turn, laboratories that mentored non-traditional URE participants and reported increased lab productivity operated under an egalitarian organizational model. In future research partnerships that place community college students in academic research laboratories, an organizational shift towards a more egalitarian structure may be beneficial for both non-traditional students and these laboratories. Recognizing that substantial efforts are often required to transition to a new organizational structure, it seems prudent to suggest an incremental progression from a hierarchical structure toward an egalitarian structure.

Co-Participatory Dialogues. The simplest and most direct reform requires only that the implicit assumptions in both models be made explicit through on-going participatory dialogues amongst laboratory personnel. Discussions might begin with the mentor's rationale for the selection of the current organizational model and could continue with solicitations for modifications to the existing laboratory structure. In the spirit of valuing every lab member equally, every voice in these dialogues should be recognized and considered. As these dialogues progress the responsibility for decision-making should be shared, as well as the responsibilities for actionable reorganization recommendations. Moreover, negotiating group decisions provides ample opportunity for

leadership. The greater the number of laboratory personnel who gain leadership experience, the more likely it is that the laboratory can function effectively with multilateral leadership. In initiating these preliminary dialogues, academic laboratory directors are advocating for environments that offer more equally distributed freedoms.

Transition to Collaborative Research Efforts and Reward Systems. A second and more fundamental reorganizational reform for academic research laboratories interested in partnerships with non-traditional students, requires a shift from the current focus on individual efforts and rewards towards recognition of group effort and group reward systems. The traditional model for laboratory success, still utilized in academia, is certainly not the model currently in use by most science laboratories in either private industry or within governmental agencies. Especially necessary at the undergraduate level is a shift towards group-designed and group-implemented experimental projects. As a result, the transition from competition to collaboration is likely to reinforce positive interpersonal dynamics and burgeoning leadership skills. Moreover, equitability in group work creates the possibility of equitable distribution of laboratory freedoms for inexperienced and experienced researcher alike.

Transition to Formal Instructional Emphasis. Academic research laboratories that engage non-traditional students in their research efforts will need to consider adopting more formal/structured training strategies that include both long-term and more immediate learning objectives. A progressive and sequenced learning schedule for neophyte researchers, incorporating regular, appropriate, scheduled training sessions followed by guided practice and formative assessments, reinforces positive intragroup trust. Academic research laboratories that employ laboratory personnel to train non-

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traditional students should invest substantial effort to ensure the trainers are prepared and competent in instructional delivery.

Incorporation of Reflexivity. Non-traditional students in this study made significant developmental gains in understanding both themselves and the social dynamics of their research environments through the use of electronically-facilitated reflexivity. Students who participated in electronic reflexivity were able to appropriate meaning using their own personal blog sites and co-appropriated meaning with other neophyte researchers using electronic discussion board sessions. For one student in this study, electronic reflexivity facilitated a transition to cognitive apprentice. Non-traditional students placed in academic research settings should be encouraged to consider electronic reflexivity as a means to metacognitive praxis. Similarly, it seems plausible that laboratory colleagues and research mentors would experience positive benefits from reflection on laboratory social interactions and their own progression to professional competence. Using electronic reflexivity would provide research mentors with opportunities to model critical thinking and problem-solving skills for other laboratory personnel.

Incorporation of Academic Advising/Career Counseling. The academic advising and career counseling opportunities available at many community colleges nation-wide are limited due to understaffing issues and budget constraints. The community colleges in the MCC system are no exception. For this reason, non-traditional students may not receive appropriate or timely academic and career advising at their home institutions, especially if their academic aspirations include graduate school. Providing URE participants with information on the transfer process, the application

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process to graduate and professional science degree programs, would be an economical method for disseminating this information to community college students. The inclusion of additional career counseling for non-traditional URE participants would expand each student's knowledge of science-related career opportunities. Because so many non-traditional students are first-generation college students, they are often unaware of alternative professional science career options. For students like Andrea and Bryan, academic and career counseling might have proven invaluable in assisting them with the reassessment and re-selection of new and more appropriate academic and professional goals. Additionally, requiring research mentors to provide URE participants academic and career counseling would present university faculty with unique opportunities to learn more about the science programming offered at local two-year institutions.

Acknowledgement of Adult Learner Competencies. A final implication for science URE programming directors and research mentors to contemplate for future relationships between non-traditional students and academic research laboratories is the essence of adult learning -- valuation of accumulated life experience. Successful and transformative partnerships resulted in this study, when non-traditional students' life experiences were not only recognized, but utilized. Adult learners are not inexperienced; they are merely inexperienced in a set of very specialized laboratory procedures. This should not overshadow the multitude of other valuable contributions they may make to the laboratory community, even prior to their acquisition of those specialized techniques.

Implications for Science URE Agency Administrators and Policy-Makers

Earlier in this chapter, it was suggested that federal agencies begin to explore ways and means to extend **national and local** science URE opportunities to community

college students. The demographic imperative for their inclusion can no longer be overlooked or minimized. But it will not be enough, if only token re-adjustments are made to URE selection criteria, or if traditional science UREs are modified only at the programming level, rather than at the philosophical level. If these are the only modifications instituted in the current URE models, community college students are not likely to experience benefits from inclusion. Beyond the recommendations already detailed, two significant implications remain to be discussed; extending the duration of URE program participation for non-traditional students to two consecutive summers, and investing in post-secondary institutions that create partnerships to support opportunities for community college students' URE participation.

Two Consecutive Summers: Adaptation to Traditional URE Model. For the non-traditional students in this study, an eight-week internship was not enough time for the majority of students to make the transition to cognitive apprentice. There are compelling reasons to believe that, if these same non-traditional students had been afforded a second internship the following summer in collaboratively-structured laboratories, those transitions might have occurred. For these non-traditional students, the initial adjustments, not only to new laboratory environments, but to new institutional environments and new living arrangements, were daunting tasks to accomplish in eight weeks, yet they did so. Returning to the same institutional environment, in laboratories with research interests similar to those of their previous assignments, it seems reasonable to expect that these students, or any non-traditional students, might make additional developmental gains leading to progress towards self-authorship and selection of more ambitious academic and professional goals.

