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The Next Generation of Innovators:
A Mixed Methods Analysis of Humanities and STEM Students’ Propensity Toward Innovation
and Their Perceptions of Influential Academic Experiences

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy
in Education

by

Tiffany Lee Tsang

2018
ABSTRACT OF THE DISSERTATION

The Next Generation of Innovators:
A Mixed Methods Analysis of Humanities and STEM Students’ Propensity Toward Innovation
and Their Perceptions of Influential Academic Experiences

by

Tiffany Lee Tsang
Doctor of Philosophy in Education
University of California, Los Angeles, 2018
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In recent decades, higher education institutions have been increasingly called upon to prepare students for work after college. STEM programs in particular have been provided with increasing federal- and institutional-level support in order to meet the demands of a competitive global marketplace as well as to provide revenue generation for colleges and universities. At the same time, support for humanities programs, especially from the federal sources, have dwindled steadily since the 1970s. Although STEM degrees are perceived to be more relevant to the workplace and the economy, recent surveys of employers from different sectors of the economy have indicated that what they value most in recent college graduates is the ability to think innovatively. Due to extant literature suggesting that humanities undergraduate education may be
better at fostering innovative thinking compared to STEM undergraduate education, this study sought to investigate if a difference indeed exists between humanities and STEM students’ end-of-college propensity toward innovation (PTI).

This mixed-methods study utilized national-level student survey data from the Higher Education Research Institute (HERI) for the quantitative phase and examined differences in outcomes between humanities and STEM students’ PTI as well as academic predictors of PTI. Sixteen participant interviews were utilized in the qualitative phase to explore why these academic experiences were particularly impactful as well as why humanities and STEM students may experience differential outcomes in PTI. Findings from the study revealed that humanities students tended to leave college with higher PTI even after controlling for important background and institutional characteristics. Findings also revealed that impactful academic experiences were highly influenced by epistemological and pedagogical differences between undergraduate humanities and STEM education.
The dissertation of Tiffany Lee Tsang is approved.

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2018
“To be a Shakespearean scholar, or to absorb oneself in black holes...is not just to take up a technical task, but to place oneself inside a cultural frame that defines and even determines a very great part of one's life.”

-Clifford Geertz (1976)
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CHAPTER 1: INTRODUCTION

In recent decades, higher education institutions (HEIs) have been increasingly charged with the responsibility of preparing students for employment due to changes in the national and global economy as well as heightened concerns over U.S. global competitiveness (Canaan & Shumar, 2008). Much of the focus on employment preparation has centered on increasing attention toward and supporting STEM (science, technology, engineering, and mathematics) programs and education (CoSTEM, 2013). However, focusing narrowly on STEM may not be the answer to changing workplace and economic demands as some scholars suggest that humanities education may be better able to provide students with the most in-demand 21st century workplace skill: innovation—which is defined by some scholars as a combination of creative thinking and initiative (Edelstein, 2010; Schneider-Bateman, 2012). To date, however, no empirical studies have been conducted to compare students’ level of innovation at the end of college by discipline. Nor have any studies attempted to identify the curricular and pedagogical factors unique to different disciplines that contribute to the fostering of innovation. By comparing humanities and STEM students’ college gains in their propensity toward innovation as well as examining the curricular and pedagogical factors that influence their gains in this area, this study is a step toward a more comprehensive assessment of disciplinary contributions to students’ preparation for work in the 21st century.

Innovation vs. the Propensity toward Innovation

According to a wide range of scholarly and popular sources, innovation has become increasingly valued by society, especially in regards to its relevance to the workplace and the economy (Fallon, 2014; Pyle, 2014). While significant figures throughout history such as
Leonardo DaVinci and Benjamin Franklin have been recognized for their innovative thinking, the concept of innovativeness as a characteristic achievable by “ordinary” individuals did not emerge until the latter half of the 20th century (McWilliam, 2008). As innovation began to be viewed as a desirable skill achievable by ordinary individuals, it also became an increasingly valued skill in the workplace. The rise of innovation as a valued workplace skill can largely be attributed to the U.S.’s dramatic shift from a production-based economy toward a knowledge-based, globalized economy—that is, an economy in which ideas rather than goods are the driving force.

According to various sources, by the late 1970s, the U.S. economy which formerly had a strong manufacturing sector had become heavily dominated by a service-based sector which included technology and financial services; and indeed, the service-based sector of the economy has continued to grow steadily in the 21st century (Johnston, 2012; Short, 2011). Currently, more than ever, employers have come to value innovation as an indispensable skill, as evidenced by the results of an extensive survey conducted by the American Association of Colleges and Universities in 2013, which revealed that 95% of employers recruiting for entry-level positions rank innovation as one of the the top skills they seek in recent college graduates (AAC&U, 2013).

Although we know that innovation is a skill that is highly sought after by employers, innovation, as it is understood in a workplace context, is rarely demanded in the college setting. Often defined as a combination of creative thinking and initiative, innovation in the workplace is primarily measured by one’s ability to produce a deliverable with either marketplace or social value (Innovation Management, 2013). Students in college, however, are rarely asked to perform these types of tasks, which may include activities such as developing a product that can be
patented and sold, procuring venture capitalist dollars, or devising creative solutions to problems in local communities (Mayhew, Simonoff, Baumol, Wiesenfeld, & Klein, 2012). Hence, it is difficult if not impossible to measure students’ ability to be innovative in a workplace-relevant definition. However, what is possible, to a degree, is to measure students’ potential to be innovative in an employment setting. In other words, since it is not possible to measure students’ actual ability to be innovative in the workplace, by using carefully selected national student survey responses that measure specific student characteristics and dispositions, we may be able to capture students’ inclination, or propensity toward innovation in their post-graduate careers.

**Purpose and Significance of the Study for Research**

The first major purpose of this study was to examine quantitatively if and how humanities and STEM students may differ in their propensity toward innovation at the end of college. Related to this first purpose was an exploration of how academic experiences correlated with humanities and STEM students’ propensity toward innovation at the end of college. Although sources suggest that humanities and STEM education may differ substantially in their ability to foster several key student outcomes, there had been no study to date that quantitatively compared the learning outcome differences between humanities and STEM students in regards to their propensity toward innovation. In addition, no study had addressed the academic and curricular factors that may contribute to this outcome. Thus far, studies focusing on college students have only attempted to measure cognitive learning outcomes such as creativity and critical thinking, arguably highly related to innovative thinking, but not directly measuring that construct (e.g. Laird, Seifert, Pascarella, Mayhew & Blaich, 2014; Peterson, Barrett, Hester, Robledo, Hougen, Day & Mumford, 2013). In addition, quantitative studies that have attempted to compare
innovation as an outcome between different groups have largely been conducted in workplace and labor settings (e.g., Scott & Bruce, 1994; Cohen & Levinthal, 1990; Zahra & George, 2002) and not in educational settings.

The second major purpose of this study was to explore qualitatively how students perceive different academic experiences and the influence of these experiences on students’ propensity toward innovation. Insights gained from the quantitative analysis were used to inform and guide the qualitative phase of this study (this will be explained more thoroughly in Chapter 3). Thus far, extant research using a qualitative lens has focused on how college students have benefitted from academic experiences in regards to encouraging creativity and other related cognitive outcomes; however, no qualitative study to date has explored how academic and curricular experiences might help to foster students’ propensity toward innovation.

In response to the need for more empirical research on this topic, this study sought to explore and measure what differences, if any, exist between humanities and STEM students’ propensity toward innovation at the end of college and identified various academic-related predictors. In addition, this study explored qualitatively how students perceive potentially beneficial academic experiences in regards to impacting their propensity toward innovation. The qualitative phase of this study also explored academic experiences that possibly undermined or inhibited students’ propensity toward innovation and why humanities and STEM students might experience differential outcomes. The need for such a study is first and foremost made evident by the dearth of studies examining innovative thinking in college students. This was of particular concern due to indicated employer need for innovative thinkers in the workplace. In addition, this study was also theoretically supported by prior research suggesting disciplinary differences in conceptually-related student outcomes.
Significance of the Study for Practice

The significance of this study in regards to practice are myriad both at the teaching and administrative levels. In regards to teaching, results from this study revealed the types of academic and curricular experiences that may contribute to and possibly detract from students’ propensity toward innovative thinking. This is especially significant as instructors have been increasingly asked by students, parents, and society to explain how the curricula they develop contribute to students’ preparedness for employment after college. Results from this study also helped to determine how instructors might be able to enhance students’ propensity toward innovation by increasing emphasis on certain pedagogical practices over others. In addition, the qualitative aspect of the study may also help instructors to understand how their students perceive their curricula choices and classroom practices.

Furthermore, this study revealed significant insights in regards to effective administrative practices and ultimately institutional goals. Just as instructors have been asked to explain how the subjects they teach and their teaching methods contribute to students’ preparedness for work after college, HEIs have been asked by the public to justify how their institutions as a whole help students prepare for post-graduate employment. As a result, administrators have often defended institutional funding practices by their perceived link to improving students’ ability to contribute to the workplace and economy (Clark, 1998; Goldin & Katz, 2008). For example, STEM disciplines’ often assumed closer ties to the marketplace and the perceived workplace value of STEM degrees have generally led to boosts in funding for STEM programs while humanities disciplines’ purported weaker ties to the market economy have both directly and indirectly led to decreased funding for humanities departments across the nation (Brinkley, 2009; Brint, 2002; Brint, Riddle, Turk-Bicacki & Levy, 2005; Mathae & Birzer, 2004). In addition, at the student
affairs level, student affairs officers and other support staff have paid increasing attention to helping students draw links between their academic work and their post-graduate careers (Gordon & Steele, 2015). Determining which disciplinary areas are helping students the most in regards to fostering their propensity toward innovation may serve to inform how institutional leaders might be able to modify both administrative procedures and co-curricular programming in order to better prepare students for work after college.

Research Questions

The research questions guiding this study were:

1) What differences, if any, exist between humanities and STEM students’ end-of-college propensity toward innovation (PTI)?

2) What academic experiences significantly predict humanities and STEM students’ propensity toward innovation (PTI)?

3) How do students perceive curricular and pedagogical practices as impacting their propensity toward innovation (PTI)?

4) What might account for the potential differences in humanities and STEM student PTI outcomes?

To answer the first two questions this study used data from the Cooperative Institutional Research Program (CIRP), administered by the Higher Educational Research Institute (HERI) at the University of California, Los Angeles (UCLA). In particular, the two surveys used were the Fall 2011 CIRP Freshman Survey (TFS) and the Spring 2015 College Student Survey (CSS). The 2011 TFS contains information about students’ pre-college characteristics including personal and academic background, values, goals and attitudes. The 2015 CSS is a follow-up for
the 2011 TFS and includes information about students’ experiences and activities while in college, as well as personal values and post-graduation plans. Perhaps most importantly, unlike other national student survey datasets, this dataset includes questions that asked students about their self-ratings on creativity as well as their value of innovation in regards to their post-graduate careers.

In order to answer the third and fourth research questions, semi-structured interviews were conducted with students from a variety of humanities and STEM disciplines. The interview protocol was informed by results from the quantitative phase of the study.

**Organization of Paper**

Broadly speaking, this study aimed to address how students’ propensity toward innovation at the end of college may differ based on students’ area of study. It also attempted to break new ground by determining the academic factors that predict humanities and STEM students’ PTI at the end of college and explore the potential factors that may account for differences humanities and STEM student outcomes. Thus far, researchers in higher education have not conducted any quantitative or qualitative studies that examine the connection between students’ academic experiences and their propensity toward innovation. Chapter 1 thus serves as an introduction to the topic and the salience of the topic in regards to research, practice, and student preparation for employment.

Chapter 2 of this paper provides a comprehensive overview of the extant literature on the topic, and in particular, research that has been conducted on skills cognitively related to innovation. Chapter 2 also provides an explanation for comparing STEM and humanities students and the theories on learning and teaching that explore why differences in outcome may
exist between students in these two areas of study. In addition, Chapter 2 provides further theoretical grounding for the dependent (or outcome) variable by introducing the theory of planned behavior.

Chapter 3 of this paper provides a detailed outline on the methodology that grounded this study and the methods that were used to measure and explore both quantitative and qualitative outcomes.

Chapter 4 presents findings from the quantitative phase of the study (which answer research questions 1 and 2) and points of interest related to these findings. Chapter 4 also addresses how the quantitative findings informed the research protocol for the qualitative phase of the investigation.

Chapter 5 presents findings from the qualitative portion of the study (which answer research questions 3 and 4) as well as points of interest related to these findings.

Chapter 6 concludes the paper with a final discussion on the limitations of this study, connections between findings and theory, as well as implications for practice, policy, and future research.
CHAPTER 2: LITERATURE REVIEW & THEORETICAL FRAMEWORK

The primary goal of this chapter is to present contextual information and theoretical frameworks that will explain the relationship between the greater higher education landscape, theories on student learning and behavior, and students’ propensity toward innovation. In order to do this, I organize this chapter into six sections:

(1) First, I provide a brief summary of the changing status of the humanities vis-à-vis the sciences from the early years of American higher education to the 20th century.

(2) Next, I examine the literature discussing how federal and institutional support for STEM has resulted from the perceived link between STEM and student employment preparation.

(3) Third, I review the literature explaining how student preparation for work has changed since the latter half of the 20th century and the increased value of innovation as a workplace skill for post-college, entry-level employment.

(4) Fourth, I explore epistemological, pedagogical, and other fundamental differences between STEM and humanities education.

(5) Fifth, I present theories on student learning that support the hypothesis of STEM and humanities education producing different innovation outcomes in students.

(6) And lastly, I present literature on behavioral theory that supports the use of students’ “propensity toward innovation” (PTI) as a suitable proxy in the absence of data that allows us to measure students’ ability to be innovative in a workplace setting.
The Changing Status of the Humanities and the Sciences from the Early Days of American Higher Education to the 20th Century

Many historians of higher education have in great detail chronicled a centuries-long intellectual trend in higher education that has been characterized by a waning value of “classical” education and a concurrent rise in prominence of science education. Historians have presented different perspectives on the reasons for this trend, but nonetheless, agree that the pursuit of classical studies began to decline as science—and especially the practical application of science—began to compete with, and eventually dominate over, the “gentlemanly pursuits” of studying classical languages and literature. Once considered the pillars of higher education in colonial-era colleges, classical studies began to wane in popularity and prestige as science education became more prominent during the age of industrial and westward expansion during the 19th century (Cohen & Kisker, 2010; Geiger, 2015; Hofstadter, 1962; Rudolph, 1962).

According to Geiger (2015), the main goal of the early colonial colleges, including Harvard and Yale, was to train young gentlemen for work either in the clergy or for municipal leadership positions. In order to be considered a learned “man of letters,” a student was expected to have studied Greek, Latin, Hebrew, and classical literature, in addition to having attained a thorough understanding of theology. Harvard College in particular was looked upon to “train the school masters, the divines, the rulers, the cultured ornaments of society—the men who would spell the difference between civilization and barbarism” (Rudolph, 1962, p. 6).

The first signs of the weakening of religious, and specifically, puritanical control over Harvard and other colonial colleges began to appear during the Enlightenment during which rationalism and increasing secular tolerance added to the decline of institutional religiosity and and a greater adoption of science education. According to Cohen and Kisker (2010), the changes
in college curriculum in the colonial era can be summed up as “a change from a curriculum based on church doctrine...to one in which science replaced divine revelation as the ultimate standard” (p. 43). In addition, Rudolph (1962) explains that a new respect for natural law, reason, and rationality began to undermine the “firm grasp of monolithic theology” and pushed colleges to be more receptive to theological and philosophic diversity (p. 10). Though “still vigorous, still in charge, [and] still respectable” the “divine arts” were undoubtedly in decline by the end of the 18th century (Rudolph, 2015, p. 40). In addition, the War for Independence also helped seal the fate of declining religiosity by fundamentally changing the public outlook on the purpose of higher education. While institutions once felt it their primary duty to train clergymen and public servants, leaders of the newly independent United States began to look to institutions of higher learning as a means to prepare individuals for their roles as citizens in the new Republic (Geiger, 2015; Rudolph, 1963).

Tensions between the old, classical curriculum and more practical education came to a head in the early 19th century and culminated in the Yale Report of 1828. During this time, college leaders were experimenting with a curriculum that was becoming increasingly fragmented and specialized as colleges grew in number. While some of the colonial-era subjects such as Latin and Greek remained, they were commonly being supplemented by studies in mathematics and the sciences. Some institutions also began to offer specialized courses and programs for students interested in the more practical fields of engineering and agriculture. However, the shift to a more elective-style system met with powerful dissent from educators who wanted to preserve the traditional college curriculum. In the Yale Report of 1828, the Yale College president and faculty declared that students should be required to study the classical curriculum in order to gain a comprehensive and well-rounded education. Despite the resistance
to changing curricula, however, the foundation had in many ways already been laid for the university model with its separate schools, elective system, and the inclusion of more practical fields of study (Geiger, 2015).

Growing support for scientific education undoubtedly hinged upon Americans’ desire to conquer and tame western lands. In fact, many of the state institutions established by the Morrill Act of 1862 were some of the earliest proponents of science education and promoted it as “an instrument for exploiting the great natural wealth of inland America” (Rudolph, 1962, p. 223). According to Hofstadter (1962), nineteenth-century Americans were confronted with a vast amount of land rich with resources, and as a result “set a premium on technical knowledge and inventiveness which would unlock the riches of the country and open the door to the opulent future” (p. 238). This “disdain for the past” and “rationalistic protest against superstition” manifested itself as a disdain for the old curriculum with its emphasis on ancient languages and theology (Hofstadter, 1962, p. 238).

At the dawn of the 20th century, science education continued to be viewed as a means to make education useful for democracy. As land grant colleges continued to develop, they often emphasized to the public the practical and utilitarian benefits of having an institution of higher learning that would push America forward by training citizens not only to harvest the land’s natural resources but also to turn desolate regions into viable communities and metropolises. As a result, in addition to traditional sciences, colleges in the midwestern and western states often developed programs in agriculture, animal husbandry, and mining. This change in curriculum from classical studies to more scientific, and arguably utilitarian, studies reflected Americans’ belief that education could be used to further the goals of “manifest destiny” and democracy. By
the 20th century, it had become clear that science education would remain a permanent and indispensable fixture of American higher education (Rudolph, 1962; Hofstadter, 1962).