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Two-Year/Four-Year Partnerships. A second investment that seems worthy of consideration is support for post-secondary institutions that undertake new science URE partnerships sponsoring community college students. There is no doubt that current efforts to incorporate research-based laboratory activities into community college course offerings, like those at North Seattle Community College (Washington) and Redlands Community College (Oklahoma), are laudable and long overdue (Cejda & Hensel, 2009). Recent NSF-sponsored efforts to create regional science research centers for undergraduates (NSF-URC Workshop Report, 2003) are also innovative advancements in enhancing pre-graduates' research efforts, but there really is no comparison to programming that offers students the opportunity of authentic experience in daily science research efforts over a prolonged period. Those experiences are available to traditional undergraduates, and should also be available to community college students.

Implications for Future Research

The findings of this study have demonstrated that six non-traditional students, recruited for science URE participation in academic laboratories throughout Maine, negotiated their internships to completion in the summer of 2008. As a next step, a similar study should be undertaken, placing greater numbers of community college students in academic laboratories at more geographic locations throughout the U.S. It is anticipated that these studies would be conducted in the qualitative genre and that the experiences of these students would remain the focus of the research questions. After further studies of this type are completed, a logical continuation would be to implement and evaluate the extended science URE program described in the previous section of this chapter. Finally, it seems important to conclude that, although substantial effort and

resources should be invested by federal "stakeholders" to ensure that access to science

research experiences is available to all undergraduates, those who best know the hopes

and dreams of these students, community college faculty and administrators must always

have their best interests at heart. We must become their most ardent advocates. Their

futures are our futures.

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APPENDICES

Appendix A

Excerpts from Talking about Leaving: Why Undergraduates

Leave the Sciences, (Seymour & Hewitt, 1997)

- When I was young, I was in all of these 'talented and gifted 'classes. I used to be impressed by it, but I'm not anymore. I never opened a book in high school-my father says he didn't either. After class we went home, played basketball, ate dinner and screwed around. I probably never did any homework. My teachers didn't like that I didn't work, but I kept scoring high on the tests, so they couldn't say anything to my dad. And I still came out of high school with a 3.7 average and over 700 in my math SAT. Six years later I'm still learning how to study. (Male white engineering switcher)

- I was never really comfortable with any of it. In fact, my entire life, I've kind of slid through science. When I was doing experiments, I didn't really know what was going on. I somehow managed to fake my way through about 17 years of math and science. Eventually you hit a point where you just can't go on without that solid understanding to pull on. (Female white engineering switcher)

- Some of this stuff is just plain hard. It's obvious that the professor understands it very well. And later on, you do too. But at the time, it's like being in third grade trying to understand multiplication. In the third grade that multiplication is a hard concept. And the professor has forgotten that it was once difficult for him and he doesn't remember why you find it so hard. (Female white science non-switcher)

- There's just too much work the first two years. The amount of pressure they put on you is mostly to see if you can stand up to them, not to make sure you understand what you're doing. I think it's kind of designed that way to weed people out. It's all a big test. (Male white engineering non-switcher)

- I think that in sociology and humanities, the quality of teachers was better. They were more interested in teaching you. They seemed more interested in if you learned something, rather than just the grade you got. The biology teachers were just interested in telling you what they had learned, and you'd better learn it too. (Male white science switcher)

- What scares me is getting in 18-year old girls who have no idea how to defend themselves. I've had to learn the hard way. If you're going to be a good student, you've got to be sound; you've got to be stable; and you've got to be secure. To get more good students graduating, we've got to prepare them emotionally, as well as mentally, for what they are going to have to face. (Female white engineering non-switcher)

- The fact that so many of them (faculty) are men is a negative in the end, even if they don't directly say anything to you about being a woman. Being all-men kind of ruins something for you. It takes something away from your education, compared with other majors. It could have been so much better. (Female white science non-switcher)

- There are very few presentations of academic excellence in the black community. So we feel we are supposed to do well, and if we don't it's kind of devastating. 'Cause its not just yourself that you're representing, it's the whole community. (Female black science non-switcher)

- They say that I will always get a job, and that I don't have to worry because I'm a minority and because I'm a woman. But either way, I'm going to catch flak. Even if I get hired, I'm going to have to be twice as good just to prove I am average.(Female Hispanic engineering switcher)

ARE YOU LOOKING FOR THE
EDUCATIONAL EXPERIENCE OF A LIFETIME?

- Would you like to travel this summer???
- Would you like to meet new people this summer?
- Would you like the opportunity to practice
    REAL SCIENCE this summer?
- Would you like to be paid up to $4000 for
    8 weeks, and be provided with free lodging
    and travel expenses?
- Yes? Then contact:

DANA PETERSON

Dana.Peterson@umit.maine.edu

THERE WILL ALSO BE

A 15-MINUTE INFO. SESSION IN

RM 219, KING HALL (A and P Lab)

FRIDAY, JANUARY 25TH:

FIRST SESSION: 10 AM

SECOND SESSION: 12 noon

Student Participant REU Rejection Letter

Re: ISU-NS-REU decision reached   http://voyager.umeres.maine.edu/Login/FOV18-000A02E9/E42A5FE....

Message: Re: ISU – NSF – REU decision reached

Tuesday, July 8, 2008 5:04 PM -0400

From: Student Participant

To: Dana Peterson

Attachments:@ Attach0.html 4K

Dana, not sure if this helps you in any way, but here is a response to one of my applications from March:

On Thu, Mar 20, 2008 at 12:38 PM, Rothschild, Max [AN S]< mfrothsc@iastate.edu> wrote:

Dear REU Applicant:

This year we had over 150 applicants for the 10 open positions in our NSF-REU supported program in Biotechnology and Genomics. Unfortunately there were:

> Too many qualified students for too few positions
> Applicant was a freshman or senior - preferred applicants are juniors
> Preferred applicants have limited research experience and are from small non-research institutions
> Non-competitive grade point or poor letters of support

If you are a freshman or sophomore and believe you are qualified we encourage you to apply next year.

Again we regret you could not be accepted into our program. We wish you luck in the future.