**STEM and Student Employment Preparation**

During the Cold War, science education and research were emphasized in colleges and universities specifically due to concerns over national security and defense. The end of WWII had brought with it a “search for security in a world made unstable by collapsing colonial regimes; the rise of the Soviet Union as a military power…and the fearsome new military capabilities headed by atomic weaponry” (Cohen & Kisker, 2010, p. 187). As a response, the federal government became a major sponsor for applied science education and research. Federal programs such as the National Science Foundation (created in 1950) and the National Institute of Health (newly enhanced after WWII) began to provide large sums of grant funding to colleges and universities to improve research and to encourage research development (Thelin, 2011). These initiatives were executed at least in part to ensure U.S. security and a strong geopolitical position in an environment of heightened polarization between capitalist and communist regimes. By 1960, the Department of Defense accounted for roughly one-third of federal support for academic science (Cohen & Kisker, 2010).

With the end of the Cold War, however, national defense became less of a driving factor behind federal support for science education and research. By 1975, the Department of Defense only accounted for eight percent of federal funding for academic research (Cohen & Kisker, 2010, p. 276). Nonetheless, the federal government and HEIs have maintained their strong support for STEM in recent decades due to its perceived link to student employment preparation. The link between STEM education and student work preparation has continued to be of national
concern due to the rising economic status of other nations that threaten U.S. dominance in the
global economy. Hence, since the 1980s, national focus has turned toward supporting and
improving STEM education as a way to prepare students for work in a changing global economy
as well as to help secure the U.S.’s place in that global economy (Canaan & Shumar, 2008; The
White House, 2009). The U.S.’s scramble to maintain its geopolitical prominence on the
international stage as well as its superior economic positioning was highlighted fairly recently by
President Obama’s address to the National Academy of Sciences in 2009 when he stated that:
“American students will move from the middle to the top of the pack in science and math over
the next decade. For we know that the nation that out-educates us today—will out-compete us
tomorrow” (The White House, 2009, p. 1)

Scholars explain that as a result of the perceived importance of STEM to our national
economy and global economic positioning, science programs have continued to receive
increasing federal and institutional funding for STEM research activities (PCAST, 2012; Taylor,
Cantwell & Slaughter, 2013). In addition, this has also led to increased institutional support in
the form of program, personnel, and operational development (Brint, 2002; Brint, Riddle, Turk-
Bicacki & Levy, 2005; PCAST, 2012). In 2012, the President’s Council of Advisors on Science
and Technology (PCAST), an advisory group consisting of the nation’s leading scientists and
engineers, for example, issued a report providing “a strategy for improving STEM education
during the first two years of college” in order to meet the goal of producing one million
additional college graduates with degrees in STEM. The objective of the report was to help
initiate policies that would improve STEM education as well as the retention rates of students in
STEM majors. The PCAST (2012) report argued that this approach would provide the “lowest-
cost, fastest policy option to providing the STEM professionals that the nation needs for
economic and society well-being.” (p. i).

Many scholars have also explained the increased ties between STEM education and
workforce preparation as a result of heightened neoliberal policies within the higher education
landscape (Bok, 2003). They argue that neoliberalism, a term that describes the global political
and economic climate that has prioritized privatization, deregulation, and the free market
economy since the 1980s, has resulted in the “transformation of higher education into a global
commodity” (Naidoo, 2008, p. 86). In the age of neoliberalism, STEM disciplines, which are
perceived to have closer ties to the market economy are favored over other disciplines that are
perceived to have weaker ties to the market economy (Brint et al., 2005; Canaan & Shumar,
2008; Taylor et al., 2013; Williams, 2013). STEM disciplines are not only favored by the
government and HEIs but also students who have increasingly come to view college education as
a commodity that ought to provide lucrative workplace skills and a financial return in investment
(Williams, 2013).

Concurrently, the value of humanities education has been called into question in recent
years because it is often perceived as not adequately training students for work after college
(Kent, 2012). Not surprisingly, federal funding and support for the humanities have continued to
decline every year since the late 1970s. As of 2012, the federal government provides 74 percent
of the funding for STEM research that occurs in HEIs while it only provides 20 percent of the
funding for humanities research (AAAS, 2014). The disparity in federal support between STEM
and humanities education and research has resulted in HEIs being increasingly responsible for
funding humanities programs themselves (Taylor et al., 2013; Zuckerman & Ehrenberg, 2009).
In an era of funding cutbacks, it has become increasingly difficult for humanities programs to
survive, and in fact, many humanities programs in HEIs have downsized or been removed altogether (Taylor et al., 2013; Wilson, 2012). One example in particular highlights the contrast in funding and support for humanities and STEM: while institutional funding for research in all areas of study suffered from setbacks caused by the 2008 financial recession, by 2011, only STEM had regained its pre-recession levels of funding (AAAS, 2014).

The 21st Century Workplace and the Rise of Innovation

A growing number of sources, however, suggest that focusing on STEM education may not be the solution for changing economic and workplace needs. For one thing, scholars argue that on top of technical and more narrow industry-related skills, employers are placing increased value on broader, transferable skillsets that meet the challenges of a knowledge-based, globalized economy—an economy in which ideas, rather than goods, are the driving force and in which skilled workers are increasingly expected to negotiate across cultural, linguistic, national, and conceptual boundaries (Casner-Lotto, 2006; CoC, 2005, 2014; OECD, 2001). Knowledge-based industries include the main producers of high-technology goods, high- and medium-high technology manufacturing and include the main users of technology—namely “knowledge-intensive services such as finance, insurance, business, communication and community, social and personal services” (OECD, 2001, p. 101). In addition, “knowledge workers” are those who have the ability to “produce and use information effectively” (OECD, 2001, p. 100). This suggests that while technical and field-specific competence associated with STEM education is important, a new set of transferable skills has also risen in importance.

Indeed, a survey conducted by the American Association of Colleges and Universities (AAC&U, 2013) revealed that employers are placing greater emphasis on transferable skills that
are highly relevant to work in the twenty-first century. The 2013 survey was completed by 318 employers who reported that 25 percent or more of their new hires held either an associate’s or a bachelor’s degree. Respondents included hiring managers and executives at private and nonprofit organizations from a broad range of industries, including science and technology. The survey, which aimed to gain a more detailed understanding of the skills employers value in their entry-level applicants, revealed that the skill most in demand was innovation. Similar findings were also reported in studies conducted by IBM (2010) and the Society for Human Resource Management and the Wall Street Journal (2008).

Broadly conceived, innovation as a skill is often defined as a combination of two separate components: creative thinking and initiative (Amabile, Conti, Coon, Lazenby, & Herron, 1996; IBM Institute for Business Value, 2010; Stein, 1974; Woodman, Sawyer, & Griffin, 1993). According to Jackson (2006), creative thinking involves holding disparate ideas together and moving them “from one state to another” to generate a “third space” (p. 8). In Koestler’s (1964) seminal work, he describes creative thinking as “the defeat of habit by originality” (p. 95). Some of the habits of mind associated with creative thinking include the ability to integrate knowledge across different disciplines, to originate new ideas, and to negotiate multiple or competing perspectives (Conference Board, 2008). However, what sets innovation apart from mere creative thinking is the ability to initiate and carry out a creative idea (Amabile, 1988; Conference Board, 2008; IBM Institute for Business Value, 2010). Hence, innovation can be defined as “creativity in action” or the “successful implementation of creative ideas” (Amabile, 1988, p. 126).

Innovation has received considerable attention in recent years as employers in a wide variety of sectors have recognized the value of innovative thinking in a changing workplace, economy, and society (AAC&U, 2013; Cunningham, 2011; Nayak & Agarwal, 2011). For one
thing, employers and educators alike acknowledge that the current economy has witnessed a growth in demand for customized products and services, which requires innovative business solutions (Conference Board, 2008). Innovation is also sought after because “it leads to new ways of understanding and directing human activities and relationships” and has been recognized as crucial for addressing concerns related to human interactions and societal needs (Aalestad, 2006, p. 6). Hence, innovation has become a transferable skill that is highly valued in fields related to science, technology, and business, as well as fields that aim to provide novel solutions to social problems, including the reduction of poverty and increasing community-based services (Goldenberg, Kamoji, Orton, & Williamson, 2009).

Innovative thinking has also gained mainstream desirability for employers in varying fields because it has gradually become known as a skill that can be fostered in “ordinary” individuals. McWilliam (2008) argues that “creativity in action” (or in other words, innovation) has in many ways become “democratized” since the latter half of the twentieth century. She explains that works documenting “big C,” first-generation creativity, which describes the ground-breaking, paradigm-shifting works of “great thinkers” such as Chaucer and Walt Disney have been replaced with literature describing and fostering “little C,” second-generation creativity which is focused on a much greater proportion of the population “than a few towering historical figures who have huge IQs” (McWilliam, 2008, p. 9). This “creative turn” attempts to dispel the myth that creativity is a largely inherent characteristic more likely to be displayed by virtuosos and prodigies and instead argues that creativity can be significantly influenced by environmental and educational factors. This “democratization” of innovation has turned innovation into a household word and a skill commonly sought after by employers in virtually all fields that require a college degree (McWilliam, 2008).
Differences between Humanities & STEM Education:

A Matter of Epistemology, Pedagogy, and Beyond

Interestingly, some scholars propose direct links between humanities education and innovative thinking. Although such arguments have not been generated from formalized studies they reflect the views of instructors who have observed the benefits of humanities education in college classrooms. Edelstein (2010) for example suggests that the humanities are better positioned to foster and encourage innovative thinking in undergraduates than other areas of study due to the “transformative processes” that are encouraged early in humanities education. According to Edelstein (2010), humanities education places strong emphasis on transforming, rather than merely reproducing knowledge and students are encouraged to apply, build upon, and interpret knowledge in original ways very early on in their undergraduate careers. While innovation could arguably be fostered in any field of study, Edelstein contends that “when one considers the curricular requirements of most scientific majors, it becomes apparent that the majority of courses focus on reproducing knowledge in students” (p. 17).

The differences in curricular requirements and pedagogy that Edelstein (2010) is referring to can be viewed as a result of the epistemological differences between humanities and STEM disciplines, and specifically the differences in the stability of their respective canons of knowledge. According to Edelstein, one needs a solid foundation in biochemistry before one can study the interaction of synapses. In addition, physics students may eventually “go on to discover new subatomic particles and rewrite the rules of quantum mechanics,” but they must first spend the majority of their undergraduate careers mastering “the more mundane—and largely unchanging—practice of deriving integral equations” (p. 17). Edelstein’s views are highly reflective of Biglan’s (1973a) classification of academic disciplines, which organizes disciplines
on a hard-soft dimension based on the rigidity of, or “consensus” around, each discipline’s respective canon of knowledge. Biglan (1973a) determined that the sciences and humanities were at opposite ends of the hard-soft spectrum. The sciences, located at the “hard” end of the spectrum, are characterized by “greater consensus on content and method” and the humanities, located at the “soft” end of the spectrum, are characterized by disciplines wherein “content and method in these areas tend to be idiosyncratic” (p. 202). In other words, STEM disciplines are characterized by a high level of consensus around foundational knowledge, paradigmatic assumptions, and epistemology whereas the humanities are characterized by less consensus around and more recurrent revisions of these areas.

Due to the more frequently evolving and malleable nature of the assumptions and knowledge base undergirding humanities disciplines, humanities courses are able to “demand originality from day one” (Edelstein, 2010, p. 17). For example, introductory history courses not only require that students know names and dates of important figures and events, they also require that students “make sense on their own of the material, that they can develop original arguments about reasons, motivations and outcomes of the past” (p. 17). The same is true for many introductory courses in other disciplines within the humanities such as literature, philosophy, and art history. While Edelstein (2010) acknowledges that STEM courses at the undergraduate level may require students to be innovative, he argues that these experiences are less frequent and are certainly not a major component of most undergraduate STEM curriculum. For these reasons, Edelstein argues that humanities education, at least at the undergraduate level, is better positioned to foster innovative thinking in students.

Similarly, Schneider-Bateman (2012) also argues that particular aspects of humanities education help to encourage innovative thinking. He suggests that the early twentieth-century
“linguistic turn” in the humanities and social sciences, marked by the emphasis on language in shaping both epistemology and ontology, promotes innovative thinking in students by encouraging the consideration of multiple realities and perspectives. By virtue of the linguistic turn, what was once considered scientific, natural, economic, and legal “truth” is now understood by humanities scholars as social constructions created and shaped by discourse. Schneider-Bateman (2012) argues that it may be useful to incorporate humanities education into engineering entrepreneurship curriculum since the process of innovation, which is in many ways a socially-oriented practice of transforming a creative idea into a deliverable of social value, requires an understanding of the complex structures that define our social world. Although Edelstein (2010) and Schneider-Bateman (2012) make a number of convincing arguments in regards to the ability of humanities education to stimulate innovative thinking, their arguments have to date, not been supported by formal studies.

 Nonetheless for many decades, higher education scholars have noted the significant theoretical, philosophical, and methodological differences between humanities and science education, including how students are expected to learn and build upon existing knowledge (Kolb, 1981), as well as academic culture and practices (Becher, 1994; Becher & Trowler, 2001; Snow, 1959). Roughly half a century earlier, the profound cultural difference between the humanities and the sciences was famously described by Snow (1959) in his seminal work, *The Two Cultures*. In it, Snow argued that the intellectual life of western society was clearly divided into two academic cultures: that of the humanities and the sciences, respectively. Snow claimed that scholars in both areas would be considered as highly intelligent individuals and yet operated under paradigms and languages that were almost incomprehensible to one another. One particularly noteworthy illustration Snow provided was that if humanities scholars were asked to
explain the Second Law of Thermodynamics, most if not all would fail to correctly answer such
a question which is essentially “the scientific equivalent of: Have you read a work of
Shakespeare’s?” (Snow, 1959, p. 15-16). Snow’s main argument was that this cultural divide
hindered British leadership and national rebuilding in the wake of the Second World War.
Nonetheless, for the purposes of this study, Snow’s work effectively implicates that the
humanities and sciences have historically been greatly divided upon many different lines. While
Collini (1993) argued that the cultural divide between the humanities and sciences had somewhat
waned in more recent decades with the rise of interdisciplinary inquiry, Collini acknowledged
that strong cultural and practical divisions nonetheless still continued to persist in humanities and
science education.

More recently, Becher (1994) elaborated on Snow’s work and argued that disciplinary
differences, which are quite significant, tend to be overlooked in higher education research,
policy making, and practice. Becher’s (1994) work presented two main arguments: first, that
there is much uniformity within disciplines, and second, that scholars in higher education often
overlook both intra-disciplinary uniformity and inter-disciplinary differences. According to
Becher (1994), it cannot be contested that disciplines are the “life-blood of higher
education…[for] they provide its main organizing base” (p. 151). In addition, “cultural aspects of
disciplines and their cognitive aspects are inseparably intertwined,” with disciplinary practices
(including teaching and learning) “closely matched with the relevant characteristics of their
associated domains of inquiry” (p. 152). In other words, disciplinary practice is often dictated by
the nature and structure of the subject matter that the discipline aims to understand. According to
Becher (1994), disciplines and areas of study tend to have distinct cultures and practices that
“transcend institutional boundaries within any given system” and in many instances “also span
national boundaries” (p. 152). Hence practices commonly found in STEM departments in one HEI are likely to be similar at other HEIs. The same also holds true for humanities departments. As evidence for the common practices shared within disciplines, Becher (1994) mentions the existence of national and often international disciplinary associations that exercise a degree of informal control on undergraduate and graduate curricula, the relative ease with which scholars and researchers in one field can move from one institution to another, as well as the frequent collaboration between scholars in a given field with those in other institutions and geographical locations.

In addition to explaining the pronounced uniformity within disciplines, Becher (1994) also argues that as a result of overlooking the distinctions between disciplines, scholars tend to reach oversimplified conclusions about teaching, learning, and issues related to higher education practice. For example, by utilizing administrative policies that do not acknowledge disciplinary differences, HEIs have often experienced disappointing outcomes. Faculty development programs for example that are geared toward enhancing efficiency of teaching and learning “often lose credibility with their potential clients because of their discipline-independent approach” (p. 156). Teaching techniques in an anatomy course for example would greatly differ from those in a literature course, mainly due to the difference in subject matter and hence, traditions in discipline-specific pedagogy. According to Becher (1994), “[i]t is difficult to see how faculty development can go beyond the most elementary level without a clear recognition that disciplinary cultures impose their own particular pattern in teaching as in other activities” (p. 156). Although sources suggest that some STEM departments have begun to push faculty to incorporate more student-centered, inclusive approaches to teaching that may be more commonly found in humanities education (Borrego & Henderson, 2014; Borrego, Froyd, & Hall, 2010;
NRC, 2012; Prince & Felder, 2006), the adoption and implementation of these approaches have not been widespread (ASEE, 2012; NRC, 2012).

Implementation of more engaging approaches to learning may also be difficult as evaluation methods often reward students who adhere to the traditional structure of disciplinary discourse (Edelstein, 2010; Kolb, 1981). Disciplines with high “factual content” and typically a more positivist orientation, such as those in the sciences, may be appropriately assessed with multiple choice examinations in which there is only one correct answer for each question, while other subjects require students to “decide between competing theories and to justify that decision” when being evaluated (Edelstein, 2010, p. 156). Hence, the most common and traditional evaluation approaches in STEM present an additional hurdle for implementing more engaging approaches to learning in STEM classrooms. According to Becher (1994), however, higher education research tends to overlook the distinctions between discipline-specific teaching, learning, and other aspects of educational practice including evaluation.

While it can be argued that disciplinary practices in physics and mathematics, for example, may greatly differ from one another, Becher (1994) argues for the practical utility of organizing disciplines into broader categories of study (such as STEM and humanities). Becher (1994) explains that while nationally-based, macro-level enquiries often ignore disciplinary differences, micro-level studies, such as at the department or single-discipline level “often encourage other researchers to draw wider conclusions from their work than the evidence should allow” and are less helpful for educational policy-making. Becher’s (1994) recommendation is clear: to “extend the research base to cover more than one discipline, so that useful contrasts can be drawn” (p. 157). By doing so, researchers are able to strike a balance between acknowledging differences in culture and practices between areas of study such as humanities and STEM (albeit,
across multiple disciplines), while avoiding micro-level, intra-disciplinary analysis that often proves unhelpful in the context of higher education policy.

**Theory of Student Approaches to Learning: Deep vs. Surface Learning**

Due to the literature pointing to major differences in pedagogy between STEM and humanities disciplines, I grounded this study in the theory of student approaches to learning (Marton & Saljo, 1976a, 1976b) in order to develop hypotheses and examine differences in humanities and STEM student gains in propensity toward innovation. Using this theory also provided a guiding framework for examining how pedagogical and academic factors may have influenced student outcomes in this area. I also drew upon theoretical perspectives that have developed from the theory of student approaches to learning that address how educational environmental characteristics, including teaching practices, may influence student approaches to learning and ultimately, different learning outcomes. The theory of student approaches to learning and its attendant theoretical perspectives were particularly relevant because they provided a lens through which we could understand why students from different disciplines might adopt different approaches to learning and hence, experience different learning outcomes. These theories were also useful because they examine outcomes that are cognitive in nature and provide a useful framework for understanding how pedagogical and academic conditions may encourage or inhibit students’ propensity toward innovation.