Sincerely,

Max Rothschild
Director

Appendix D

Student Participant Letter of Inquiry

April 7, 2008

Dear

My name is   and I am currently enrolled in the Biological Sciences program at   Community College in   Maine. I plan to transfer to a four year undergraduate pre-dentistry program after completing my sophomore year at   Beyond that, I anticipate working for several years, so that I can finance a graduate degree in dentistry. Securing an opportunity in a research lab this summer would greatly assist me in my pursuit of a graduate education. In addition, the chance to meet other students that share my same passion for microbial science and to collaborate with them to complete an authentic research project is the opportunity of a lifetime.

I grew up and still live- in a small rural town in Maine. Maine is a beautiful place full of wonderful personalities and hard working people. The downside of living here is that our opportunities are limited. The Maine state community college infrastructure cannot provide the same level of exposure to technology, laboratory facilities, faculty expertise or library resources as a major university campus. I chose to begin my science studies at a community college because it was the financially responsible choice for both my family and me. I am proud of my parents, grandparents, and great-grandparents, working-class people who have passed their work ethic to me. They have fueled my desire for an education, and I know that through my own hard work, I can become the first in my family to complete a graduate degree.

I am a motivated and determined individual. I work hard, take initiative and assume responsibility both in the classroom and in my professional commitments. Currently, my GPA is a 3.8. I have attached to this letter a brief description of the research and laboratory skills I have acquired this past year. I am confident that these skills would be an asset to completing an individual research project this summer. I am also certain that I will gain new skills, and most importantly, will learn to apply them to an authentic research question.

 Thank you very much for your consideration,

Molecular and Biological Laboratory Skills that I currently have:
Research Skills:

1. Ability to find peer reviewed journal articles in current scientific databases: Web of Science, PubMed, Highwire Press, etc.

2. Ability to utilize Bibliographic software tools: EndNote, NoodleBib

3. Ability to search peer-reviewed journal articles for relevant information specific to research project

Presentation Skills:

1. Familiarity with the following presentation software: Powerpoint , Publisher, FrontPage, Adobe Illustrator, Paint

2. Familiarity with the graphing functions associated with both Excel and Powerpoint

3. Familiarity with importing/uploading digital images from memory cards

4. Numerous academic and organizational opportunities with oral presentations

Laboratory Skills:

1. Ability to extract nucleic acids (DNA and mRNA) from tissue of interest

2. Comfortable with PCR protocols and primer design software

3. Experience with agarose gel electrophoresis

4. Familiar with basic cell culture techniques

5. Experience preparing common laboratory buffer solutions, preparing general purpose microbiological media and autoclaving glassware

6. Experience with compound binocular light microscope/oil immersion lens

Appendix E

Research Mentor Recruitment E-mail

Dear Faculty:

I am interested in your personal observations and experiences as you mentor a community college student in your laboratory this summer (2008). I am hoping that you might be interested in sharing these experiences with me during the next eight weeks. I am a doctoral candidate at the University of Maine, and I am interested in collecting your thoughts during two separate interviews, each of which will last approximately one hour. These interviews will be scheduled at a time and place that is convenient for you. I have included a few sample questions, so that you might have a better idea of the type of questions I would like to have you comment on…

- Please describe for me what a "typical day" for YOU is like during the summer session?
- Have you had an opportunity to observe any differences in the ways that your undergraduate students approach their laboratory work compared to your community college student?
- What aspects of the research process are you most concerned that your community college student understands by the end of the summer internship?

Except for your time and inconvenience, there are no potential risks to you for your participation in these interviews. In addition, although there are no direct benefits to you, sharing your experiences may help the scientific community better understand how to create undergraduate research experiences that specifically meet the needs of community college students.

If you are interested in participating, please feel free to call me at (207) 299-7793 or email me at: Dana.Peterson@umit.maine.edu.

Warmest regards,
Dana Peterson

Appendix F

University of Maine IRB: Letter of Approval for Use of Human Subjects

Office of the Vice President for
Research
*Protection of Human Subjects Review
Board*

1 8 6 5 THE UNIVERSITY OF MAINE

5717 Corbett Hall
Orono, Maine 04469-5717
Tel: 207-581-1498
Fax: 207-581-1446
www.orsp.umesp.maine.edu
www.umaine.edu

MEMORANDUM

TO: Dana Peterson
           1052 Main Street
           Veazie, ME 04401

FROM: Gayle Anderson
           Assistant to the Institutional Review Board (IRB) for the Protection of
           Human Subjects

SUBJECT: "Community College Student Participation in Undergraduate Research,"
           #2008-06-01

DATE: June 9, 2008

The above referenced project has approval by the University of Maine's Institutional Review Board for the Protection of Human Subjects. **The approval period is 6/4/2008 through 6/3/2009**. A continuing review of this project must be conducted by the IRB before the end of the approval period. Although you will receive a request for review information approximately 6-8 weeks before that date, it is your responsibility to submit review information before the approval period expires.

Enclosed are approved, stamped copies of the informed consent documents for this project. The approval for these informed consents expires on 6/3/2009. **These approved, stamped copies must be duplicated and used when enrolling subjects during the approval period.**

Please remember that each subject must be given a copy of the informed consent document. Any unanticipated problems or harm to the subject must be reported to the IRB immediately. Any proposed changes to the research must be approved by the IRB **prior** to implementation. Any significant new findings must be reported to the subject.

If you have any questions, please contact me at 1-1498. Thank you.

pc: Herman Weller

MAINE'S LAND GRANT AND SEA GRANT UNIVERSITY
A Member of the University of Maine System

Appendix G

Informed Consent Letter for Student Participants

You are invited to participate in a research project conducted by Dana Peterson, a graduate student at the University of Maine. The purpose of the research is to collect information on summer science research experiences for community college students. You must be at least 18 years of age to participate.

What will you be asked to do?

If you decide to participate you will be asked to share your experiences with the researcher by on-site interviews, on-site observations and by electronic journaling. The interviews will occur on three separate occasions this summer (2008). It is expected that each interview will require approximately one hour of your time. The interviews will be scheduled at a time that is convenient for you.