The theory of student approaches to learning was first developed by Marton and Saljo (1976a, 1976b) who posited that students approach learning by adopting an “understanding approach to learning” or by adopting a “reproductive approach to learning.” These two approaches are commonly referred to as “deep” and “surface” approaches to learning,
respectively. In addition, students’ different approaches to learning also lead to differences in learning outcomes (Marton & Saljo, 1976b).

A deep approach to learning is characterized by an active search for meaning. It also reflects a personal commitment to understanding coursework and involves strategies such as “reading widely, combining a variety of sources, discussing ideas with others, reflecting on how individual pieces of information relate to larger constructs or patterns, and applying knowledge to real world situations” (Laird, Shoup & Kuh, 2005, p. 470). In Marton and Saljo’s (1976a) study, students were asked to read a simple passage of text in which the author makes an argument about a well-known contemporary issue. Students who used a deep approach to understanding a passage of text tried to understand the meaning of the text “by looking for relations within the text or by looking for relations between the text and the phenomena of the real world, or by looking for relations between the text and its underlying structure” (p. 43).

A surface approach to learning, on the other hand, is characterized by memorization. If a deep approach is one in which students seek meaning in order to understand, a surface approach is one in which students attempt to learn material by rote memorization in order to reproduce it (Trigwell & Prosser, 1991). In Marton and Saljo’s (1976) study, students who used a surface approach to understanding the passage of text utilized a “spasmodic effort to memorize the text…and seemed, metaphorically speaking, to see themselves as empty vessels to be filled with the words on the pages” (p. 43) These students appeared to have missed the greater meaning of the passage and opportunities to draw connections to other sources of knowledge as they were focused primarily on retaining what was presented in the text and then reproducing facts and arguments presented by the author.
The effectiveness and value of a deep approach to learning over a surface approach has been supported by a growing body of research in the past several decades. These studies point to the relationship between learning approaches and qualitative differences in outcome. For example, study findings suggest that students who use deep approaches to learning are better able to retain, transfer, and integrate information at higher rates than students using surface approaches to learning (Biggs, 1988, 1989; Entwistle & Ramsden, 1983; Laird et al., 2014; Prosser & Millar, 1989; Ramsden, 2003; Whelan, 1988).

Students from Marton and Saljo’s (1976a, 1976b) seminal study who used deep approaches to learning, in contrast to their surface-learning peers, attempted to understand the text and evaluate the author’s argument from various perspectives. Instead of viewing themselves as “empty vessels to be filled,” these students viewed themselves “as creators of knowledge who ha[d] to use their capabilities to make critical judgments, logical conclusions and come up with their own ideas” (p. 43). In addition, other researchers have also found that deep approaches to learning encouraged students to “integrate and synthesize information with prior learning in ways that became part of one’s thinking” and also allowed students to “see things from different perspectives.” This approach and subsequent outcome is in stark contrast to surface approaches which tended to only foster knowledge reproduction (Ramsden, 2003; Tagg, 2003).

Throughout the years since Marton and Saljo (1976a, 1976b) first introduced the theory of student approaches to learning, many higher education researchers have utilized the theory in various capacities. In particular, scholars have focused on the model of deep versus surface approaches to learning in order to investigate college student learning outcomes in various college environments. While several groups of researchers have been known to utilize the model
in their research, there is no clear consensus on the definitions of “deep” and “surface” approaches to learning. For my study, I chose to use the definitions offered by Trigwell and Prosser (1991) who define “deep” approaches to learning as those that promote meaningful engagement with coursework and “surface” approaches to learning as those that promote knowledge acquisition. I chose to use Trigwell and Prosser’s (1991) definitions due to their conceptual clarity. It should be noted, however, that this study is not based the assumption that students only choose one method of learning or that students even necessarily prefer one over the other. Instead, this study investigates the academic environmental conditions that may reward or encourage one method of learning over the other.

Different Approaches to Teaching and Learning across Disciplines

Highly relevant to this study was research demonstrating how deep and surface approaches to teaching and learning vary across academic disciplines. Laird, Shoup, Kuh, and Schwarz (2008) found that compared to their counterparts in hard disciplines, faculty in soft disciplines, such as humanities disciplines, more frequently and consistently utilized deep approaches to teaching that were more likely to encourage deep approaches to learning. As mentioned previously, the hard-soft dimension distinguishes between disciplines with a high degree of consensus around their respective canons of knowledge and those where consensus is low (Snow, 1959; Biglan, 1973a, 1973b).

Faculty in hard disciplines tended to use pedagogical practices, or “surface approaches to teaching” that were more likely to encourage surface approaches to learning (Laird et al., 2008, p.). These pedagogical practices included encouraging students to memorize portions in textbooks and evaluation methods (such as multiple choice examinations) that tend to reward rote memorization (Laird et al., 2008). Scholars have also criticized introductory STEM courses
for focusing too much attention on content acquisition and too little on fostering students’ meta-
cognitive skills (Handelsman, Ebert-May, Beichner, Bruns, Chang & DeHaan, 2004; Hurd, 1997; Williams, Papierno, Makel & Ceci, 2004). These findings support extant research suggesting that instructional approaches are highly related to discipline (Braxton & Hargens, 1996; Neumann, Parry & Becher, 2002). Not surprisingly scholars have also found that students in hard fields more often utilized a surface approach to learning and that students in soft fields more frequently utilized a deep approach to learning (Jones, Reichard, & Mokhtari, 2003; Laird et al., 2008).

This is not to say that deep approaches to teaching and learning are completely absent from STEM courses. Gasiewski, Eagan, Garcia, Hurtado and Chang (2012) found that students in introductory STEM courses could be highly engaged when instructors “consistently signaled an openness to student questions and recognized her/his role in helping students succeed” (p. 229). In addition, some studies show that when laboratory work is modified to go beyond “cookbook” formats it can effectively promote deep learning by encouraging students to problem solve and to think critically (Brownell, Kloser, Fukami & Shavelson, 2012; Dinan, 2005).

Nonetheless, studies examining high attrition rates in STEM disciplines have found that key factors including reliance on large lecture-based courses and lack of engaging pedagogy are extremely common especially during the early years of STEM education and often impede meaningful engagement and learning (Biggs, 1999; Bransford, Brown & Cocking, 2000; Seymour & Hewitt, 1997).

Although sources suggest that STEM disciplines as a whole tend to more frequently utilize surface approaches to learning than do humanities disciplines, the theoretical framework for this study does not rest upon a simplistic dichotomy suggesting that STEM disciplines’ use of
surface approaches leads to poorer learning outcomes while humanities disciplines’ utilization of deep approaches leads to superior outcomes. While the theory of student approaches to learning provides a guiding framework, this study acknowledges that the relationship between disciplinary utilization of deep versus surface approaches to learning and student outcomes is complex and nuanced. For example, introductory STEM courses tend to encourage more surface approaches to learning while upper division STEM courses are more successful in encouraging more deep approaches to learning as students engage with other students in smaller class sizes and on projects that require creativity and original thinking (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, & Wendoroth, 2014). In addition, STEM disciplines should not be viewed as a homogenous group. Approaches to teaching and learning may vary significantly depending on how each discipline is structured in regards to undergraduate education (Singer, Nielsen, & Schweingruber, 2012).

Similarly, humanities disciplines also do not exist as a homogenous group. The frequency at which deep approaches to teaching and learning are experienced by students may also vary depending on the specific discipline and how it is structured in regards to undergraduate education. Students studying history, for example, may find themselves in similarly large lecture halls that their peers in STEM encounter at the lower division level where deep approaches to teaching and learning are rarely utilized. On the other hand, students studying comparative literature may find that deep approaches to teaching are utilized as early as the first day of instruction and that deep approaches to learning are more easily and frequently encouraged.
“Propensity Toward Innovation”: Operationalizing Student Innovation as an Outcome

For several decades, innovation has been a popular topic in the workplace and society. As a result, many scholars working in fields such as business management and labor studies have explored how innovation can be fostered and utilized in order to maximize organizational efficiency and profit. Scott and Bruce (1994) for example used a path model in order to examine the possible determinants of individual innovative behavior in the workplace. They hypothesized that leadership, individual problem-solving style, and work group relations affect innovative behavior directly and indirectly through their influence on individuals’ perceptions of the climate for innovation. Using structural equation analysis, Scott and Bruce (1994) found that the variables they proposed accounted for much of the driving force behind individuals’ innovative behavior. They also found that task type moderated the relationship between leader role expectations and innovative behavior.

Using a more organizational perspective, researchers such as Cohen and Levinthal (1990) posited that a company’s ability to be innovative hinges upon its “absorptive capacity,” or in other words its prior related knowledge base. Hence, the greater a company’s absorptive capacity, the better it is able to “recognize the value of new information, assimilate it, and apply it to commercial ends” (p. 128). Cohen and Levinthal (1990) also acknowledged that an organization’s absorptive capacity rests upon the absorptive capacity of its individual workers. Zahra and George (2002) expanded upon Cohen and Levinthal’s (1990) definition of absorptive capacity and suggested that it is composed of two subsets of processes: “potential absorptive capacity,” which refers to a company’s knowledge acquisition capabilities, and its “realized absorptive capacity,” which focuses on its ability to transform knowledge for its own profit.
Studies such as those conducted by Scott and Bruce (1994), Cohen and Levinthal (1990), and Zahra and George (2002) have grown in number as innovation continues to be an ever-more popular area of scholarly inquiry in various fields. However, what is still lacking is an assessment of the role HEIs play in preparing students for being innovative workers, and as of now, studies on innovative thinking have largely been conducted in the workplace. The major hurdle in conducting a national study on the role and effectiveness of HEIs is quite clear: undergraduate students are rarely asked to perform in innovative ways that would be expected of them in a workplace setting. For one thing, college courses seldom require that students produce a deliverable of marketplace or social value, which is what would be expected of innovative workers (Mayhew et al., 2012). Instead, humanities students are often asked to write essays analyzing texts or visual media and STEM students are often expected to learn the basics of scientific theorems and principles from lectures, laboratory work, and textbooks. Because innovation has typically not been regarded as a major learning outcome compared to other cognitive skills such as critical thinking and problem solving, it comes as no surprise that national student surveys have not been specifically designed to measure student innovation levels at the end of college. In fact, studies on student gains in innovation have been limited to small samples of students at either a single institution or a small sample of institutions using customized surveys designed by the researchers (Bulut, Eren, & Halac, 2013; Joy, 2004; West, Tateishi, Wright, & Fonoimoana, 2012). To date there has been no study measuring undergraduate student innovation using U.S. national-level data.

However, I argue that by using the theory of planned behavior (Ajzen, 1991, 2002), what can be measured is college student gains in their inclination toward innovation. In other words, while it may not be possible to effectively measure student gains in pure innovation using
national survey data, it is possible to at least measure student gains in regards to their “propensity toward innovation.” Findings therefore helped to determine which students are more likely to be creative thinkers and engage in innovative work after college and also revealed the academic experiences that may contribute to this outcome.

In order to create a framework for defining and supporting the use of this outcome I followed the model established by Mayhew, Simonoff, Baumol, Wiesenfeld, and Klein’s (2012) study which explored innovative entrepreneurship and its ties to higher education. Mayhew and colleagues (2012) conducted their study on 3,700 undergraduate students from five different HEIs and administered a series of assessments in order to gain insight into the educational experiences and practices that increase the likelihood of students graduating with “innovative entrepreneurial intentions.” They found that after controlling for background factors, taking an entrepreneurial course and faculty use of pedagogical assessments for teaching course content were significantly related to students’ innovation intentions. Due to the difficulty of measuring pure innovative entrepreneurship, Mayhew and colleagues (2012) turned toward measuring innovative entrepreneurial intentions. Their justification for using a modified outcome was that “the essence of innovative entrepreneurship, often measured by the number of patents received or venture capitalist dollars procured, could not necessarily be captured as a higher education outcome, as few undergraduate students would have had the opportunity to design and bring new products and processes to market” (p. 832).

Due to similar constraints in my study, I follow Mayhew and colleagues’ (2012) example of creating a modified dependent variable. Luckily, national student surveys are able to measure students’ college gains in creativity, a major component of innovation. However, they do not directly measure student gains in initiative, the other component of innovation. Instead they are
able to measure the degree to which students value opportunities for innovative work after college. Hence by combining student gains in creativity as well as their value of innovative work, I create an outcome I call “propensity toward innovation” (PTI).

In order to examine students’ intention to engage in innovative entrepreneurship, Mayhew and colleagues (2012) used the theory of planned behavior (Azjen, 1991, 2002), which posits that behavior is a function of intention. Intention is comprised of three components: attitude toward (or value of) the behavior, adherence to subjective norms, and perceived behavioral control. Undergirding this theory is the assumption that individuals have volitional control over their behaviors and respond to subjective norms. Hence, those who believe in the importance of innovation are more likely to behave in innovative ways or seek opportunities for innovation than those who do not value the importance of innovation. In a similar fashion I use tenets of the theory of planned behavior (as well as the literature on creativity and its links to innovation) to theoretically inform the creation of my outcome measure.

Clearly, it is difficult to measure how innovative students are at the end of college in a way that would be meaningful and pertinent in a workplace context. Measuring students’ propensity towards innovation helps us to assess students’ disposition towards and value of innovation while also capturing a vital component of innovation itself: creativity. The following chapter will explain how a mixed methods study is an effective way to quantitatively assess students’ end-of-college levels in propensity towards innovation (PTI) while also gaining a qualitative assessment, through student perceptions, of how academic experiences may impact their disposition towards innovation.
CHAPTER 3: METHODOLOGY

Though innovation has been determined to be a vital skill in the workplace and has appeared to only grow in importance in the past several decades, surprisingly few scholars have attempted to measure students’ college gains in this area. Such a study, especially one using national student survey data, would undoubtedly help to contribute to our knowledge about U.S. student preparation for work after college. It was reasoned that a study measuring college students’ gains in propensity toward innovation (PTI) would also serve to further our knowledge of the impact of college on students in a way that is especially important in the context of 21st century workplace and global economic demands. Through a mixed methods design, this study aimed to address the current gap in research and the experiences that relate to college students’ PTI.

This chapter is organized in the following order:

(1) An overview of the research questions, hypotheses, and rationales
(2) A discussion of mixed-methods research, and lastly
(3) A summary of the data samples, analyses, and reliability/authenticity issues

The first phase of the study analyzed national survey data to test for statistically significant differences between humanities and STEM students’ end-of-college PTI. These analyses also explored academic and classroom experiences that were potential predictors of humanities and STEM students’ end-of-college PTI. The second, and qualitative, phase of this study was informed by the findings from the quantitative phase and sought to understand how students perceive academic experiences as impacting their PTI and why humanities and STEM students may experience differential PTI outcomes.
Research Questions, Hypotheses, and Rationales

Quantitative Questions

*Question 1.* What differences, if any, exist between humanities and STEM students’ end-of-college propensity toward innovation (PTI)?

*Hypothesis 1.* Because of the difference in epistemology and pedagogy between humanities and STEM disciplines, it was reasonable to expect to see differences in student learning outcomes including their propensity toward innovation. In particular, I hypothesized that humanities students would surpass their STEM peers in their PTI at the end of college.

*Rationale 1.* Extensive literature supports the idea that differences in humanities and STEM education contribute to a wide variety of differences in learning outcomes (Braxton & Hargens, 1996; Laird et al., 2008; Neumann et al., 2002). As mentioned previously, differences in epistemology between these two areas of study lead to differences in the nature and stability of the canons of knowledge that constitute and define these disciplinary areas (Biglan, 1973a, 1973b). Because humanities disciplines are structured around canons of knowledge that change more frequently, humanities education has a higher tendency to encourage creative thinking and originality early in students’ undergraduate careers (Edelstein, 2010). Furthermore, soft disciplines, such as those in the humanities, are associated with deep approaches to learning, which are linked to a variety of positive learning outcomes that are foundations of innovative thinking (Marton & Saljo, 1976a, 1976b, 1984; Laird et al., 2005). In contrast, undergraduate STEM education is often structured around the memorization of large canons of knowledge that are extremely stable (Biglan, 1976a, 1976b; Edelstein, 2010). As a result, STEM students may spend the majority of their undergraduate careers learning and memorizing foundational principles before they are able to move on to more creative and innovative tasks either at the end
of their undergraduate careers or in graduate school. In other words, humanities students are more often encouraged to offer critiques and creative ideas early in their undergraduate careers while STEM students are more often encouraged to spend their early years as undergraduates memorizing and internalizing the foundational scientific principles that undergird their respective disciplines.

**Question 2.** What are the academic predictors of humanities and STEM students’ propensity toward innovation?

**Hypothesis 2.** Predictors of humanities and STEM students’ propensity toward innovation would include academic experiences that are either consistent with or related to deep approaches to learning and teaching.

**Rationale 2.** A deep approach to teaching is that which encourages an active search for meaning and engagement. A deep approach to learning reflects a personal commitment to understanding coursework and involves strategies such as “reading widely, combining a variety of sources, discussing ideas with others, reflecting on how individual pieces of information relate to larger constructs or patterns, and applying knowledge to real world situations” (Laird et al., 2005, p. 470). Deep approaches to teaching and learning, as mentioned in the previous chapter, have been found to be strongly related to many positive learning outcomes, including those that are cognitively related to innovative thinking, such as creativity. Hence, it was reasonable to suspect that academic experiences that are either consistent with or related to deep approaches to teaching and learning would be predictors of students’ propensity toward innovation.

Classroom experiences included, among other variables, the experience of having “Challenged a professor’s ideas in class.” Curricular/pedagogical experiences included survey items related to coursework and quality of instruction. In order to capture students’ interaction
with faculty, and more specifically the mentorship they received from faculty, the CSS “Faculty Interaction” construct was used. These variables were chosen due to literature suggesting that these types of experiences are related to deep approaches to teaching and learning and therefore were likely to influence students’ propensity toward innovation. The section on variables will describe in more detail the prior research, literature, and rationales that supported the selection of specific variables.

**Qualitative Questions**

*Question 3.* How do students perceive academic and curricular experiences as impacting their propensity toward innovative thinking?

*Rationale 3.* The first qualitative question for this study was developed from the same contextual and theoretical framework as the quantitative questions. The main goal of question 3 was to examine a distinct yet intersecting issue that would help to more fully explain students’ propensity towards innovation and approached the issue from an angle that could not be adequately explored by quantitative measures—that is, individual student perspectives (Mason, 2006). In addition, this question served as a foundation for the research protocol used to collect data to extend and build upon the findings from the first two research questions. The structure and nature of the qualitative research protocol will be discussed in detail in the research strategies section.