Examples of the type of questions that may be asked during these interviews are provided below:

- If you could change one thing right now about your summer URE what would it be?
- If you could keep only one thing about your summer URE what would it be?
- If you were able to advise other community college students about appropriate coursework/preparation for a URE what suggestions would you have?

The summer research experiences are expected to begin sometime after June 15, 2008 and will be completed by August 30, 2008.

Risks:
- Except for your time and inconvenience, there are no risks to you for your participation in this study.

Benefits:

The benefits for **your participation** may include:

There is no direct benefit to you, but the **overall benefits** for the scientific community and for federal, state and local science educational foundations/funding agencies may include:

- Enhanced understanding of the intellectual, social and emotional gains that are possible for community college students participating in traditional and non-traditional undergraduate science research experiences.

Confidentiality

Your name will not be used on any documents. A code number will be used to protect your identity. Data will be kept in the investigator's locked file cabinet/home office. Your name or other identifying information will not be reported in any publications. All data (including the key linking your name to the data) will be destroyed after seven years.

Voluntary

Participation is voluntary. If you choose to take part in this study, you may stop at any time during the study. You may skip any questions you do not wish to answer.

Contact Information

If you have any questions about this study, please feel free to contact me at (207) 299-7793. You may also contact me at: Dana.Peterson@umit.maine.edu.

My dissertation adviser is Dr. Herman Weller. He may be contacted by email at:

 Herman.Weller@umit.maine.edu or by phone at (207) 581- 2441. If you have any questions about your rights as a research participant, please feel free to contact Gayle Anderson, Assistant to the University of Maine's Protection of Human Subjects Review Board at (207) 581-1498 or gayle.anderson@umit.maine.edu.

Your signature below indicates that you have read and understood the above information. You will receive a copy of this form.

_____   _____

Signature   Date

Appendix H

Informed Consent Letter for Research Mentors

You are invited to participate in a research project conducted by Dana Peterson, a graduate student at the University of Maine. The purpose of the research is to collect information on summer science research experiences for community college students. You must be at least 18 years of age to participate.

What will you be asked to do?

 If you decide to participate you will be asked to share your experiences with the researcher during two on-site interviews. It is expected that each interview will require approximately one hour of your time. The interview will be scheduled at a time that is convenient for you.

Examples of the type of questions that may be asked during these interviews are provided below:
- Please describe for me your current research projects and how you perceive that your community college intern can contribute to these efforts this summer?
- Please describe the way that "new" laboratory members are trained in your lab? How did you come to establish your training methodologies?
- Please describe the ways that you monitor the progress of your undergraduate students in the laboratory? In what ways, if any, does that differ for your graduate students?

The summer research experience interviews are expected to begin sometime after June 15, 2008 and will be completed by August 30, 2008.

Risks:

- Except for your time and inconvenience, there are no risks to you for your participation in this study.

Benefits:

There is no direct benefit to you, but the **overall benefits** for the scientific community and for federal, state and local science educational foundations/funding agencies may include:

- Enhanced understanding of the intellectual, social and emotional gains that are possible for community college students participating in traditional and non-traditional undergraduate science research experiences.

Confidentiality

Your name will not be used on any documents. A code number will be used to protect your identity. Data will be kept in the investigator's locked file cabinet/home office. Your name or other identifying information will not be reported in any publications. All data (including the key linking your name to the data) will be destroyed after seven years.

Voluntary

Participation is voluntary. If you choose to take part in this study, you may stop at any time during the study. You may skip any questions you do not wish to answer.

Contact Information

If you have any questions about this study, please feel free to contact me at (207) 299-7793. You may also contact me at: Dana.Peterson@umit.maine.edu.

My dissertation adviser is Dr. Herman Weller. He may be contacted by email at:

 Herman.Weller@umit.maine.edu or by phone at (207) 581- 2441.

If you have any questions about your rights as a research participant, please feel free to contact Gayle Anderson, Assistant to the University of Maine's Protection of Human Subjects Review Board at (207) 581-1498 or gayle.anderson@umit.maine.edu.

Your signature below indicates that you have read and understood the above information. You will receive a copy of this form.

_____   _____

Signature   Date

Appendix I

Informed Consent Letter for Lab Colleagues

You are invited to participate in a research project conducted by Dana Peterson, a graduate student at the University of Maine. The purpose of the research is to collect information on summer science research experiences for community college students. You must be at least 18 years of age to participate.

What will you be asked to do?

If you decide to participate you will be asked to share your experiences with the researcher during a single on-site interview. It is expected that the interview will require approximately one hour of your time. The interview will be scheduled at a time that is convenient for you.

Examples of the type of questions that may be asked during these interviews are provided below:

- Have you ever attended a community college or do you know anyone that has/or does attend a community college? Can you describe your experience/or provide any information about the experience of the person that you know that attended a community college?
- What are your impressions of the type of courses taught at community colleges?
- What are your impressions of the kinds of laboratory facilities/laboratory equipment that might be available to community college students?

The summer research experience interviews are expected to begin sometime after June 15, 2008 and will be completed by August 30, 2008.

Risks:

- Except for your time and inconvenience, there are no risks to you for your participation in this study.

Benefits:

There is no direct benefit to you, but the **overall benefits** for the scientific community and for federal, state and local science educational foundations/funding agencies may include:

- Enhanced understanding of the intellectual, social and emotional gains that are possible for community college students participating in traditional and non-traditional undergraduate science research experiences.

Confidentiality

Your name will not be used on any documents. A code number will be used to protect your identity. Data will be kept in the investigator's locked file cabinet/home office. Your name or other identifying information will not be reported in any publications. All data (including the key linking your name to the data) will be destroyed after seven years.

Voluntary

Participation is voluntary. If you choose to take part in this study, you may stop at any time during the study. You may skip any questions you do not wish to answer.

Contact Information

If you have any questions about this study, please feel free to contact me at (207) 299-7793. You may also contact me at: Dana.Peterson@umit.maine.edu.

My dissertation adviser is Dr. Herman Weller. He may be contacted by email at:

 Herman.Weller@umit.maine.edu or by phone at (207) 581- 2441. If you have any questions about your rights as a research participant, please feel free to contact Gayle Anderson, Assistant to the University of Maine's Protection of Human Subjects Review Board at (207) 581-1498 or gayle.anderson@umit.maine.edu.

Your signature below indicates that you have read and understood the above information. You will receive a copy of this form.

_____   _____
Signature   Date

Appendix J

Student Participant Interview Questions

Student Participant Interview Questions: (Week One)

1. Please describe any challenges/obstacles that have presented themselves during the first week in your laboratory setting.
2. Please describe a "typical day" in your research laboratory.
3. What experience has been the most exciting for you this first week in your research laboratory?
4. If you were writing a "how –to-manual" for incoming summer interns what are some of the topics that you would definitely want included?
5. What are the most significant intellectual goals have you set for yourself for this summer experience?
6. What are the most significant personal development goals you have you set for yourself for this summer experience?
7. How have you and your research mentor shared your visions for accomplishing these goals that you have?

Student Participant Interview Questions: (Week Five)

1. If you were to describe the intellectual gains you have made during the last four weeks, what would those include?
2. How important is it to you that your lab colleagues/research mentor shares his/her time/knowledge with you on a:
   a. Daily basis
   b. Weekly basis
   c. Monthly basis
3. Describe the way(s) that you communicate with other:
   a. Researchers in your field
   b. Your research mentor
   c. Your lab colleagues
   d. Your community college supporters
   e. Your significant family members/others
4. If you could change one thing right now about your summer URE what would it be?
5. If you could keep only one thing about your summer URE what would it be?
6. If you were able to advise other community college students about appropriate coursework/preparation for a URE what suggestions would you have?

8. How would you describe your URE to date…positive or negative? What factors might have influenced your choice?
   o Your Age? Age of your mentor?
   o Your Gender? Gender of your mentor? Gender(s) of your primary lab colleagues?
   o Money issues?
   o Preparation issues? Experience of your research mentor?
   o Receptiveness of mentor?
   o Receptiveness of lab colleagues?
   o Other factors?

Student Participant Interview Questions: (Week Eight)

1. Please describe for me the gains in research skills that you have made this summer.
2. How has this experience affected your plans to continue your undergraduate education?
3. Before you began your summer research experience, had you considered pursuing a graduate degree? What were some of the factors that motivated your decision?
4. How has this research experience impacted your original decision to consider a graduate degree?
5. If you were able to continue this research experience (or one similar to it), through the next school year what new intellectual goals would you set for yourself?
   a. If you were given the choice between designing your own research project or collaborating on an on-going research project in the lab, which might you choose…and why?
6. How do you see your summer research experience affecting your motivation in the classroom in the upcoming school year?
7. Describe your most memorable experience from this summer opportunity.

Appendix K

Field Observation Contact Summary Form

Student Participant: _____

Other Research Triad Members Observed: _____

Observation Date: _____

1. Specific examples of laboratory skills attained by the student participant at the mid-point of the summer research experience.

      Skill   Proficiency level

2. Specific examples of verbal exchanges between student participant and other research triad members that signify:
   - Instructive Exchange:

   - Clarification Exchange:

   - Assessment/Evaluative Exchange:

   - Conversational Exchange (non-science related):

3. Specific examples of non-verbal exchanges between student participant and other research triad members that signify:

   - Positive Relationship Indicators:

   - Negative Relationship Indicators:

4. Other/Additional observations that need further exploration/explanation during remaining interview sessions.

Excerpts from Student Participant's Electronic Journals

Joshua

Tuesday, July 8, 2008

Take a little trip with meeeee

OK, yesterday I sold my house... sort of. I am owner financing the place for the first year which basically means they are renting it until they get a loan to pay me off. In theory this means I will get even more money because I get all the interest from that year. It sounds good, but I have my doubts about the buyers ability to make the payments or get the loan. It is possible I will end up taking it back when they don't pay. I hope it doesn't come to that situation.

So this morning and really all day, I drove down to Brooklin to dig out a pot of clams and get a filtered water sample. The drive took over an hour and was very very warm. to get the water samples, here is what I do: filter water through a super duper screen filter into a spray bottle, spray out filter with filtered water, scoop 10 liters of surface water and pour through filter, then turn filter upside down and spray from the underside to send plankton into a vile, repeat for the 2nd sample into formaldehyde except use only 2 liters. the tubes should have 15 ml of fluid in each at the end. The idea here is to concentrate the plankton so it can be easier to measure. the clams I dug up will me mashed up and toxin levels will be measured. I BELIEVE the water sample and the mashed clam testing are directly related since I get them at the same time from the same location. After getting the sample I drove for another hour to "DMR" in Lamoine to drop them off. We don't do this kind of testing so it gets handed off to them. It's all mostly a day of driving and maybe 30 minutes of actual "Scientific" work. I don't have a problem with this because I like to drive and see new areas of the state.

I got back to the lab around 3:30 and didn't do much lab work after that. I took care of some loose ends with my credit card dispute, my phone bill, my house sale, and some misc other stuff.

So I have been taking an online class this summer (ENG 101) and sometimes I feel like I have bit off a little more than I can chew. I have never been as busy as I am this summer and it is challenging. When I get out of the lab during the week, I have to focus on my online class which is hard because I am tired and want to do summer type stuff. I also am still volunteering at the Brunswick hospital laboratory every Saturday after my martial arts class. The combination of all that and the sale of my house just about puts me

to my limit of what I can do. I am going to Montreal this coming weekend (Friday - Sunday) and have to get my week of homework done before Thursday evening. It's going to be rough. I just absolutely hate this English class.

Sam

Week 2

It's always the new guys fault. I had just gotten all the computers working when the wireless system went down. Of course, since I was working on the computers and the wireless sits less than two feet from me, I had to spend half of Monday gently explaining that the computers and the wireless are independent from each other to the four others who use the system, and the other half of the day trying fix the damned thing. Come to find out, it's just old and dying and needs replacement.