*Question 4.* What factors might influence humanities and STEM students to experience differential levels of PTI at the end of college?

*Rationale 4.* This additional qualitative question emerged as participant interviews progressed. As students explained how they perceived academic and curricular experiences as
impacting their propensity toward innovative thinking, it became evident that humanities and STEM students had very different educational experiences that impacted their PTI. The interviews with students revealed patterns and themes that allowed me to determine why humanities and STEM students may leave college with differential levels of PTI.

**Mixed Methods Research**

The nature and scope of the questions that this study explored required a mixed methods approach. Mixed methods research is defined by Johnson & Onwuegbuzie (2004) as “the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study” (p. 17). In the past several decades, mixed methods research design has become increasingly recognized, especially in the social sciences, as a means to more fully and deeply examine topics that are best served by a combination of quantitative and qualitative modes of inquiry (Creswell & Plano Clark, 2007; Johnson & Onwuegbuzie, 2004). It can be considered philosophically to be a “third wave” that moves past the paradigm wars between quantitative and qualitative research “by offering a logical and practical alternative” (Johnson & Onwuegbuzie, 2004, p. 17). It can also be viewed as an attempt to legitimize the use of multiple approaches to answering research questions and is a rejection of the dogmatism that constrains researchers to either a qualitative or quantitative approach.

According to Johnson and Onwuegbuzie (2004), “It is an expansive and creative form of research, not a limiting form of research. It is inclusive, pluralistic, and complementary, and it suggests that researchers take an eclectic approach to method selection and the…conduct of research” (p. 17). Perhaps most importantly, it symbolizes an acceptance that knowledge can be
viewed as being both socially constructed (the qualitative assumption) and based on the “reality” of the world we live in (the quantitative assumption). Although traditionally, quantitative methods have been favored in the study of higher education, historian and social scientist Fischer (1970) argued that “…the Book of Nature, like a merchant’s ledger, might be kept in double entry style, one column listing phenomena which can be quantified and another listing thing which can be qualitatively known. The latter is always longer than the former and can never be dismissed” (p. 91).

In addition to the philosophical and paradigmatic arguments in favor of mixed methods research, there were also several practical advantages to using mixed methods. Due to its flexible nature, mixed methods encourages and enables the researcher to ask the research questions first and allows the appropriate methods to follow after (Johnson & Onwuegbuzie, 2004). Because mixed methods allows for the usage of both qualitative and quantitative methods in the same study, researchers are not limited to asking certain types of questions but rather, are free to ask the questions that best fit the topic and have the opportunity to apply the appropriate methodology afterwards. In addition, a mixed methods study design calls for the collection and analysis of multiple sources of data using a combination of strategies and approaches. This encourages a high level of triangulation and hence a high degree of reliability in regards to findings (Creswell & Plano Clark, 2007). Lastly, a mixed methods approach is highly useful when a study asks distinctive but intersecting questions (Mason, 2006), such as in this study.

The quantitative and qualitative phases of this study can be viewed as distinctive but complementary as both were derived from the same theoretical framework. The quantitative phase addressed the question of what areas of study and academic experiences are correlated with students’ PTI and the qualitative phase addressed the question of how these experiences
(from the perspective of students) influence the outcome. According to Creswell and Plano Clark (2007) it is both a common and acceptable practice for a mixed-methods study to utilize a “sequential approach” in which a quantitative phase is followed by a qualitative phase, or vice versa (p. 116). More specifically, my study utilized an “Explanatory Design” as the quantitative data was collected first, and the results helped to inform the collection of the qualitative data (p. 121). In this type of data collection, the quantitative and qualitative data collections are related to each other and are not independent—in essence “one builds on the other” (p. 121).

Quantitative Analysis

Source of Data

The quantitative phase of this study used survey data from the Cooperative Institutional Research Program (CIRP), administered by the Higher Educational Research Institute (HERI) at the University of California, Los Angeles (UCLA). More specifically, data came from the Fall 2011 Cooperative Institutional Research Program (CIRP) Freshman Survey (TFS) and the Spring 2015 College Student Survey (CSS). Both are national surveys administered by the UCLA Higher Education Research Institute (HERI). The 2011 TFS contains information about students’ pre-college characteristics including personal and academic background, values, goals and attitudes. The 2015 CSS is a follow-up for the 2011 TFS and includes information about students’ experiences and activities while in college, their personal and professional goals and values, and post-graduation plans. The TFS and CSS were chosen for this study because of the variety of questions that address students’ pre-college and college characteristics regarding cognitive and interpersonal skills as well as academic experiences. In addition, unlike other national student surveys, the CSS is unique in that it includes questions asking students about
their self-ratings on creativity as well as their value of innovation in regards to post-graduate employment.

The sample for the quantitative phase of this study was composed of humanities and STEM students from four-year HEIs who completed both surveys. Humanities students included those who majored in disciplines, such as art history and English, that are listed in the *Humanities Indicators* (AAAS, 2014). STEM students included those who majored in disciplines, such as physics and chemistry, that are listed in the National Science Foundation’s (NSF) (2016) list of approved STEM fields (for a full list of majors see Appendix A).

**Variables**

**Dependent variable.** The survey items of interest were first tested to see if they were able to sufficiently measure “propensity toward innovation” (PTI) as a unidimensional, latent construct. This composite dependent variable was first considered using exploratory (EFA) and then confirmatory factor analysis (CFA) to combine appropriate survey items. The PTI factor was explored initially using three survey items capturing students’ creativity and value of innovative work after college. Survey items included: 1) students’ self-rating on “creativity,” 2) the importance that their career path provides “opportunities for creativity and initiative,” and 3) the importance that their career path provides “opportunities for innovation.” Factor loadings ranged from .551 to .952 with a satisfactory internal reliability (Chronbach’s alpha) of .742.

As mentioned previously, innovation as a skill has often been defined as a combination of creative ability and initiative (Stein, 1974; Woodman, Sawyer, & Griffin, 1993; Amabile, Conti, Coon, Lazenby, & Herron, 1996, p. 1155; IBM Institute for Business Value, 2010). Students’ creative aptitude was captured by the survey question asking students to rate themselves on creativity. Because students’ ability to initiate was not asked explicitly in the survey it was not
possible to measure students’ innovation levels as it would apply to a workplace setting. Although some could argue that survey items such as “drive to achieve” and “risk taking” could be used as proxies for students’ ability to take initiative, it seemed likely that these items were too conceptually different from “taking initiative” and would introduce conceptual weaknesses to the dependent variable. Both of these variables were tested, nonetheless, and then discarded as they weakened the statistical power of the construct.

**Independent variables.** Independent variables were grouped according to the following categories: 1) pre-college characteristics, 2) institutional characteristics, 3) area of study, and 4) college academic experiences. As mentioned previously, justification for the selection of the variables was informed by the theoretical framework. The organization and order in which the variables entered the model was informed by prior research investigating college impact (Astin, 1993). Following Astin’s (1993) Input-Environment-Output (IEO) model of student development which posits that student outcomes are influenced by pre-college characteristics and the educational environment, I organized independent variables into blocks that entered the equation in an order that was consistent with the IEO model.

It was presumed that independent variables such as gender, high school GPA, and institution type were not likely predictors of students’ propensity toward innovation due to literature pointing to the insignificance of these variables in regards to student outcomes that are cognitively related to innovation, such as creativity and intention to innovate (Amabile, 1983; Harris, 2004; Baer & Kaufman, 2008; Mayhew et al., 2012). Nonetheless, these variables were included in the model as they had never been used in a national-level analysis of students’ innovation at the end of college and had been known historically to be important variables to control for in higher education research (Astin, 1993).
The first block in the regression model consisted of “pre-college characteristics” to control for including race, gender, high school GPA, and socioeconomic status (SES). Students’ race and SES was of particular interest as Kaltsounis’ (1974) seminal work on student creativity levels suggest that these factors may also be predictors of students’ propensity toward innovation. Using the Torrance Creativity Test, Kaltsounis (1974) found that Black students from low SES backgrounds outperformed White students in regards to creativity. Due to this reason, race and SES were important demographic characteristics to include as controls in the regression model. SES was determined by students’ estimates of their respective family incomes and parental education and race was accounted for by the creation of the following dummy variables: “Asian vs. White,” “Black vs. White,” “Latino/a vs. White,” “Native American vs. White,” and “Multiracial/other vs. White.” The first block of variables also contained students’ self-rated creativity upon entering college as measured on the 2011 Freshman Survey (TFS), and this item served as a proxy pretest. Although creativity only partially captured the concept of propensity toward innovation, it was the only available option given that the TFS does not ask questions about student career priorities in regards to innovation.

The second group consisted of “institutional characteristics,” to control for including selectivity as well as public versus liberal arts/private status. Institutional selectivity had not been shown to be a strong predictor of cognitive outcomes when controlling for students’ pre-college characteristics (Pascarella, Cruce, Umbach, Wolniak, Kuh, Carini, Hayek, Gonyea, & Zhao, 2006; Toutkoushian & Smart, 2001) but was still added to the model to see if it would play a role in students’ propensity towards innovation. In addition, institutions’ public versus liberal arts status was added to the model since literature suggests that students at liberal arts colleges more frequently experience stronger relationships with faculty members and feel more positively about
their educational experiences (Astin, 1999). Since Astin (1993) found that students often gained more in “existential outcomes” (i.e. more positive perceptions of their education) than in “educational outcomes” (i.e. actual cognitive gains) it seemed important to explore the potential impact of the liberal arts college experience on students’ propensity toward innovation, which is also existential in nature. An additional institutional characteristic that was tested for was a peer measure of creativity. This was done by creating an aggregate of the self-rated creativity item from the TFS to represent, on average, how creative students rated themselves at each HEI.

The third block was comprised of the “area of study” dummy variable. This dummy variable was coded as “humanities vs. STEM” with humanities students serving as the reference group. The regression coefficient and statistical significance associated with this variable directly answered the first research question by determining the potential gap between humanities and STEM students in regards to their propensity towards innovation and whether or not this gap was statistically significant.

The fourth block included variables that represented “college academic experiences.” Based upon the available items on the survey, I examined the following student experiences:

- Supported your opinion with logical argument
- Evaluated the quality/reliability of information you received
- Challenged a professor’s ideas in class
- Sought feedback on academic work
- Performed community service as a part of class
- Posted on a course-related online discussion board
- Integrated skills/knowledge from different sources & experiences
- Communicated regularly with professors
• Worked with classmates on group projects during class
• Made a presentation in class
• Contributed to class discussions
• Completed a culminating experience/capstone project
• Participated in an undergraduate research program
• Academic Disengagement Construct
• Faculty Interaction/Mentorship Construct

The variables in the preceding list were carefully selected due to prior research and literature suggesting that these types of academic experiences may impact students’ propensity towards innovation because of their conceptual relationship to deep approaches to learning. Experiences such as “faculty interaction/mentorship,” “contributed to class discussions,” “challenged a professor’s ideas in class,” “asked questions in class” “performed community service as a part of class,” “worked with classmates on group projects” both inside and outside of class, “made a presentation in class” and “completed a culminating experience for their respective degree” are all in varying degrees examples of deep approaches to learning, which based upon my theoretical framework, were likely to be predictors of students’ propensity toward innovation (Laird, Shoup & Kuh, 2005; Marton & Saljo, 1976a, 1976b, 1979). For the sake of parsimony and to limit the list of variables to concrete student experiences that were consistent with the theoretical framework, survey questions that captured experiences that were more “existential” in nature (Astin, 1993), such as “overall satisfaction with coursework,” and “overall perception of quality of instruction” were excluded from the study.

Data Analysis
**Missing data.** First, cases with missing data on the items comprising the dependent variable or categorical variables (such as demographic characteristics) were removed from the sample through list-wise deletion. To account for non-responses on continuous and ordinal variables, the expectation-maximization (EM) algorithm was used when small proportions of data (roughly less than 5% of cases for each variable) were missing. The EM algorithm uses maximum likelihood to impute missing values for variables and is arguably a more accurate estimation for missing data than other techniques such as mean substitution, which reduces variability, or list-wise deletion, which reduces the sample size and hence statistical power (Allison, 2002; Schafer & Graham, 2002).

**Descriptive statistics & t-tests.** Before beginning my regression analysis, I performed an assessment of the distribution of the data both graphically and numerically in order to check for normality. Group means and crosstabulations from the two areas of study (that is, humanities and STEM) were compared on the separate items making up the dependent variable: students’ self-rating on “creativity,” the importance that their career path provides “opportunities for creativity and initiative,” and the importance that their career path provides “opportunities for innovation.” Group means and crosstabulations were also compared on the dependent variable (PTI) as a whole. In addition, independent samples t-tests were conducted to test for significantly different group means in the final factor representing students’ propensity toward innovation and the individual items comprising that factor. Group mean comparisons and crosstabulations provided an idea of how humanities and STEM students compared to each other at the end of college in regards to their propensity towards innovation.

Correlations were also investigated to identify potential issues related to multicollinearity among independent variables. Highly correlated independent variables typically overlap
significantly in explaining variability in the outcome. For this study, problematically high correlations, that is, higher than .70, were not found.

**Multiple regression analyses.** Using college impact research as my conceptual and analytical guide for model building, I individually introduced each conceptual block of variables described in the previous section into a multiple regression model predicting students’ senior-year propensity toward innovation. Multiple regression was an appropriate statistical technique because it allowed me to answer the first two research questions effectively and efficiently. The coefficient of the “area of study” variable answered the first research question asking if there are differences between humanities and STEM students’ end-of-college propensity towards innovation. The final regression coefficients of the “college academic experience” variables allowed me to answer my second research question asking which college academic experiences were influential in humanities and STEM students’ levels of PTI at the end of college.

Statistical significance thresholds were determined by the size of the sample. Due to the relatively large sample size (N = 4,582), the more stringent values of p<0.01 and p<0.001 were used. In order to help account for possible clustering of data, the lower significance level of p<.05 was used as the threshold for determining the significance of institutional variables (Astin & Denson, 2009). In addition, the adequacy of the independent variables in accounting for variance in the dependent variable was assessed by the R² value.

**Reliability and validity.** Various techniques were used in order to test the reliability of the regression models. The assumption of normality was tested through a visual inspection of data plots, skew, kurtosis, and P-P plots. In addition, the Kolmogorov-Smirnov test provided inferential statistics on normality and outliers were observed through a visual inspection of histograms and frequency distributions. The assumptions of linearity and homoscedasticity were
tested by an examination of residual plots. Variance inflation factors (VIF) were also examined to check for multicollinearity. As mentioned previously, variables with high levels of collinearity (above 70%) were checked for but none were detected (Berry & Feldman, 1985; Pedhazur, 1997).

Qualitative Analysis

Source of Data

Study site. The study site for the qualitative component of this study was “Southwest College” (pseudonym), a selective, moderately-sized, liberal arts consortium with roughly 7,500 students. This site was chosen because it participated in both the 2011 TFS and 2015 CSS surveys and was also representative of both national surveys, which garnered higher participation rates from liberal arts colleges than other types of HEIs. Southwest College was also chosen due to the wide range of STEM and humanities majors that are offered there. In addition, out of all the liberal arts institutions that were geographically accessible for student interviews, it was the only one that offered a full-fledged engineering program.

Participants. Participants for the study were recruited through purposeful sampling (Patton, 1989; Seidman, 2013). A “maximum variation” of individuals was selected to be as fairly representative of the campus as possible (Seidman, 2013, p. 56). Unlike the quantitative phase of the study, the objective here was not to generalize findings to a broader population, but instead “to present the experience of the people…in compelling enough detail and depth that those who read the study can connect to that experience, learn how it is constituted, and deepen their understanding of the issues it reflects” (Seidman, 2013, p. 54). As much as possible, participants were recruited from a variety of disciplines and from those viewed as “core” to the
area of study. For example, in order to gain the perspective of humanities students, efforts were made to recruit students who were language and literature majors. In order to gain the perspective of STEM students, special efforts were made to recruit students who were biology, physics, and engineering majors. Disciplines such as these were focused on because they represent foundational disciplines within their respective areas of study and are consistently found in humanities and STEM divisions in HEIs across the nation. In regards to race and ethnicity, all efforts were made to have the participant population reflect the campus population which at the time, was roughly 40 percent White, 15 percent Hispanic, 10 percent Asian, 5 percent two or more races, and 4 percent Black (roughly 20 percent were classified as “nonresident aliens” or “unknown”). Because the campus at the time was roughly 50 percent men and 50 percent women, attempts were made to recruit students to reflect this balance in gender.

Participant recruitment was first implemented by contacting gatekeepers—which in this case, were administrators and student affairs professionals who worked at Southwest College and were helpful in granting “access to the setting” (Engel & Schutt, 2009, p. 328). Following the advice and recommendation of gatekeepers, either direct contact (such as emails) or indirect contact (such as posted flyers) were used to recruit students for the study. Participants each received a $15 gift card for participation. In addition, participants were limited to those who had just completed their third or fourth year of study. Although not screened intentionally for this, participants ended up being those who were of traditional college-going age (i.e. 18-24 years old) at the time of the interview. The number of participants was primarily determined by student availability at the end of the spring term and to a certain degree by “sufficiency” (Seidman, 2013, p. 58). Sufficiency was reached when the types of participants loosely reflected the range of
students that make up the larger population in regards to gender and race/ethnicity. This was
done in order to create as balanced a sample as possible that was not overly dominated by one
identity group. In addition, an equal number of humanities and STEM students were also
recruited (Bogdan & Biklen, 2007; Lincoln & Guba, 1985; Warren, 2001).

In total, sixteen participants were recruited. Nine participants identified as “female” and
seven participants identified as “male.” In regards to race/ethnicity, ten identified as “White,”
three identified as “Latino/a,” two identified as “Asian/Asian American,” and one identified as
“Black.” Participants were also selected in order to gain a variety of viewpoints from disciplines
across the humanities and STEM. In order to help ensure that participants had enough classroom
experiences and interactions with faculty in order to adequately answer interview questions,
participants were limited to those students who had just completed their third or fourth year of
undergraduate studies and had entered the institution as first-year students (versus as transfer
students). A list of participants can be found in Appendix B.