I had originally planned to live aboard Wyvern this summer on a harbor mooring. However, I couldn't get down to work on the boat so I am stuck living on land. It's not all bad. I am in "the Plume". It's a small shack where graduate students stay and it's right up my ally. I have to walk around the back of the adjacent building and through a basement to use the bathroom. But that's fine with me, I enjoy the privacy. After this week, I am the sole occupant of the Plume; my roomy rented a cabin for the summer.

I actually got a lot done on the project after the wireless got somewhat straightened out. I am going through the tapes shot this spring in the Caribbean and cutting out clips relevant to [research mentor's] research on coral recruitment. This week I had to choose and cut out clips for a presentation [research mentor] has this weekend in Fl. Since the clips are shot on an inexpensive camera under water, I had

quite a bit of color correcting to do. That brought me back to my days at the newspaper, color correcting photos for prepress. In fact, that was the last time I had to work on macs. They haven't changed, still useless.

Bryan

Field Work

Today I worked for eleven hours. It was a long day and when I finally got home I passed out for two hours. Never the less I had a great time today. We went into the fields to gather together soil samples. I learned how to use a core soil sampler. The contraption was a pain in the neck. The sampler looked like a pogo stick. You were to put it in the soil and pull t up. By doing this a hollow space in the metal rod would fill with earth. The problem was that the soil would stick in the space and it was hard to remove. I came up with a method that made my efforts a little easier. We were supposed to take the sample and shake it into the bag. I would take the sample and run my finger down the opening, quickly depositing the contents into the bag. I found this way more effective then "shaking it" into the bag.

I want to add that I like ALL the people I am working with! It is great to work with a bunch of smart amiable people all day. We have some great conversation. Way better than working at Wal-Mart!!!

Andrea

Saturday, July 26, 2008

Data Analysis

As you know I have been doing different strengths of acetycholine injections on the wild type pupae. As the strength become more diluted I am finding the results more typical to what I would expect from the injections. Friday [research mentor] showed me how to convert the raw data into correlations and other mathematical sequences for analysis. Since there is so much data I am thankful that a computer does most of work for you; but it is nice to make sense of everything that I have been doing and to see it on paper.

I also learned more about taking electrocardiograms from the pupae this week. I had a little trouble because there are two electrodes that are inserted just under the external layer of tissue on the pupae, and one electrode was sharp but the other was much more blunt and gave me some trouble. Hopefully next week the problems with

the electrodes will be worked out; I believe that [research mentor] was planning on spending Friday afternoon on getting everything in line.

As goes the xenopus; we received three more females early on this week so now we are up to a total of six patients. [Lab colleague] and I were talking about what differences might be found between the younger frogs and the older ones; the age of the oocytes and whatnot. I suppose that we will find out next week because the surgery we are performing on Monday is on one of the younger frogs.

Tabitha

Wednesday, July 9, 2008

<u>After work!!</u>

I really believe this is the best summer job I have had!! it allows me not to spend all my money on clothes at the Gap outlet.. although i use to get a ridiculous discount.. After work today Lo Lo aka [lab colleague] asked if i wanted to go to Range Pond .. Its in Auburn and i use to go there when i was little.. ahhh.. so I said yes.. partly cause it was boiling in my room at 4 p.m. and partly because they all went to see Walle yesterday and I didnt go cause i promised my sis i would watch it w/her.. Ne ways.. So i went it was [lab colleague], [friend of lab colleague] (works in admissions-gives tours etc) and Me. We got there just in time to leave.. literally we were there for less than 15 min. if you count the time it took us to walk down to the water.. The thunder clouds rolled in and the lightning started flashing in the distance..the air got really crisp and beautiful.. It was nice and we would have stayed there if the wind had picked up and created a sand storm which caused sand to fly into our mouths, ears, hair, and worst of all eyes.. So we went back to [campus] and to [dining hall]- which doesnt have as much food to offer as lunch does.. My guess is that the chef's dont want to make so much food cause that means they have to stay longer to clean it all up.. I totally do not balme them.. :))

Nite.. .. This was the color mixture of the thunder storm clouds today. .. ohhhh ahhhh

Appendix M

Representative Dialogue Exchange from Electronic Discussion Board

Week 2, day 2.

So I came in this morning at 9:30 because I took longer than usual to get ready this morning. My sort of girlfriend stayed over last night at the house. Anyway, I have a flexible schedule at my lab, but they are usually in at 9:00. [Research mentor] had some people in talking about a special DNA sensing field device and she had hoped I would be there for the meeting. I wasn't aware of the meeting last night. I asked [lab colleague] if [research mentor] was upset about me coming in later than 9:00 this morning and She said it wasn't a big deal, she just had wanted me to hear the talk. They printed out a powerpoint thing for me to look at which covers what was said in the talk anyway. No big deal supposedly, but I want to make sure I am in at 9:00 in the future just to make sure they don't think I am a slacker.

I was sort of set free on the clam weighing project and both [lab colleagues] stopped by to make sure I wasn't screwing it up. I wasn't so that was cool.

I got a cold sore yesterday morning and I wonder if it had anything to do with the brief UV exposure in the UV room. It's a possibility. Just another reason for me to be paranoid.
Posted Jun 17, 2008 12:52 pm - [delete]

Trademark re: Week 2, day 2.
Oh.. cold sore.. I have never had one but i assume they must suck.. You remind me of myself.. getting paranoid over things.. but, here they also said to be careful with the U.V. so it of could potentially had an affect. But, stress could have very well brought on your cold sore. I will let you know if Prof. P has any tips about your bone loss. etc. How old are you if you don't mind me asking?
Posted Jun 17, 2008 1:01 pm - [delete]

re: Week 2, day 2.
I am 29. I don't think they have adequate UV protective gear here, but the other people in the lab haven't had any problems with it.
Posted Jun 17, 2008 2:02 pm - [delete]

Appendix N

Research Mentor Interview Questions

Research Mentor Interview Questions: (Week Two)

1. Please describe for me your current research projects and how you perceive that your community college intern can contribute to these efforts this summer?
2. Please describe the way that "new" laboratory members are trained in your lab? How did you come to establish your training methodologies?
3. Please describe the ways that you monitor the progress of your undergraduate students in the laboratory? In what ways, if any, does that differ for your graduate students?
4. Please describe for me what a "typical day" for YOU is like during the summer session?
5. Have you had an opportunity to observe any differences in the ways that your undergraduate students approach their laboratory work compared to your community college student?
6. What aspects of the research process are you most concerned that your community college student understands by the end of the summer internship? Which aspects of the research process are of the least concern?
7. Can you describe for me the type(s) of undergraduate research efforts you undertook? What was the most valuable aspect of your undergraduate research experience?