**Interview protocol.** According to Seidman (2013), the method of “in-depth,
phenomenological interviewing applied to a sample of participants who all experience similar
structural and social conditions gives enormous power to the stories of relatively few
participants” (p. 59). In order to capitalize on the benefits of phenomenological interviewing,
semi-structured interviews were conducted in order to provide as much space as possible for
participant perspectives to be heard while still providing guidance through an interview protocol
necessary…avenue of inquiry” when a researcher’s goal is “to understand the meaning people
involved in education make of their experience” (p. 10). Mainly, this is because in-depth
interviews are an excellent avenue toward understanding “the lived experience of other people
and the meaning they make of that experience” (p. 9). In contrast to the quantitative phase which served to test hypotheses from the first two research questions, the interviews in the qualitative phase not only answered the third and fourth research questions but also aided in uncovering a deeper and richer understanding of the quantitative findings. As mentioned previously, the first two questions focused on asking what area of study and academic experiences influenced students’ propensity toward innovation and the qualitative component attempted to uncover, through student perspectives, how this process occurred. According to Maxwell (2005), the flexibility of semi-structured interviews makes them “particularly useful in revealing the processes that lead to specific outcomes” (p. 80).

After participants were selected, individual 60-minute interviews were conducted with each participant. The three-part interviews were structured in a way to allow both the interviewer and participant to: 1) “explore the participant’s experience,” 2) “place it in context,” and 3) “reflect on its meaning” (Seidman, 2013, p. 20). Phenomenological theory emphasizes exploring participants’ experiences in the context of their lives, which is crucial for exploring the meaning of their experiences (Patton, 1989). In other words, the objective was not to simply ask students a list of questions about their academic experiences but to understand how students make meaning of their experiences in the greater and deeper context of their lives. According to Bazeley (2013), the “meaning of speech, action, or anything else of interest to a behavioral scientist is always situated, and laws of behavior cannot be assumed to hold independently of context” (p. 81).

The first part of each interview focused on the participant’s background and her/his journey towards selecting an academic discipline at Southwest College. Rather than asking a direct question, I asked participants to describe their journey to choosing their respective major and also encouraged students to share parts of their background that were relevant. This part of
the interview was the least structured and helped to establish “a space within which the participant feels free to tell his or her story” (Olson, 2011, p. 39).

The second part of the interview was more structured and focused on the participant’s academic experiences in her/his major—specifically the participant’s exposure to deep approaches to teaching and learning. The academic experiences that were focused on were those that ended up as significant predictors of propensity towards innovation in the quantitative phase of the study (at the p<0.01 and p<0.001 levels). In particular, students were asked the degree to which they had been exposed to these academic experiences.

Lastly, the third part of the interview was also semi-structured and focused on how the participant perceived these academic experiences as impacting her/his propensity towards innovation. The major focus of this part of the interview was on the process by which deep approaches to learning and teaching influenced student outcomes, as perceived and explained by the students themselves. The interview protocol can be found in Appendix C.

Data Analysis

Interviews were digitally recorded and then transcribed verbatim. Transcripts were then coded in order to identify emerging themes across participants and areas of study (Strauss & Corbin, 1998). Using constant comparative analysis, I began by identifying several emerging themes and developed more detailed sub-themes as new data became available (Bogdan & Biklen, 2004, p. 73). Web-based coding software (Dedoose) was used to facilitate the process. As the analysis continued, different methods of coding (such as process, emotion, and thematic coding) were used to identify codes and to categorize them (Saldana, 2013). After coding and categorization was complete, themes were fully analyzed.
Authenticity. The authenticity of the interview protocol, transcript coding, and interpretation processes was enhanced through peer auditing (Lincoln & Guba, 1985). The interview protocol, anonymized transcripts, and codes were shared with colleagues whose feedback assisted in the assessment of my own biases and assumptions during the data collection and analysis processes. Authenticity was also enhanced through member checking (Lincoln & Guba, 1985), which occurred in two phases. After individual interviews were completed, participants were given the opportunity to elaborate on subjects that were discussed during the interview. After interview transcripts were coded and analyzed, participants were provided with a summary of preliminary findings and were given an additional opportunity to provide feedback or comments.
CHAPTER FOUR: QUANTITATIVE FINDINGS

Using linear regression to analyze a longitudinal dataset of undergraduate college students, the quantitative phase of analysis sought to determine whether humanities and STEM students leave college with different levels of propensity toward innovation (PTI). In addition, this study aimed to identify the key academic experiences and disciplinary contexts that account for variation in undergraduate students’ development of PTI during college. I initially hypothesized that humanities students would have stronger PTI compared to their STEM peers and that in-college predictors would include academic experiences more closely related to deep approaches to learning, or in other words approaches that require stronger and more meaningful student engagement with curriculum. After briefly describing the characteristics of the sample, this chapter presents the results of the regression analyses and places the findings in context. The chapter then concludes by considering possible implications of the findings and discussing how the findings informed the qualitative analysis, which is discussed in Chapter 5.

Descriptive Statistics & T-tests

Crosstabs revealed that humanities students rated their creativity higher than their STEM peers (Table 1). For example, 73.2% of humanities students rated their creativity as “above average” or in the “highest 10%” compared to the average person their age; by contrast, slightly more than half (51.3%) of STEM students rated themselves similarly, which represents a gap of 22.9 percentage points. These figures suggest that humanities students finish college with significantly greater confidence in their creativity than their STEM peers. Creativity levels were important to examine due to conceptual link between creativity and PTI.

When asked to evaluate the importance of various considerations regarding future career opportunities, humanities students placed greater importance on creativity and the opportunity
for innovation compared to students majoring in STEM fields. For example, 82.8% of humanities students reported that the opportunity for creativity and initiative was “very important” or “essential” for their career compared to only 57.1% of STEM students. Similarly, more than two-thirds of humanities students (68.6%) reported that the opportunity for innovation was “very important” and “essential” when thinking about their future careers, which was slightly higher than the 65.3% of STEM students who felt similarly. Collectively, these differences suggest that humanities students finish college significantly more inclined to see value in creativity and innovation than their STEM counterparts.

Table 1

<table>
<thead>
<tr>
<th>Percentage Reporting “Above Average” and “Highest 10%”</th>
<th>STEM</th>
<th>Humanities</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity\textsuperscript{a}</td>
<td>51.3</td>
<td>73.2</td>
<td>+22.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage Reporting “Very Important” and “Essential”</th>
<th>STEM</th>
<th>Humanities</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Career Concern: Opportunity for creativity and initiative\textsuperscript{b}</td>
<td>57.1</td>
<td>82.8</td>
<td>+25.7</td>
</tr>
<tr>
<td>Career Concern: Opportunity for innovation\textsuperscript{b}</td>
<td>65.3</td>
<td>68.6</td>
<td>+3.3</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Students’ self-rating on creativity (Five-point scale: From Lowest 10% = 1 to Highest 10% = 5)

\textsuperscript{b}Students’ self-reported career concerns (Four-point scale: From Not important = 1 to Essential = 4)

An independent samples t-test also provided further evidence that humanities students have significantly stronger PTI at the end of college than their counterparts in STEM. Results
from the t-test suggest that at the end of college, humanities students’ higher average score on PTI compared to that of their STEM peers was statistically significant (Table 2).

Table 2

<table>
<thead>
<tr>
<th>Results of T-test and Descriptive Statistics for PTI by Area of Study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STEM</strong></td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>n</td>
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<tr>
<td>PTI</td>
</tr>
</tbody>
</table>

**p<0.001

Regression Results Predicting End-of-College Propensity toward Innovation

Pre-college and institutional characteristics

In regards to pre-college characteristics it was not surprising that students’ self ratings on creativity upon entering college ended up being a significant predictor of end-of-college PTI ($\beta = 0.38, p<0.001$) (Table 3). In other words, students who rated themselves as highly creative upon entering college also were more likely to have stronger PTI at the end of college. As mentioned previously, self ratings on creativity is one of three survey questions making up the PTI construct and was a crucial variable to control for.

One unexpected finding in regards to pre-college characteristics related to differences in PTI by race, as the analyses identified one statistically significant racial gap among students. At the end of college, Asian students had significantly higher PTI scores ($\beta = 0.06, p<0.001$) compared to their White peers. No previous study has explored the relationship between students’ racial backgrounds and either innovation or value of innovation. However, some
studies have suggested a connection between racial background and orientation towards various forms of innovation. Groeneveld, Sonnad, Lee, Asch and Shea (2006) found that individuals of different racial backgrounds in the U.S. had different attitudes toward medical innovations, with Whites tending to be more open to new medical technologies compared to those who identified as Black. Nonetheless, studies have yet to explore how Asian students compare to their peers of other racial groups in regards to innovative thinking. Due to the lack of research on this topic, further studies ought to explore in more detail how racial or ethnic background, and specifically having an Asian background, may impact or be related to students’ innovative thinking.

In regards to institutional characteristics, no variables ended up being significant predictors of PTI. “Liberal arts vs. Public” institutional status was included in the model due to previous literature indicating that students who attend liberal arts colleges versus other types of HEIs tend to have more positive perceptions of their educational experiences. Results from the regression model suggest that liberal arts status as well as institutional high selectivity status do not play a significant role in humanities and STEM students’ PTI at the end of college. An institutional creativity mean was also included to control for the potential normalizing effects of particularly high or low average student creativity in each institution represented in the sample. However, this variable also did not end up being significant.

Table 3

*Final Regression Coefficients for Predictors of PTI (N = 4,582)*

<table>
<thead>
<tr>
<th>Block 1. Pre-college Characteristics</th>
<th>Standardized Coefficients</th>
<th>Unstandardized Coefficients</th>
</tr>
</thead>
</table>

58
Self Rating: Creativity (pretest proxy)  0.38** 0.41
Sex: Female (vs. Male)  -0.04 -0.07
Average High School GPA  -0.03 -0.03
Asian (vs. White)  0.06** 0.19
Black (vs. White)  0.02 0.15
Hispanic (vs. White)  0.02 0.13
Multiracial/Other (vs. White)  0.01 0.04
Socioeconomic Status (SES)  0.00 0.00

Block 2. Institutional Characteristics
Liberal Arts/Private Institutions (vs. Public)  0.02 0.08
Selectivity: High (vs. Low & Medium)  0.01 0.02
Creativity Mean (Institutional Level)  0.04 0.46

Block 3. Area of Study
Humanities (vs. STEM)  0.18** 0.35

Block 4. Academic/Classroom Experiences
Frequency: Supported your opinion with logical argument  -0.02 -0.04
Frequency: Evaluated the quality/reliability of information you received  0.04 0.07
<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency</th>
<th>p Value</th>
<th>1-β Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenged a professor’s ideas in class</td>
<td>0.07**</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Sought feedback on academic work</td>
<td>0.04*</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Performed community service as a part of class</td>
<td>0.03</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Posted on a course-related online discussion board</td>
<td>-0.02</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>Integrated skills/knowledge from different sources &amp; experiences</td>
<td>0.04*</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Communicated regularly with professors</td>
<td>0.03</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Worked with classmates on group projects during class</td>
<td>0.02</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Made a presentation in class</td>
<td>-0.01</td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>Contributed to class discussions</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Completed a culminating experience/capstone project</td>
<td>-0.01</td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>Participated in an undergraduate research program</td>
<td>-0.01</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>Academic Disengagement Construct</td>
<td>0.03</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Faculty Interaction/Mentorship Construct</td>
<td>0.09**</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Overall GPA</td>
<td>0.01</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Final R²</td>
<td>0.26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .01, **p < 0.001, †CIRP construct
Area of study

Multiple regression analysis allowed me to answer my first research question which asked what differences if any exist between humanities and STEM students’ end-of-college PTI. Controlling for characteristics such as high school GPA, self-reported pre-college levels of creativity, and various experiences while in college, humanities students finished college with significantly stronger PTI than their STEM peers ($\beta = 0.18$, $p<0.001$) (Table 3). This standardized regression coefficient had the second greatest magnitude of all coefficients in the model, suggesting that the humanities-STEM distinction was the second most important predictor of differences in senior-year PTI (only students’ self reported creativity levels upon entering college had stronger predictive power). This finding also confirmed the hypothesis that humanities students would outperform STEM students in regards to end-of-college PTI.

This significant gap between humanities and STEM students’ PTI corroborates previous research that has shown that the college sub-environment that students choose to participate in (such as academic department and area of study) differentially influence their skill and cognitive development. Smart, Feldman, and Ethington (2000), for example, found that academic sub-environments had a socializing affect on students and influenced the way students engaged with curricula inside and outside the classroom. This was largely due to the fact that faculty in different environments reinforced and rewarded different patterns of thought and action. Franklin (1995) and Pike and Killian (2001) also found that differential college sub-environments had a significant impact on students’ reports of their own cognitive development.

Academic and classroom experiences

In addition to students’ area of study, differences in end-of-college PTI were also explained by various academic and classroom experiences. For example, students who more
frequently challenged a professor’s ideas in class finished college with significantly higher scores on PTI ($\beta = 0.07$, $p<0.001$). This finding seems to be supported by the fact that some of the foundations of innovative thinking include the ability to originate new ideas and the ability to negotiate multiple or competing perspectives (Conference Board, 2008). Put another way, given the literature that links innovative thinking to the ability to originate new ideas and negotiate multiple or competing perspectives, it is possible that when students more frequently test out their ideas in class or navigate the process of challenging an instructor’s perspective with their own, they are exercising some of the skills that are the foundations for innovative thinking. This finding also seems to make sense given that “academic self concept” was significantly related to students’ PTI in a previous study that explored both personal characteristics as well as academic experiences (Tsang, 2017). It is possible that students with a positive academic self concept are also those who display greater confidence in their intellectual abilities and are more likely to challenge their professors’ ideas. While this study aimed to focus on academic and classroom experiences that may be predictors of PTI, future studies could investigate how conceptions of self and other more existential aspects of students’ mentalities may be linked to their innovative thinking.

PTI scores at the end of college also tend to be higher among students who more frequently sought feedback on academic work ($\beta = 0.04$, $p<0.01$). Research has shown that high quality and timely feedback is important for enhancing student learning and engagement (Black & William, 1998; Gibbs and Simpson, 2004; Hattie & Timperley, 2007). Hattie and Timperley, who define feedback as “information provided by an agent (e.g. teacher, peer, parent, etc.) regarding aspects of one’s performance or understanding,” explain that feedback from an instructor can play a significant role in both filling the gap between “what is understood and
what is aimed to be understood” as well as pushing students to engage further or more deeply into course content (p. 82).

It is also possible that the impact of this variable could lie in the connection between the ability to take initiative (in asking for feedback) and innovative thinking. From a theoretical standpoint, the ability to initiate is a major component of innovation. Although the relationship between the ability to take initiative and skills in innovation has not been studied in a higher education context, various studies have examined this connection in the workplace. Rice, Kelley, Peters, and O’Connor (2002) for example found that taking initiative is often viewed by workers in R&D as the most challenging yet crucial “front end of the innovative process.” Sergeeva (2014) also found that factors such as motivation to implement an idea had a stronger influence on an employee’s willingness to be innovative compared to an employee’s status in the company or potential financial reward.

In addition to seeking feedback, the frequency with which students integrate skills/knowledge from different sources and experiences also positively predicted PTI ($\beta = 0.04$, $p<0.01$). Based on extant literature, it would seem to make sense that having to integrate skills and knowledge from different sources and experiences would encourage students to think in innovative ways. Integrating skills and knowledge from different sources and experiences is arguably quite akin to what Jackson (2006) describes as holding disparate ideas together and moving them “from one state to another” to generate a “third space” (p. 8). Jackson (2006) argues that this process is a foundation for creative thinking, which is a major component of PTI. Although the survey question does not refer specifically to integrating skills or knowledge from different disciplines, it is likely that some students answered this question based on their experience of integrating what they have learned from classes across different areas of study. If
this is the case, prior research also seems to suggest that such experiences could lead to differential outcomes in PTI. Studies have shown that interdisciplinary studies are highly effective in promoting deep learning and creative thinking in particular (Boehm, 2003; Duerr, 2008; Jones, 2009; Nissani, 1997). Scholars believe that creative thinking is fostered by interdisciplinary studies because they encourage students to consider a wide range of viewpoints and to synthesize information.

Findings also point to the importance of frequent faculty mentorship in finishing college with higher PTI scores ($\beta = 0.09, p<0.001$). Of all the classroom and academic predictors discussed so far, this experience has the largest body of scholarship supporting its connection to a wide range of positive educational experiences as well as greater academic and personal development (Campbell & Campbell, 1997; Campbell, Smith, Dugan & Komives, 2012; Gallup, 2014; Jacobi, 1991; Johnson, 2015; Lau, 2003; Pascarella, 1980; Pascarella & Terenzini, 1977; Pascarella & Terenzini, 1991). Studies show that students who had mentorship relationships with faculty members displayed stronger academic performance (Campbell & Campbell, 1997; Jacobi, 1991), persistence (Campbell & Campbell, 1997; Pascarella & Terenzini, 1977), career development (Gallup, 2014; Johnson, 2015), and leadership development (Campbell et al., 2012). In regards to outcomes that may have a relationship to PTI, studies have shown that students who have more contact with faculty members also display greater intellectual growth (Endo & Harpel, 1982; Kuh & Hu, 2001; Marra & Palmer, 2004; Volkwein, King, & Terenzini, 1986). One study, though not conducted on college students, found that young adults who experienced mentorship also had greater levels of creative achievement compared to their peers who did not have mentorship experiences (Torrance, 1983). An additional study conducted by Haensly and Parson (1993) found that adolescents and young adults experienced creative,
intellectual, and psychosocial development after receiving mentoring from an older adult. To date, however, no studies have focused specifically on the college environment and the role of faculty mentorship on fostering college students’ development as it relates to creativity or PTI.

**Connections to Deep Approaches to Learning and Teaching**

Overall, regression findings confirmed the hypothesis that variables that would end up being predictors of PTI would include those that are consistent with deep approaches to learning and teaching. Deep approaches to learning and teaching, as opposed to surface approaches, encourage an active search for meaning and engagement (Trigwell & Prosser, 1991). A deep approach to learning reflects a personal commitment to understanding coursework and involves strategies such as “reading widely, combining a variety of sources, discussing ideas with others, reflecting on how individual pieces of information relate to larger constructs or patterns, and applying knowledge to real world situations” (Laird, Shoup & Kuh, 2005, p. 470). Both deep approaches to teaching and learning have been found to be strongly related to many positive learning outcomes, including those that are cognitively related to innovative thinking, such as creativity. Hence, it was reasonable to suspect that experiences that are either consistent with or related to deep approaches to teaching and learning may be predictors of students’ propensity toward innovation.

It can be argued that academic experiences such as challenging a professor in class, seeking feedback on academic work, integrating skills/knowledge from different sources and experiences, and having a strong mentorship relationship with faculty are all related to deep approaches to teaching and learning. Challenging a professor’s ideas in class, seeking feedback on academic work, and integrating skills/knowledge from different sources and experiences
require students to be more actively engaged with the learning process compared to more rote or passive forms of learning. The frequency that students are able to have these types of experiences may also be related to deep approaches to teaching in the sense that students may be more likely to engage in these types of practices if instructors allow or encourage these types of experiences. In addition, having a strong mentorship relationship with faculty members requires both students to seek a more meaningful relationship with their instructors as well as instructors who are open and willing to provide time both inside and outside of class to cultivate such relationships with students. Hence, it can be argued that this mentorship variable is conceptually related to both deep approaches to learning as well as deep approaches to teaching.

As mentioned in Chapter 2, literature and prior research suggests a possible link between deep approaches to learning and teaching and innovation. Findings from the quantitative analysis suggest that academic experiences that could be considered deep approaches to learning (and that may be encouraged by deep approaches to teaching) are significant predictors of PTI. These experiences were explored more thoroughly in the qualitative analysis in order to uncover how they influenced students’ PTI. One question that remains for future study, however, is why the other variables in the final block, which could also be considered deep approaches to learning, did not end up being significant predictors of PTI.

**Summary of Findings**

Findings from the descriptive statistics suggested that at the end of college, humanities students displayed stronger PTI compared to their STEM peers. Crosstabs revealed various ways in which humanities students demonstrated stronger characteristics related to PTI compared to STEM students, such as believing themselves to be more creative and indicating a stronger value
of opportunities for creativity, initiative, and innovation in the workplace. T-tests confirmed that differences in group means in regards to PTI as a whole as well as the disaggregated components of PTI were statistically significant. In summary, descriptive statistics suggested that, compared to their STEM peers, humanities students ended college with stronger indications of PTI as well as the individual components making up the PTI construct. These results, however, did not account for a true pre-test or pre-college and institutional characteristics. The multiple linear regression, however, confirmed the gap in PTI between students in humanities and their peers in STEM, even when controlling for a proxy pre-test and important pre-college and institutional characteristics.

The regression analysis also answered research question two which asked what are the academic predictors of humanities and STEM students’ PTI. Regression analysis indicated that the more that students challenged a professor’s ideas in class, sought feedback on academic work, integrated skills/knowledge from different sources and experiences, and had stronger mentorship from faculty, the more likely they were to also display stronger PTI at the end of college. All four academic experiences that ended up being significant at the p<0.001 level were supported by extant literature suggesting that such experiences help to promote student development in areas that are arguably related to PTI such as creative thinking and the ability to further develop emerging or nascent ideas.

The $R^2$ value of 0.26 indicated that the regression model accounted for roughly one quarter of the variance in students’ senior year PTI. It is common in social science research for the $R^2$ value to be lower than 0.40. Although it could be argued that the $R^2$ value is on the lower side, the significant coefficients still represent the mean change in PTI for one unit of change in the predictor variable while holding other predictors in the model constant. Such information is
still valuable despite the arguably low $R^2$ value. Nonetheless a slightly lower $R^2$ value implies that there are likely many other predictors of PTI that the model does not capture (Pedhazur, 1982).

**How Findings Informed the Qualitative Analysis**

The quantitative and qualitative components of this study can be viewed as somewhat distinct phases, but complementary, as both are derived from the same theoretical framework. The quantitative component attempts to answer the question of *what* area of study and academic experiences foster students’ PTI and the qualitative component attempts to answer the question of *how* these academic experiences (from the perspective of students) contribute to the outcomes. In other words, the qualitative component provided insight and explanations as to why some of these academic experiences ended up being significant predictors in the quantitative component. Due to the finding that humanities students tended to leave college with stronger PTI, the qualitative component of the study also helped to shed light on how humanities education may provide some advantages compared to STEM education in regards to fostering students’ PTI. According to Creswell and Plano Clark (2007) it is both a common and acceptable practice for a mixed-methods study to utilize a phased or “sequential approach” in which a quantitative component is followed by a qualitative component, or vice versa (p. 116). More specifically, my study utilized an “Explanatory Design” as the quantitative data was collected first, and the results then helped to inform the collection of the qualitative data (p. 121).

The academic and curricular experiences that were selected to be examined in the qualitative portion of the study were those that ended up being statistically significant predictors of PTI from the quantitative analysis at the $p<0.01$ and $p<0.001$ levels. As mentioned previously,
due to the relatively large sample size (N = 4,582), it was appropriate to determine significance at these more stringent levels. Using the four academic predictors, an interview protocol was created to explore how these experiences (from the perception of humanities and STEM students) impacted their PTI development. The four predictors that were used to create the interview protocol were students’ experiences of having:

1) Challenged a professor’s ideas in class
2) Sought feedback on academic work
3) Integrated skills/knowledge from different sources and experiences
4) Faculty Interaction/Mentorship

The interview protocol will be discussed in more detail in Chapter 5.
CHAPTER FIVE: QUALITATIVE FINDINGS

The first phase of this study, which was discussed in Chapter 4, analyzed national survey data to test for statistically significant differences between humanities and STEM students’ end-of-college propensity toward innovation (PTI). These analyses also revealed the academic and classroom experiences that were predictors of humanities and STEM students’ end-of-college propensity toward innovation. The second and qualitative phase of this study, presented in this chapter, was informed by the findings from the quantitative phase and sought to understand how students perceive academic experiences as impacting their propensity toward innovation. One finding in particular from the quantitative phase of the study determined that humanities and STEM students had differing levels of PTI at the end of college and specifically that humanities students had stronger PTI compared to their STEM peers. Due to this reason the findings from the qualitative phase separates and compares humanities versus STEM students’ experiences in regards to the four predictor variables. Another reason why humanities students’ experiences were compared to STEM students’ experiences was due to Becher’s (1994) suggestion that more nuanced and accurate conclusions about teaching and learning could be achieved when distinctions are made between different areas of study.

This chapter provides findings that address the study’s third and fourth research questions:

3) How do students perceive academic and curricular experiences as impacting their propensity towards innovation?

4) What might account for the differences in humanities and STEM student PTI outcomes?

The objective of the third research question was to examine a distinct yet intersecting issue that helped to more fully explain students’ PTI and approached the issue from an angle that
could not be adequately explored by quantitative measures—that is, individual student perspectives (Mason, 2006). The four academic predictors from the quantitative findings that were used to create the interview protocol were students’ experiences of having:

1) Challenged a professor’s ideas in class
2) Sought feedback on academic work
3) Integrated skills/knowledge from different sources and experiences
4) Faculty Interaction/Mentorship

Separate, open-ended questions were created for each predictor that asked students how each experience impacted both their ability to be innovative thinkers and their value of innovative thinking. Because it was reasoned that students would have difficulty answering questions about their “propensity towards innovation,” the concept of PTI was operationalized as: a) the ability to think in innovative ways and b) the valuing/appreciation of innovation. Students were asked to explain to what degree and how each academic experience impacted their ability to think in innovative ways as well as their value or appreciation of innovation. Students in general had much more to say about how certain academic experiences influenced their ability to think in innovative ways and were less inclined to give detailed answers about how experiences impacted their value of innovation. This was likely owed to the more existential nature of the second question. Due to the open-ended nature of the questions, students were also given space to explain the degree to which these experiences may have not impacted their innovative thinking or appreciation of innovation or may not have been relevant to their college experience (see Appendix C for interview protocol).

The fourth research question emerged as participant interviews progressed. As students explained how they perceived academic and curricular experiences as impacting their ability to
think in innovative ways and their value of innovation, it became evident that humanities and STEM students had very different educational experiences that impacted their overall PTI. The interviews with students revealed patterns and themes that allowed me to deduce why humanities and STEM students may leave college with differential levels of PTI.

Source of Data

Sixteen interviews, lasting one hour each, comprised the data for the qualitative phase of the study. These semi-structured, individual interviews were digitally recorded, transcribed verbatim, and then analyzed using online software (Dedoose). The sixteen participants were selected in order to reflect, as much as possible, the campus demographics both in terms of race and gender. A list of participants and relevant background information can be found in Appendix B.

Participants were also selected in order to gain a variety of viewpoints from disciplines across the humanities and STEM. As mentioned previously, humanities disciplines were determined by guidelines set forth by the Humanities Indicators. Humanities students represented disciplines such as history, gender studies, musicology, American studies, East Asian studies, Eastern European studies, and English. STEM disciplines were determined by guidelines set forth by the National Science Foundation (NSF) and participants represented disciplines such as chemistry, physics, biology, neuroscience, bioengineering, and engineering. In order to help ensure that participants had enough classroom experiences and interactions with faculty in order to adequately answer interview questions, participants were limited to those students who had just completed their third or fourth year of undergraduate studies. All students had entered campus as first-year (versus as transfer) students, which also helped to ensure that participants
had adequate experience at the institution in order to meaningfully reflect on their academic experiences and experiences with faculty. Recruitment of participants was conducted through flyers posted on or near campus (see Appendix D) as well as through referrals. A total of sixteen interviews, eight from humanities and eight from STEM students, were completed.

Findings Related to Participant Backgrounds & Academic Context

Participant backgrounds

Interviews with participants followed basic guidelines set forth by Seidman (2013) who recommends multi-part interviews that first begin with exploring participant backgrounds in order to help ground findings as much as possible in the context of participants’ lived experiences. In other words, interviews that are phenomenological in nature ought not function as a means to obtain answers to a battery of questions. But rather, they ought to explore in detail participants’ experiences in the context of their lives, which is crucial for exploring the meaning of their experiences (Patton, 1989). Hence, whenever possible, findings in this chapter will also highlight relevant student background and contextual details.

I began all interviews by briefly asking students about their overall experience thus far at Southwestern College (pseudonym), including both curricular and extra-curricular aspects. Interviews revealed that all students were generally satisfied with their experience and their choice of attending Southwestern. Next, I asked students about the journey they took to choosing their major. Some students had decided on their area of study very early on in their undergraduate careers or even before attending college while others spent the greater part of their first year exploring different major options. Answers to this question revealed that students came from a multitude of backgrounds and experiences that led them to choosing their area of study.
Sabrina, an Asian-American student (all names are pseudonyms) explained that her decision to be an engineering major was quite “straightforward.” Both of her parents were engineers and they encouraged her to also go into engineering “mainly for the job security.” Sabrina agreed with her parents’ pragmatic advice but also “enjoyed engineering enough to make a career out of it.” Other students had more complex journeys that led them to their respective areas of study. Lauren for example, spent her childhood abroad and attended a STEM-focused private high school in the U.S. She came to Southwestern assuming she would be a mathematics major but after taking several courses in European literature and history “her eyes were opened to the world of humanities,” and she decided to change her area of study to Eastern European studies. Lauren felt that she excelled both in the sciences and the humanities but found greater enjoyment studying the humanities.

**Classroom structure and coursework**

During the first portion of the interviews I also asked students about how classes were structured for their respective majors. Patterns began to emerge early in the interview process that revealed discipline-specific ways in which class time was structured. Humanities students explained that most classes, especially at the upper-division level, were primarily seminars that centered heavily around discussion. One student reported having a seminar that only included two other students and hence, each student was expected to come to class prepared to discuss readings in great length and detail. Many humanities students also mentioned that professors often used a “flipped” class model in which instructional content, such as lectures, were delivered online and students came to class having watched lectures and completed assigned readings. Class time was then spent discussing readings and working on homework-style
questions collaboratively, often with instructors acting as moderators. These “flipped” classrooms largely shifted the instruction to a learner-centered model in which class time was used to explore topics in greater depth and enhanced more meaningful learning opportunities, instead of using class time primarily to deliver content, such as in traditional lecture-based classes.

STEM students explained that lower division classes generally followed a lecture-based format either with or without lab sections. At the upper division level labs were usually included as a component of classes and provided students with opportunities to test what they had learned in lectures and from textbooks. Several STEM students also mentioned that professors sometimes used a “flipped” class model.

In terms of coursework, humanities students reported that professors often assigned weekly readings and students were required to be prepared to discuss these readings in class. Many students reported that over 100 pages of reading would be required per week. Often, short periodic response papers were also assigned, sometimes on a weekly basis. A large component of coursework evaluation consisted of midterm and final papers.

STEM students reported that lower division coursework mainly consisted of assigned readings from textbooks and weekly problem sets for homework. Lower division classes also introduced students to lab work. Some lab work was independent while some classes required students to pair up with a classmate to complete lab reports together. STEM students also reported that upper division classes generally assigned more projects, sometimes in conjunction with lab work and problem sets. Upper division STEM classes also more frequently required students to critique research articles either as homework or during class time.
Academic Experiences and How They Impact Students’ PTI

Findings from the quantitative portion of the study revealed that certain experiences were predictors of students’ end-of-college PTI. These experiences included having 1) “Challenged a professor in class,” 2) “Sought feedback on academic work,” 3) “Integrated skills/knowledge from different sources and experiences,” and 4) “Faculty interaction/mentorship.” The qualitative phase of the study sought to bring more depth to these findings by exploring how students perceive these four academic experiences as impacting their propensity towards innovation. In other words, the qualitative phase of the study aided in illuminating the reasons why these four experiences were particularly impactful for students.

Challenging a professor in class

For both humanities and STEM students challenging a professor in class was an important factor in supporting their PTI development because it fostered faculty support for emerging ideas and an appreciation of different perspectives. Both humanities and STEM students had experiences challenging professors in class, but it became clear early in the interview process that humanities students experienced this much more regularly and in a much more direct manner than their STEM peers. Most humanities students were able recall many instances of directly challenging a professor’s ideas in class while the several STEM students who did “challenge” a professor’s ideas in class explained that they usually were asking questions that pushed the professor to clarify a previous statement, rather than posing a direct challenge to the professor’s ideas. For humanities students who did experience challenging a professor’s ideas in class, many explained that it was a “regular occurrence” and all humanities students, whether they experienced personally challenging a professor or not, explained that it
was “highly encouraged” by instructors. A couple students expressed that they were too shy to challenge a professor in front of other students and preferred to have more meaningful exchanges with professors during office hours.

For humanities students who did challenge professors in class, many explained that their experience had a direct impact on their ability to think in innovative ways as well as their appreciation for innovative thinking. Amy, a gender studies major, explained that challenging a professor’s ideas in class helped her to develop budding ideas. Being in a class setting that encouraged students to challenge the instructor gave her the confidence to “test out ideas in class” and to further her innovative thinking “because she never felt like she would be shot down or judged because her ideas weren’t fully watertight.” In addition, she explained that, “it was also very validating when a professor, who is someone with a PhD, was receptive of the ideas she had because it encouraged her to be confident with some of the more off-the-wall ideas she had and to the continue to develop those ideas.” Amy’s experience was echoed by Lauren an Eastern European studies major who explained that:

It makes me feel really smart to be able to come up with a different interpretation or idea than my professors. And because they take it so welcomingly, I think that definitely encourages me to keep coming up with innovative ideas without feeling self conscious or scared.

Kate, a musicology major also felt similarly about her experience with her professors:

So I’m basically one of the few students here studying musicology and in many ways I had to kind of design my own major. I’ve loved music my whole life and I play different instruments but in college I wanted to learn more about the history of music and especially how music is perceived and used around the world. I take a lot of classes with professors in different majors and I feel like I’m always the odd one bringing a music perspective to things like art history or sociology and that involves challenging professors at times even in front of the whole class. It’s sometimes a little scary but all of the humanities professors I’ve had have been really receptive to my ideas and that definitely encouraged me to keep pushing boundaries—like on an intellectual level.
Hence, for humanities students, interviews suggested that challenging a professor in class impacted their innovative thinking abilities by encouraging them to “test out” new ideas in a safe space.

Humanities students also expressed ways in which challenging a professor’s ideas in class also helped to increase their appreciation for innovative thinking. Amy explained that challenging a professor regularly helped her to see “how many new and interesting ways there were to look at something and that these new ideas could be really inspirational or paradigm-shifting.” According to Tony, an American studies major, challenging a professor’s ideas in class impacted his appreciation of innovative thinking because it not only prompted his appreciation for his own ability to come up with new ideas but also allowed him to appreciate the innovative ideas of his peers. He explained that “lots of times I’ll challenge the professor and think, well that’s that. End of story. I sort of shut him down [laughs]. But then one of my classmates will raise his or her hand and then challenge my idea, so yea, it makes me appreciate how there are lots of way to interpret a situation or a text.” For humanities students, challenging a professor in class often influenced their valuing of innovation because it helped them to identify and appreciate the different ways there were to looking at a particular issue or topic.

Interviews with STEM students revealed that opportunities to challenge a professor’s ideas in class were much less frequent. According to Nick, a physics major, “there were never any open opportunities to challenge professors. It would just be like if they were solving a problem and they did something wrong you could raise your hand and say something, but we were never really encouraged to challenge them.” Maggie, another physics student, also explained that opportunities to challenge a professor were infrequent but that she sometimes
challenged how ideas were presented. Instead of directly challenging or negating a professor’s idea, she had on some occasions asked professors to explain topics from a different angle.

While opportunities to challenge a professor’s ideas in class were rare, both Nick and Maggie as well as other STEM students expressed that if they had questions during lecture they preferred to go to office hours to discuss these matters with professors rather than speak up in front of the entire class. Students expressed that sometimes they felt self-conscious about making a controversial statement in front of so many other students and preferred a lower-pressure environment such as office hours to have discussions with instructors. Anna, a neuroscience major, explained that:

If I were to push back on an idea, I would discuss those in office hours more so than in class because I would just feel self-conscious that I had it totally wrong. Personally, when it comes to science class if I hear something I don’t agree with or don’t know much about I would want to research it before questioning it especially in front of people and I would rather have a separate conversation about it versus taking up class time. I just feel like it wouldn’t be as useful in class because I wouldn’t have a lot of time to discuss it versus putting my ideas out there in a more relaxed way.

For Carl, a physics and chemistry double major, it was much harder to challenge a professor in lecture compared to lab, which offered a more informal setting. According to Carl, professors in his majors were receptive to challenging ideas but he was hesitant to bring up these ideas during a lecture because of the many students that were in attendance; in a large lecture setting “you don’t want to stop the professor and cause a disturbance.” Other STEM students also expressed that they felt hesitant to challenge ideas in class or even ask too many questions because they felt that it would either put an uncomfortable spotlight on them or would be too disruptive.