Research Mentor Interview Questions: (Week Eight)

1. Describe for me some of the developmental gains you perceive your community college intern has made this summer.
2. Based on your experiences this summer, how would you feel about placing another community college student in your lab next summer?
3. What have been some of the unanticipated outcomes of having a community college student work in your lab this summer?
4. Can you describe any instances this summer when you were able to offer your community college intern either academic or career guidance?
5. All things being equal, would you be willing to "guest lecture" at a local community college for a semester if offered the opportunity?

Appendix O

Lab Colleague Interview Questions

Lab Colleague Interview Questions: (Week Four)

1. Have you ever attended a community college or do you know anyone that has/or does attend a community college? Can you describe your experience/or provide any information about the experience of the person that you know that attended a community college?
2. What are your impressions of the type of courses taught at community colleges?
3. What are your impressions of the kinds of laboratory facilities/laboratory equipment that might be available to community college students?
4. When you were told that a community college student would be working in the lab this summer, do you remember what your first thoughts/or impressions were?
5. For you, what have been some of the challenges in the laboratory this summer?
6. Can you describe for me the research project that you are currently working on?
7. What are your ultimate educational and career goals?

Lab Colleague Survey

Lab Colleague Survey: (Week 4)

1. Please indicate your present level of education.
   - o Freshmen
   - o Sophomore
   - o Junior
   - o Senior
   - o Graduate student
   - o Post-Doctorate

2. Please indicate your age.
   - o 18 – 22
   - o 23 – 29
   - o 30 – 39
   - o 40 – 49
   - o 50 and older

3. Please indicate your gender.
   - o Female
   - o Male

4. Please indicate which category best describes your ethnicity/race.
   - o African-American
   - o American Indian or Alaskan Native
   - o Asian or Pacific Islander
   - o Caucasian/White
   - o Hispanic
   - o Other
   - o Prefer not to respond

5. Are you currently a student at this institution?
   - o Yes
   - o No

6. How long have you worked in this research laboratory?
   - o 0 – 3 months
   - o 4 – 6 months
   - o 7 – 12 months
   - o 1 – 2 years
   - o 3 – 5 years
   - o 6 years or more

7. Current GPA:
- o No credits earned
- o 1.99 – or below
- o 2.0 – 2.49
- o 2.5 – 2.99
- o 3.0 – 3.49
- o 3.5 or above

8. Employment status:
- o Full-Time, stipend supported
- o Full-Time, voluntary
- o Part-Time, stipend supported
- o Part-Time, voluntary

9. Residence classification:
- o In-state
- o Out-of-state
- o International (not a US citizen)

10. Physical disability or diagnosed learning disability?
- o Yes
- o No

Appendix Q

Audit Trail: Data Reduction Strategies

Excerpt from: Joshua's First Interview Transcript

Researcher: Do you want to talk a little bit about...ahm.. if you were going to come back next year and talk to people in that very first recruiting session about undergraduate research experiences - would here be anything that has happened in the first week that you wouldn't wish like, on your worst enemy? That you would want to say, okay, here are the things you should get under control the very first week?

Joshua: Well, when you first get in there you want to be cautious a little bit, you want to ahm not go in with a ... big ego or an attitude that you know what you're doing. You want to... go in there with skills but you want to make sure they show you how to do these things anyway. And ahm ... what else?

Researcher: Was it, things so much in the laboratory, or was it things like navigating how do I get a key to the building, or find a parking space, or those kinds of things that were challenging?

Joshua: Oh yeah, you definitely want to get the parking situation figured out. What I'm doing is I go to the student ahm, student center the < > card center, and you can get a free parking pass there. You have to renew it every week. But it's great. So you want to do that right away. And ahm...

Researcher: Was the size of the campus, at all, intimidating to you?

Joshua: No, it wasn't intimidating, but I did drive around it and walk around it at little bit before I even started in the lab. I wanted to figure out where everything was in the beginning. It's also helpful that my, ah, the other members of my lab all go to lunch at the same time…and I go with them. And so they took me to the Student Union, and showed where the food was and showed me around there.

In this series of exchanges between the researcher/interviewer and the student participant (Joshua), all three of these responses were coded to the open coding category, "How to Manual." From this first interview with Joshua, there were a total of twenty-one different responses that were coded to fourteen different open coding categories. Based on total textual data from this first interview with Joshua, these three responses comprised 4.2% of the total interview. Four other student participants (Andrea, Bryan, Catherine and Sam) contributed responses during their interview sessions that were coded to this same category. Responses coded to this category (How to Manual), were not directly related to either one of the axial coding categories.

Appendix R

Excerpts from the Researcher's Reflexivity Journal

On: The Power Differential between the Student Participants and Myself

Knowledge is power…I think some of the students began to understand that as they became more proficient in their science laboratories. As time went forward over the course of the summer, they became as knowledgeable, or more knowledgeable than I about their projects…in that regard there was no power differential between us – if anything, each of them became knowledge empowered.

On: Non-Traditional Students Understanding of Graduate School

Many students are unaware of the limitations of an associate's or a bachelor's degree in the sciences. Since so many of these students are first generation college students, they are totally unaware of the challenges and the opportunities of graduate school science programs. And where will they get that information? Certainly not in their textbooks, nor from their instructors, and usually not from their classmates, who are also first generation college students. Many of the students I work with every day, and certainly the students involved in this URE this summer, did not have even the most basic understanding of the process of graduate school ("You have to take a test to get in???") or the difference between a master's degree and a doctorate, or that you don't necessarily have to earn a master's degree before pursuing a Ph.D.