Students also explained that the lack of opportunities to challenge a professor’s ideas mainly stemmed from the subject matter that was being taught and expressed that often topics
were extremely positivist in nature with only one right answer, especially at the lower division level. Jack, a biology major who had just completed his fourth year, explained that larger lecture settings in his earlier undergraduate years had put him “in this mindset that he didn’t really have anything to contribute to the class because it was very fact-based” and that he wasn’t going to “raise his hand and be able to solve some major scientific thing especially in those big math and science classes.” Gabe, an engineering major expressed a similar view when he explained that “It’s a bit difficult to challenge a professor’s ideas because they’re basically feeding us information from a textbook that is kind of fixed knowledge so there really isn’t a lot of room for mistakes.” Cathie, a bioengineering major, also emphasized that due to the positivist nature of her science classes as well as the perception that the canons of knowledge presented to her were quite “fixed,” she also felt that there was little to no room to challenge her professors. According to Cathie:

I would say there really aren’t that many opportunities. Like I said, I just feel like we were kind of set up to not really feel like we could contribute anything new in class. And I’m not saying that I feel like I’m stupid or that we were made to feel stupid, it’s just that we all had this understanding that scientists have already discovered and examined the things we were learning about and there wasn’t much we could add to it or challenge.

Some students did note, however, that opportunities to challenge a professor’s ideas in class became more plausible at the upper-division level. Vanessa, who had just completed her fourth year as a neuroscience major, explained that the frequency of opportunities to challenge a professor’s ideas in class “depended on the subject.” According to Vanessa, challenging a professor’s ideas in class became more feasible when she started to take upper-division physics courses, “where lots of times no one really knows the answers and a lot of things are just theory so there are more opportunities there to challenge ideas, unlike basic ecology or chemistry classes where lots of things are just assumed to be facts.” These student experiences revealed that
while opportunities to challenge a professor in class might be rarer in STEM classes, opportunities were also dependent on the level of the class as well as the subject matter.

STEM students who did take the opportunity to challenge professors’ ideas in less formal settings, such as office hours or lab, also reported that such experiences had an impact on their ability to think in innovative ways as well as their valuing of innovation. Nick explained that during office hours there were more opportunities to challenge a professor’s ideas since “they might propose an approach they don’t necessarily know the answer to or know what the outcome will be, just like how you don’t know the answer, so there’s just more room for back and forth and it provides more opportunities to challenge their ideas.” Carl felt that lab sessions in particular were a much more ideal environment to challenge a professor’s ideas (compared to lectures) and that these opportunities also helped him to think in more innovative ways.

According to Carl:

One-on-one situations are really helpful for getting me to think in more innovative ways because I just feel like there’s more equal footing and you’re like cracking jokes with professors so you feel less scared to test out some new ideas. I also feel like we’re kind of problem-solving together—almost as if I’m a grad student or something. It just helps when there’s a smaller gap in that hierarchy. So yea in terms of innovation I just feel more free to explore different ideas without the fear of sounding stupid.

Carl was one of several students who was especially fond of Southwestern’s small student-to-faculty ratio and explained that that was one of the main reasons why he enjoyed being a Southwestern student. The intimacy and lack of formality of office hours and lab sessions gave both Nick and Carl the low-pressure setting they needed to be able to test out ideas with instructors without fear of “sounding stupid.” Office hours and lab sessions also helped students feel less inferior to their instructors in terms of knowledge and provided an atmosphere where teaching and learning was more collaborative rather than top-down and didactic. Having these
opportunities to challenge professors helped them to be more innovative thinkers because they gave them the confidence to propose new ideas and to develop these ideas in settings, unlike lectures, where knowledge was not as “fixed.”

For the majority of STEM student participants, challenging a professor’s ideas in class was not an experience that resonated with them. Hence, most were not able to comment on concrete ways that challenging a professor’s ideas in class influenced their valuing of innovation. Nonetheless a couple students were able to comment on this topic. Jack mentioned that most if not all of his classes for his major (biology) emphasized learning and memorizing class materials. However, one class he took included a lecture on bioethics which did help him to appreciate innovative thinking. During the lecture the professor proposed a hypothetical situation in which eco-tourism, including the allowance of sport hunting, was implemented with financial proceeds going toward supporting sustainable environment initiatives. During this lecture Jack remembered challenging both his professor as well as the opinions of other classmates. He was surprised to learn that “there could be so many different viewpoints on this topic, including a lot of perspectives he hadn’t considered.” This experience of challenging a professor’s ideas in class increased his valuing of innovation because it “made him realize that in order to create a better planet, or a better society…sometimes cut-and-dry tactics don’t work. You need a bunch of people who are considering other peoples’ opinions and are coming up with creative solutions. That experience made me really appreciate innovative thinking.”

Overall in regards to challenging a professor’s ideas in class, humanities students overwhelmingly felt that these opportunities were frequent and were highly encouraged by the instructors in their respective disciplines. STEM students on the other hand generally felt that, especially at the lower division level, there were seldom any opportunities to challenge a
professor’s ideas in class. Humanities students also explained that challenging a professor’s ideas in class influenced both their ability to think innovatively as well as their valuing of innovation. Opportunities and encouragement to think in innovative ways allowed them to test out ideas and to continue to develop these ideas by boosting their confidence in their intellectual abilities. Humanities students also felt that challenging a professor’s ideas in class also increased their valuing of innovative thinking because it helped them to appreciate how topics can be viewed from different perspectives. Many STEM students felt uncomfortable challenging a professor’s ideas in lecture but some were willing to question and push back on some ideas during more informal settings such as office hours and lab sessions. For the few students who did challenge a professor’s ideas in less formal settings, these experiences also positively influenced their ability to think more innovatively in much the same way that applied to humanities students: these experiences allowed them to test out ideas with instructors and boosted their confidence in further developing emerging ideas.

Findings suggest that disciplinary and epistemological differences especially at the lower division level between humanities and STEM areas of study affected the degree to which students were able to have the experience of challenging a professor in class. Due to the more positivist nature of lower division STEM coursework there were less opportunities for students to voice challenging or dissenting opinions compared to their humanities peers. Many students explained that there were no opportunities to challenge professors’ ideas because because students were there to absorb and learn foundational principles that were “accepted as facts.” Office hours, during which more casual conversations could occur, seemed to provide more opportunities for STEM students to pose challenging questions or to push back on some ideas. This discrepancy in experiences especially at the lower division level is somewhat troubling.
considering the wealth of literature pointing to the value of deep approaches to learning. It can be argued that challenging instructors’ ideas constitute a “deeper” approach to learning as it requires students to engage with course materials in a way that goes beyond information absorption and retention. If STEM students are indeed spending the majority of their first and second years in college mainly attending traditional-style lectures it seems they would from the outset be at a disadvantage compared to their humanities peers in terms of experiencing deep approaches to learning and potentially developing stronger PTI.

**Seeking feedback on academic work**

Students explained that seeking feedback on academic work was especially beneficial in the form of multi-stage feedback, helping them to move past “simplistic” ways of thinking, and in regards to faculty providing “leads” and “probing questions.” Interviews also revealed that in terms of seeking feedback on academic work, there were clear differences between humanities and STEM students’ experiences. In general humanities students tended to seek feedback on academic work more frequently than their STEM peers and also received more detailed and impactful feedback that helped them to think in more innovative ways. This was at least partially due to the fact that a larger proportion of assignments and assessments (such as midterms and final exams) in humanities disciplines were in the form of written assignments. Eddie, a history student, went so far as to say that in regards to providing feedback “a lot of history professors really go to town on papers.” Many humanities students also sought additional feedback on papers by attending office hours. STEM students expressed being less inclined to seek feedback due to the fact that assessments, especially at the lower-division level, were often in the form of multiple choice exams where explanations for answers were posted online. At the upper-division
level, however, STEM students reported having more opportunities to seek feedback as projects with accompanying written papers became a part of the curriculum. Both groups of students explained the ways in which seeking and receiving feedback helped to enhance their innovative thinking and at times, their valuing of innovation.

For several humanities students seeking feedback on papers was especially conducive for fostering innovative thinking because they were able to seek feedback at multiple stages that encouraged them to push the boundaries of their intellectual and creative thinking. According to Wyatt, an English student who had just completed his fourth year, “feedback that came in multiple stages or waves was the most helpful because when you’re done with one draft you sort of feel like okay, that was pretty much all I could do in terms of thinking in innovative ways, but when you get your draft back with comments they will often push you even further and then you realize that, hey, I can actually develop these ideas more.” Tony also echoed Wyatt’s sentiments when he explained that multiple-stage critiques on papers helped him the most to improve his innovative thinking. Many times Tony would feel quite satisfied with a draft of a paper and would submit it for feedback before having to turn in a final draft. He would often discuss the draft feedback with his instructors during office hours where he was able to “bounce ideas off of them.” Tony liked that he could turn in a draft and then go to his professors during office hours to talk to them about the comments and have them expand upon their comments in person. Often professors would say, “ohh okay that’s fine but have you thought about this?” and this type of pushing during the initial stages of writing helped Tony to further develop ideas even when he had thought there wasn’t more expanding he could do. Sometimes Tony even submitted multiple drafts before turning in a final paper. According to Tony, this process of receiving feedback in
multiple stages on a single paper or project had a great impact on improving his ability to think in innovative ways by continuously challenging him to push his intellectual limits.

An additional aspect of the benefits of receiving multiple-stage feedback is that it also helped to validate student ideas and gave them the confidence to keep pushing forward with fledgling ideas. Erin, an East Asian studies major, remarked that submitting a draft before turning in a final paper was helpful in improving her innovative thinking because she would often submit ideas she was unsure about. Receiving feedback often gave her the encouragement she needed to continue developing an idea. According to Erin:

If a professor writes that they think I have something with this then I think okay, that’s kind of the go-ahead to think about it some more. Most of my best papers have come from ideas I originally was not very sure about but sometimes my professor might point me to a source to help me back up my idea or something like that; and that just gives me the confidence to expand on my idea and flesh it out into a full-fledged paper.

Erin emphasized that the boost in confidence she received from professors when they validated her ideas or provided her with additional sources was “a key component” in helping her to think in more innovative ways. Wyatt, an English student also expressed a similar sentiment:

Usually with my English papers the first draft seems good to me but then the feedback I receive tells me otherwise [laughs]. Not that professors are super harsh or anything, it’s just that often I think my ideas are pretty polished and my analysis is good but a comment or something will sort of pave the way for an entire new section of analysis. And then it’s even better if I can resubmit for feedback again if the professor is willing to do that. It definitely has helped me to push into some really unique and innovative territory with my writing.

In terms of influencing their appreciation for innovative thinking, seeking feedback also played a role for humanities students. For one student in particular, seeking and receiving feedback was especially meaningful. Melody explained that her appreciation for innovative thinking was sparked when she realized that it pushed her to move past “simplistic” or even “ethnocentric” ways of thinking. This push to think beyond “cookie cutter beliefs” came from
recurring critiques from professors who encouraged her to think about how historical events may seem to be “factual” but could be experienced completely differently by people of different identity groups or backgrounds. Melody was a very serious history student and was contemplating teaching history at the high school or college level. She often sought feedback on papers and welcomed feedback because for her, any sort of constructive criticism that could help her become a more insightful history scholar was highly valued. Melody, who was White, felt that she often looked at historical events in U.S. and world history from a very White-American, ethnocentric viewpoint. However, as a person who identified with the LGBTQ community, Melody felt it was very important for her as a history student to give voice and recognition to marginalized groups. Receiving feedback on papers that challenged her White-American, ethnocentric viewpoint increased her appreciation of paradigm-shifting, innovative thinking because in her words, it “made her a better historian and future teacher.”

STEM students also benefitted greatly from seeking feedback from their instructors although this was typically an experience that occurred at the upper-division course level especially with written assignments that accompanied projects. Generally, STEM students reported that instructors were all available and willing to provide feedback but many assignments did not require extensive feedback, such as homework problem sets. Often, answers were posted online. Seeking feedback or additional help most often occurred in the context of office hours. The most helpful feedback in terms of helping students to think in innovative ways usually occurred when students were able to have informal conversations with instructors about various class topics or assignments.

When answering the question of how feedback helped them to think in more innovative ways, many students explained that it was most impactful when professors provided “leads” or
“further probing questions” on an assignment or project. Maggie, a physics major, explained that she appreciated it when a professor would “sort of lead her to the answer without just telling her the answer.” In other words, Maggie felt that she was pushed to think in innovative ways when professors provided feedback that “helped her to expand on how she was thinking about an issue or concept and from there she could make some of the connections herself.” Jack also felt similarly and commented that if he had done something incorrectly on an assignment, he found it most helpful in terms of encouraging his innovative thinking when the instructor “provided him with some leads to find the answer on his own.” Nick remarked that “feedback that included more probing questions was the best.” According to Nick, he would sometimes go in to office hours for further explanations on answers to problem sets. While explaining how the problem could be solved, some professors approached the issue by asking Nick how a problem might be changed if a variable were added or removed. This would help Nick to “think about the problem differently and see something he didn’t originally see.”

Cathie, a bioengineering student, provided an especially interesting example from her senior year capstone project, which explored the different ways of developing a pulse-oximetry device, that is, a device that can measure oxygen levels and blood-flow through a person’s fingertip. Such a device could potentially serve as a non-invasive way of detecting early lung problems in infants. During her capstone circuitry class, Cathie used gelatin to mimic different types of tissue to see how the device would work on different kinds of tissue but was not experiencing much success. According to Cathie:

My professor asked me about different types of LEDs I could try and he was just really good about guiding me to potential answers but didn’t do too much of the work for me. I think partially it's because the work I was doing was so experimental that he didn't even really know what the results would be necessarily. But his suggestions really helped me to explore more on my own and just pushed me to think creatively about ways to get to a solution.
Many other STEM students also remarked that feedback was most impactful on their innovative thinking when it was in the form of suggestions or questions that allowed students to make connections or get to answers on their own.

An additional way that seeking feedback contributed to STEM students’ development of innovative thinking was when professors encouraged them to do more research or exploration related to an assignment or project. Again, this type of feedback usually occurred in the context of casual conversations that took place during office hours. Carl, a double major in chemistry and physics, was particularly interested in the intersection where chemistry and physics meet. Not many other students had developed this particular interest and so Carl explained that he could not rely on help from peers on this topic and “had to go into office hours to bounce ideas off someone.” According to Carl: “the type of feedback that is most helpful is the kind that I get from going in to office hours. So for example if I got some notes or comments written on a draft it really helps for me to…talk it through with my professor. It almost always leads to these amazing conversations where the professor might mention articles or randomly pick up a book off his bookshelf and let me borrow it because it’s related to what I’m studying.” Carl went on to explain that it was “these types of conversations that organically led to professors pushing him into new areas she had never considered and that had sparked a lot of innovative ideas.”

Overall, both humanities and STEM students reported that seeking feedback on academic work helped them to become more innovative thinkers. Humanities students sought feedback on academic work more frequently than their STEM peers and had more opportunities to receive more detailed and impactful feedback even during their lower-division years while STEM students often did not seek out meaningful feedback until beginning their upper-division coursework. For humanities students, seeking feedback helped them to think in more innovative
ways when professors were able to provide feedback at multiple stages which encouraged students to push the boundaries of their intellectual and creative thinking. Feedback from professors also helped to strengthen students’ valuing of innovative thinking by helping them to move past “simplistic” ways of thinking in order to become better scholars. For STEM students, seeking feedback helped to enhance their innovative thinking when professors provided them with “leads” or asked questions that helped students make connections or to solve problems themselves. An additional way that seeking feedback helped STEM students to think in more innovative ways was that seeking feedback from an instructor often occurred in the context of office hours where conversations on class assignments could inspire students to do additional exploration on a certain topic or issue.

Once again, disciplinary differences seemed to make it easier for humanities students to have more enriching experiences in regards to receiving multi-stage feedback. This in part seemed to be owed to the pedagogical differences between humanities and STEM education especially at the lower division level. Humanities students were able to reap the benefits of assignments and teaching practices that allowed for multi-stage feedback whereas STEM students tended to not experience multi-stage feedback until they had reached upper-division coursework. These findings highlight the importance of having students work on projects as early as possible that are collaborative and provide more opportunities for multi-stage feedback from professors. STEM instructors in particular ought to consider how to incorporate multi-stage feedback even in regards to problem sets and homework assignments that tend to constitute the majority of lower division coursework. The importance of discussion opportunities was also highlighted by students, suggesting that STEM professors ought do as much as possible to make office hours accessible, thereby providing more opportunities for professors to ask probing
questions and provide leads that nudge students towards more intellectual engagement and growth. Such strategies would also encourage more deep versus surface styles of learning, during which students have more experiences “understanding” coursework and approach coursework with an “active search for meaning” versus more simplistic knowledge absorption and retention.

**Integrating skills/knowledge from different sources and experiences**

Students explained that integrating skills and knowledge from different sources and experiences impacted their PTI by helping them to make connections between disparate areas of knowledge and by encouraging them to “think for themselves.” Overall, humanities students reported that integrating skills and knowledge from different sources and experiences was highly encouraged by professors and opportunities for such experiences were plentiful in the classroom and in regards to assignments. As was the case for challenging a professor in class and seeking feedback, integrating skills and knowledge from different sources and experiences tended to be a rare occurrence for STEM students at the lower-division level but became more common at the upper-division level. Some STEM students, however, felt that this experience was not relevant to them for the entirety of their undergraduate career.

In regards to influencing their innovative thinking, many humanities students explained that integrating skills/knowledge from different sources and experiences helped them to be more innovative by encouraging them to make connections between disparate areas of knowledge that may not seem related. Wyatt, an English major, explained that for him the “innovative process” depended on the type of paper he was required to write. The papers that “sparked more innovative thinking for him were the ones that allowed him to use texts from outside of class.” One particularly impactful assignment was the final paper for his senior seminar class which
required that students use a majority of sources that were from outside of class. According to Wyatt, “that was one of the most innovation-inducing experiences for me. I had to really think about how to creatively incorporate sources from outside of class to create a final product and it definitely made it more of a challenge versus just having a select list of sources to choose from.”

When asked how integrating knowledge from different sources and experiences influenced her ability to be an innovative thinker, Lauren explained that in her major, Eastern European studies, connecting coursework to knowledge or experiences outside of class was the norm and essentially “the culture of the major.” Having grown up in Eastern Europe, Lauren took a class on Russian fairytales because she was already familiar with some aspects of the topic but wanted to learn more. Lauren explained how integrating knowledge from different sources and experiences was especially salient in this class:

> In Russian literature there is a lot of focus on maternal figures, much more so than in fairytales from other cultures. And what I did was I brought in my knowledge from a feminist studies class I took to analyze Russian fairytales from a feminist perspective. That definitely was one of the most innovative ideas I have ever had in college and I don’t think it would have been possible if we weren’t allowed and even encouraged to bring knowledge from other classes.