On: Locus of Control

This summer, each of the student participants, in his or her own way, navigated the system successfully. They gained confidence in their ability to do science research but, more importantly, they gained confidence in their ability to be doers, rather than the "done-to." The perceived locus-of- control shifted from external to internal. In many ways, they achieved the highest level of Maslow's hierarchy – they actualized their potential…they will forever be changed by their summer experience for that reason.

Appendix S

Representative Computer Screen Shots of ®™NVivo 8 Open Coding Categories

Electronic Discussion among Students

Questioning the norm
Joshua:
So I learned something today about my PI [Principal investigator]. She is married. Before you throw my previous theory out the window, her husband does go with her on her "expeditions" to aid in research. So I guess you can have a "full" life as a higher-up researcher, but you have to find people that are willing to tag along. I don't know if she has kids, but I bet she doesn't. Kids take up too much time. The idea scares me a little. You might think I am in an easier position as a man, but there is an angle that is often forgotten here. Very few women out there know they don't want children. To be a man searching for a future wife while saying they don't want kids just won't work (sure it can work, but we are talking about a very low percentage). So what does this mean? I think it can be made as simple as this:

Women choose: Do I want to have kids or not?
Men Choose: Do I want to have a wife or not?

I think we are sort of in a transitional stage our cultural development where the standard family is beginning to melt away and we just don't know what to do anymore. My culture and some other mysterious part of my brain influence me to have a standard family, but my new age mind allows me to question it. What benefit does it bring to me? Is it just a burden wrapped up in some kind of hormonal disguise? The clock continues to tick and I still don't have the answers.
Posted Jun 25, 2008 12:37 pm

Andrea: re: Questioning the norm
So is it that you don't want to have kids? And if that is the case then I might suggest some editing to you're simplification. I think perhaps you have over-simplified it and I hope that if it is the case that you don't want kids that you shouldn't feel that it defines you or limits you; there are plenty of women that I know that don't want to have kids. One of my best friends had known since she was in high school that she didn't want kids. Continue to question the norm.
Posted Jun 28, 2008 5:49 am

Bryan: re: Questioning the norm
I would like to comment on your questions about family by giving you part of my outlook.
For me, raising a family has to do with manhood, honor, personal satisfaction and the evolution of the species. Because contemporary society has put a damper on the validity of family life, I think this gives me all the more reason to take the lead, set an example and develop strong, healthy and emotionally sound familial relationships. I want to stress

that this view is my own personal view and may not be right for everyone.

First, raising a family has to do with manhood. As men we are genetically programmed to have children. I feel that as a man it is my mission to have children. For me, having babies and raising a family is the true meaning of manhood.

Secondly, raising a family has to do with honor. I feel that taking responsibility in the vows of marriage is a serious, honorable commitment. By a husband and wife sticking to their promises they behave honorably. When taking the responsibility of bringing children into the world I realize children deserve mature, stable parents who are committed to each other, the family and the children. This idea of marriage may not be true for everyone but I have faith that it is right for me.

The evolution of the species is also of paramount importance. I feel like my genetics have a lot to offer the Gene pool. This means propagating my seed. Nature loves large litters and relishes the struggle for servile. Their must be some counterbalance to the reckless ecstatic fertility of the ignorant and uninformed with the fertility of the educated, moral family.

Raising a family offers me a séance of personal satisfaction. I work with the idea that everything I acquire, everything I learn, every accomplishment I earn and every trial I pass cane be passed on the my family and, ultimately, my children and my children's children. This gives me an enormous feeling of personal satisfaction to know that I labor not for my self but for untold generations into the future.

Contemporary life has assaulted the foundations of family. Family no longer has the economic base it used to have. People do not have time to raise children because of work. Who is raising the generation of the future? Is it the school, church, government, or media? Or is it the family? What should it be? I choose the family! Because it is all the more difficult, in today's fast paced world, to raise a holistic family I have all the more reason to take the responsibility into my own hands. If I don't who will!?

What are your thoughts??
Posted Jun 29, 2008 4:53 pm

Joshua: re: Questioning the norm
I understand what you are saying and I have felt the same way at times. I believe there is honor and important responsibility involved with having children. The NEED to have a marriage and children I am questioning.

There are some problems with a few things you said. How can you say that your genes are superior? What makes your genes superior? You have gone to college, you don't do drugs and you don't kill people. What does this have to do with genetics?

I like to think I have good genes too, but do I really? I have receding gums which may be linked to heart problems, one of my eyes doesn't work as well as the other, I have a sensitive digestive system and my elbows are weak. If I have children, I will possibly

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pass this on to them. I am not saying I am a flaw in a perfect genetic world. I am saying we are all flawed and it's hard to say who has better genes and who doesn't.

It is honorable to be a father. I don't mean for this to be a stretch, but there are so many children out there in need of adoption. So is it selfish to have your own children? Wouldn't it be more honorable to adopt? When you have your own children purposefully, in a way you are saying it's okay that there is a child out there living parentless.

I don't know. I am feeling scatterbrained today. I am still questioning the norm and questioning why I do what I do.
Posted Jun 30, 2008 1:34 pm

Bryan: re: Questioning the norm
It is good to question things. In fact, I have faith that it is essential! Good job Joshua. If my genetics are bad I trust that natural selection will iron them out of the gene pool in the long run. However, I still think that I should at least roll the genetic dice and give my unborn snowflake a chance. I agree with you on adoption and I think adopting is honorable as well. I will adopt as well as have children of my own.
As far as the need goes maybe there is not one! Maybe here is no need unless we create one… hmmmm……
Posted Jul 2, 2008 8:03 pm

BIOGRAPHY OF THE AUTHOR

Dana Peterson was born in San Diego, California on June 30, 1958. She attended high school in Kansas City, Missouri and graduated from Park Hill High School in 1976. She attended the University of Missouri and graduated with a Bachelor's degree in Biological Sciences in 1983. She completed her first Master's degree in Education in 1991 at the University of Oklahoma. Her second Master's degree was awarded from the University of Colorado in 1998 in Biology. She has been a member of MENSA since 1991. Her professional career has been spent teaching and practicing science in higher education. She is a candidate for the Interdisciplinary Doctor of Philosophy degree in Biochemistry, Molecular Biology and Higher Education from The University of Maine in August, 2009.