Erin, an East Asian studies major also explained how she even incorporated elements from the social sciences into her humanities coursework:

> For one paper I was writing about the Korean experience of being occupied by the Japanese and writing about this one character in particular from a book we read. I really felt like this character was suffering from post traumatic stress and all sorts of identity issues and crises from being subjugated by the Japanese. And these were all concepts I learned about in psych but I talked about it with my professor and he was totally cool with me using concepts from psych. It was a really awesome experience to be able to make connections like that. I wasn’t sure if it was going to work but the more I looked at it the more it felt legitimate and then the ideas really started to build on each other until I had something solid.
For Wyatt, Lauren, Erin, and others, having the opportunity to integrate knowledge from different sources and experiences was the catalyst to innovative thinking because it encouraged them to make connections between subject areas that were not closely related.

For STEM students, integrating skills and knowledge from different sources or experiences was not a regular occurrence. According to Nick, physics classes for his major rarely called for knowledge from other fields of study, although math and sometimes computer science skills were relied upon. Nick explained that “in general, we could get through a class with just what was provided for us, like our textbook and information from lecture.” When asked to what degree did classes for his major encourage or require integrating knowledge from different sources or experiences, Jack, a biology student answered: “Honestly, we don’t really incorporate a lot of stuff from outside of biology so I would have to say that the question doesn’t really apply to me.”

The students who did have concrete examples of integrating knowledge from different sources and experiences were engineering students, Gabe and Sabrina, as well as Carl, a double major student in chemistry and physics as well as Vanessa a neuroscience major. Students who were able to speak in more detail about the experience of integrating knowledge from different sources and experiences were those who were either engineering students or those who had an interest in where different fields intersect and majored in an area that was conducive for such exploration. For Gabe, integrating skills and knowledge from different sources and experiences enhanced his innovative thinking because it “forced him to think for himself.” When he had the opportunity to bring in knowledge from other fields such as chemistry or biology, it made the project or assignment he was working on “uniquely his own” and with that came the responsibility to “think out every step for himself and troubleshoot for himself.” At the upper
division level, he also found that sometimes he could not rely on professors for answers because they themselves did not always know the answers or what the outcome would be for a project he was working on. Having this type of “sole responsibility forced him to think in innovative ways.” Sabrina, also an engineering major, echoed a similar sentiment when she explained that she was most excited about electrical engineering problems that “forced her to think about the material science behind it and pushed her to work things out on her own.” Much like Gabe, Sabrina explained that integrating knowledge from other fields helped her to think in more innovative ways because she felt sole responsibility for how to use knowledge from other fields since the knowledge was not readily provided by the instructor for the course.

Both Carl and Vanessa whose studies were more interdisciplinary in nature explained that integrating knowledge from different sources and experiences helped them to be more innovative because it encouraged them to make connections between areas of study that may not seem connected. Carl, who was a double major in chemistry and physics often chose projects that allowed him to integrate knowledge from both fields. According to Carl:

This was sometimes a challenge in chemistry classes because the professor might not necessarily be an expert in physics and vice versa. Luckily professors are pretty accessible so I can consult with them a lot but the responsibility is on me to make sure that I am merging the two fields and asking the right questions when I go into office hours. But yea, being passionate about both chemistry and physics and especially the area where they intersect has sometimes really pushed me to my limits to make legitimate connections. I think there’s a lot of be explored where these two fields meet but I’m a little bit of a lone wolf in my studies so I have to be innovative.

The intellectual process of merging two fields into one viable study also encouraged Carl to be a more innovative thinker because he was not able to rely as much on course materials or the professor for the class and had to independently bring in sources from other classes and consult with professors from other classes. Vanessa, a neuroscience major, explained that “for
neuroscience you need to have the physical and chemical elements of it as well as the psychological elements in order to fully understand the human brain.” For many projects, Vanessa needed to have a molecular understanding of the brain but explained that one cannot “really get how those molecular processes play out to create certain behavior unless you also have psychology and cognitive science to show you.” Integrating knowledge from different sources and experiences was a bit easier for Vanessa than her other STEM peers because of the more interdisciplinary nature of her major. Vanessa explained that being able to integrate knowledge from different sources helped her to think in more innovative ways because it has encouraged her to “blur the lines between the different fields, even between the hard and softer sciences.” This process has made her realize that although fields of study may seem rigidly defined, there are in fact “areas where they mesh together and even enhance each other.”

In sum, integrating skills and knowledge from different sources and experiences was a much more relevant experience for humanities students compared to STEM students. Humanities students explained that having these experiences enhanced their innovative thinking by encouraging them to make connections between different areas of study. For STEM students, the experience of integrating skills and knowledge from different sources and experiences was mainly relevant to those in more applied fields such as engineering as well as those who chose to major in areas that were somewhat interdisciplinary to begin with. These STEM students also explained that the experience of integrating skills and knowledge from different sources and experiences helped to enhance their innovative thinking because it encouraged them to truly “think for themselves” as well as to make creative connections between different areas of study.

Findings from this area suggest that the “softer” nature of humanities disciplines (Biglan, 1973a) enable humanities students to integrate knowledge and skills from different sources and
experiences when completing coursework and in class discussions. According to students, humanities instructors also welcomed and encouraged the incorporation of ideas and knowledge from other fields of study into their classrooms and in regards to coursework. According to Marton and Saljo (1976a), a deep approach to learning includes “reading widely” and “combining a variety of sources.” Based on Marton and Saljo’s theory of student approaches to learning it seems that humanities students are also at an advantage compared to their STEM peers when it comes to this additional aspect of deep approaches to learning. However, not all STEM students were at a disadvantage. Those students who were in more applied and interdisciplinary STEM areas of study seemed to reap many of the same benefits as their humanities peers in regards to integrating knowledge and skills from different sources and experiences. Engineering students such as Gabe, for example, were able to integrate knowledge from other fields due to the applied nature of his major. Physics and mathematics was used very early in his undergraduate career in order complete engineering projects. Other STEM students who chose more interdisciplinary paths (such as Carl and Vanessa, who were mentioned previously) also had a wealth of experience with integrating knowledge and skills from a variety of classes and disciplines into their coursework and projects.

Faculty interaction and mentorship

Many students reported that having a strong mentorship-type of relationship with faculty was important for their PTI development because it helped to foster their intellectual confidence and provided opportunities for faculty to serve as role models for innovative thinking. As with the previous three predictors, humanities students more frequently reported having close and regular contact with faculty members. For humanities students having frequent interactions with
faculty and a mentorship relationship with some faculty members contributed to their skills in innovative thinking as having this type of relationship often gave humanities students the confidence they needed to be innovative thinkers. STEM students who had strong relationships with faculty members also mentioned that interactions with faculty members gave them the confidence to be more innovative. Insofar as affecting their valuing of innovation, both humanities and STEM students reported that having regular conversations with faculty members, often in casual settings, encouraged their appreciation of innovation due to being inspired by the innovative ideas of their professors.

Lauren, an Eastern European studies major, explained that her Russian professor, whom she was on a first-name basis with, had been her most helpful mentor at Southwestern in terms of fostering her innovative thinking. According to Lauren, what helped the most was that “Clarissa [her professor] sees a lot of potential in all of us and I think that gave her a heightened sense of confidence to think creatively.” When asked to elaborate on this, Lauren explained that:

Lots of times professors, especially in other disciplines, feel really above you and you sort of leave office hours maybe getting some answers but you still feel a little timid to really do things on your own. Clarissa is just always encouraging us to think beyond the superficial level and even for ideas that aren’t fully formed she makes us feel like there is something we can take away from it. Talking with her about all sorts of ideas throughout the years and having her approval and encouragement has given me a lot of confidence to strike out on my own in terms of innovative thinking.

Clearly, seeing her professor on a regular basis and receiving regular encouragement has given Lauren the confidence necessary for her to be a more innovative thinker. This close mentorship relationship that Lauren had with her professor also had a positive impact on her appreciation of innovation. Lauren explained that “If I ever bring Clarissa a paper with some ideas I am not sure about she will give me some leads or suggestions and help me to think harder and more
creatively about the issues. Clarissa is definitely an advocate for innovative thinking. She’s always quoting Einstein, I think, who said that ‘Without creativity, intelligence is nothing.’”

Amy, a gender studies major, also explained how developing a mentorship relationship with one professor in particular gave her the encouragement and ultimately confidence she needed to be a more innovative thinker. Amy was an avid scholar of gender studies and considered herself to be a “gender advocate” and planned to someday go to graduate school to obtain an advanced degree in gender studies. Due to this reason Amy decided to take a seminar that was open to both undergraduate and graduate students. Amy had received good grades in her undergraduate level gender studies classes but was nervous to be in a small class with graduate students where “there was nowhere to hide if she didn’t have anything remarkable to say.” After meeting with the professor for the class it was decided that Amy could select some readings for the class that would also be relevant for her senior thesis. Amy remembered that:

Professor Henkins was really accommodating and encouraging. Whenever I met with her she just gave me this sense of confidence that I truly belonged in the class and could hang with these super intelligent grad students. She would always give me some really good constructive criticism but did it in a way where I felt like she still respected my ideas. I really felt like she believed in my ability to be a good scholar and that gave me the confidence to continue striving with new and innovative ideas even if I felt initial insecurity about them. I guess she gave me the confidence to take more risks intellectually.

Just like Lauren, Amy reported that a key way in which her relationship with a faculty mentor enhanced her innovative thinking was that it gave her confidence in herself and her intellectual abilities.

When asked about how faculty mentorship impacted their valuing of innovative thinking, many humanities students mentioned the idea of faculty acting as creative role models. By modeling the positive attributes of innovative thinking, faculty also inspired humanities students to value innovative thinking. Tony, for example, was a fourth-year history major who began to
seek out professors during office hours on a somewhat regular basis during his second year after he had decided on his major. When asked how and if faculty mentorship had impacted his valuing of innovative thinking he responded by saying that “pretty much all his professors remind him of how important it is to be an innovative thinker.” One professor in particular was someone Tony admitted was his main role model and inspiration. According to Tony, this professor was “absolutely brilliant” and whenever he went in to office hours “he would write down almost everything he said because was always saying things that made him scratch his head and think of things in new ways. His professor had also written books on obscure but really interesting topics and it was very inspiring.” In Tony’s words:

This professor has really inspired me to not just think of history as learning about facts about the past but its more about how can we reinterpret what we know about the past. Or how can we shed light on an area that has never been addressed before. I took a course with him on World War II and I loved that he knew about all of these sources that talk about the experience of black European soldiers and other topics that people kind of overlook. I feel really inspired to do my senior project on a really innovative topic because of him.

As with Tony, other humanities students also explained the main way that strong mentorship relationships with faculty members impacted their valuing of innovative thinking was by faculty members modeling innovative thinking and hence, acting as role models that students were inspired by.

Overall STEM students were less inclined to report mentorship relationships with faculty members. Those who could speak in detail about mentorship relationships with faculty were fourth year students and this is was due to the fact that mentorship opportunities were more accessible during the summer before senior year when students often conducted research with professors and during their senior year while they were completing capstone projects under the guidance of professors.
When asked about how relationships with faculty members outside the classroom impacted their ability to be more innovative thinkers, STEM students, like the humanities students, mentioned that gaining confidence from faculty members was a crucial aspect. Vanessa, a neuroscience major explained that for more than a year she had been cultivating a strong relationship with the principal investigator for a lab she was working in. As the main advisor for her senior year project this professor had “helped her to feel like she was head of the project and that had true ownership over it, which gave her the confidence to just go for ideas she had.” In addition, for projects where the professor was the principal investigator, he “encouraged her to collaborate with him versus just taking orders and working under him.” For Vanessa the relatively egalitarian nature of their relationship that was cultivated over time made her feel like her opinions were respected by her professor. Due to this feeling of respect, Vanessa had more “confidence and inclination to think creatively and to share those ideas with him.”

As with the humanities students, strong relationships with faculty members increased STEM students’ valuing of innovation because of the role that faculty members played as role models for scholarship. When asked how their relationships with faculty members impacted their appreciation of innovation, many STEM students explained that getting to know professors and speaking to them during office hours made them realize how “brilliant” and “incredibly insightful” their professors were. They were often impressed by the groundbreaking and interesting work that their professors were conducting and according to Maggie and others, this made them “recognize the value of thinking outside the box.”

Perhaps the most compelling example of the influence of professors as role models for innovative thinking came from Sabrina, an engineering student who chose her major because her “typical Asian parents” were also engineers and encouraged her to choose a pragmatic college
major that would lead to “job security.” When asked what she meant by “typical Asian parents,” Sabrina explained that her parents instilled in her a more pragmatic approach to college and her career and preferred that she do something “safe and not too out there.” She attributed this mindset to their cultural background. Sabrina was the only participant who openly admitted that she was “not an innovative thinker by nature.” She also admitted that she was much more comfortable “following instructions and completing tasks that had set guidelines” rather than “thinking about creative ideas on her own.” In addition, Sabrina had the least to say when answering interview questions overall and revealed she was more motivated by grades than the pursuit of intellectual exploration. When asked to elaborate on this, Sabrina attributed this to her upbringing and to some degree her cultural background. However, when asked how faculty members had impacted her valuing of innovation, Sabrina had much to say on this topic. According to Sabrina:

Whenever I go in to office hours to ask about problem sets or guidance on how to complete a project I’m always really blown away by how knowledgeable my professors are. They are seriously brilliant. There is one professor I’ve seen several times and I’m thinking about asking him to be my senior year project advisor. He comes up with the most amazing ideas that stem from my own ideas about a potential senior year project and it does make me think about how important it is to sort of think outside the box as a scientist. I think he reminds me that if I really want to be a good engineer I’ll have to work on trying to get more creative and innovative. He’s sort of a good role model and even though I don’t think I could get to his level, I always leave office hours feeling pretty inspired and with a deeper appreciation for innovative thinking.

Much like Sabrina, Jack, a biology major was also positively influenced by his professors who served as role models for innovative thinking. As mentioned previously, Jack felt that much of his coursework did not require or inspire much innovative thinking. But similarly to Sabrina, Jack felt that his professors inspired him to be a more innovative simply by demonstrating the positive outcomes of being an innovative thinker. Jack explained that:
I decided to major in bio because I want to be a physicians’ assistant. So in a sense I kind of just needed to get the basics down and learn about human anatomy and all that stuff for grad school. That’s the main thing pushing me forward in college. But it has definitely been inspiring when I learn about what my professors are working on or what they’re publishing and it definitely makes me respect it a lot. I feel like a lot of it doesn’t really apply to what I want to do career-wise but some of the stuff they’re doing is truly incredible and it just really makes me sort of value innovative thinking a lot more. I mean if it’s not me, someone’s got to be pushing the boundaries right [laughs]?

Other STEM students also reported how their professors impacted their valuing of innovative thinking due to acting as good role models. Again, opportunities to see professors as creative role models tended to arise during upper-division coursework rather than lower-division coursework during which professors were often viewed as lecturers and purveyors of information, rather than as potential collaborators. According to Gabe, his third year was the year that he was able to get to know professors on a much more personal level compared to his first two years. Instead of viewing professors as somewhat intimidating and inaccessible figures he only saw during lectures, Gabe became more comfortable conversing with professors while discussing class projects during office hours. Gabe explained that his engineering professors were all “role models” to him because “they did some of the most mind-blowing work and were great resources when he was looking for ways to further his quest for knowledge.” Gabe explained that faculty members deepened his appreciation for innovative thinking because “Innovative thinking is what got them to be where they are. So by being innovative they were able to conduct some of the most amazing research projects.” Gabe revealed that this had “inspired him to try to be as innovative as possible when he did his senior year project next year.”

Once again disciplinary differences seemed to come into play. Generally, class sizes tended to be on the larger side for STEM students at the lower-division level, although still small compared to what would be experienced at a larger, public institution. While some humanities
courses were lecture style, often first and second year students were already able to take seminar-style classes with extremely small student to faculty ratios. Many humanities students reported taking small, seminar-style classes as early as their first year and beginning to cultivate meaningful relationships with faculty outside the classroom as early as their first year. For most STEM students, mentorship relationships often did not begin until their third or even fourth year. As with some of the other salient academic experience, findings from this area reinforce the important role that faculty play in engaging students in the learning process—a process that seems to be the most profound for many students when it is outside the classroom. This is consistent with the theory of student approaches to learning which emphasizes the importance of meaningful engagement with course materials and and what Marton and Saljo (1976a) and Trigwell and Prosser (1991) describe as an “active search for meaning.” Findings from this area also reinforce the findings from previous areas that point to the important role that faculty play in terms of fostering student confidence in their intellectual ability and their ability to think in innovative ways.

Why humanities and STEM students experience differential end-of-college PTI

Epistemological differences as a contributing factor

Findings from this study support Laird and colleague’s (2008) suggestion that instructors from different ends of the hard-soft spectrum utilize different teaching methods and that it is precisely these epistemological differences that contribute to differences in pedagogy. STEM students in particular reported that innovative thinking was not necessarily encouraged and when it was encouraged by instructors it was in the context of upper-division coursework and projects. The majority of the STEM students who were interviewed reported that their lower-division
years were focused on memorizing and being tested on content from textbooks. Jack, a biology major, explained that:

For pretty much the first two to three years I was at Southwestern, most of my classes involved a lot of memorization and multiple choice exams. I’m also a bio major and there are kind of a lot of bio students so maybe instructors felt like this was the most efficient way to teach and test us. I did notice that the humanities classes I took during my first couple years were smaller and there was just more free thinking involved and there was more room to be creative.

Jack was one of many STEM students who felt very strongly that memorization was the main way that they were encouraged to learn class content and that instructors did not actively encourage innovative thinking.

Other students also reported that in STEM classes it was much harder to incorporate knowledge from other areas of study and that compared to humanities instructors, STEM instructors did not actively encourage it. Vanessa, a neuroscience major, explained that in terms of encouraging innovative thinking the difference between her “philosophy classes and physics classes was like night and day.” Instructors in her philosophy classes “seemed to expect her make lots of sophisticated connections to other areas of study while physics professors wanted her to just really know the stuff in the textbooks like the back of her hand. The difference in teaching styles and expectations was really palpable.”

All humanities students who were interviewed reported that their instructors encouraged innovative thinking from the very beginning of their undergraduate careers. Students explained that making a sound argument was the most important factor in humanities classes and that many different arguments could be successfully made on the same topic as long as sources or evidence was used “to back up your argument.” In other words, expertise on a topic was not required but rather the ability to make and support a claim. Amy, a gender studies major, explained that:
In the humanities I really like that you don’t have to have taken a bunch of classes on a subject area before you can make a contribution or get something really great out of class. I felt like I was able to participate comfortably during my first class here at Southwestern. In my classes we read scholarly articles that dissect the cultural messages embedded in Seventeen Magazine or topics like how men go to barber shops and experience homo-erotic intimacy there—whereas in the hard sciences I felt like I needed a great deal of expertise before I could really contribute or get a lot out of the classes.

Erin, an East Asian studies major, echoed this sentiment about the relative epistemological fluidity found in humanities compared to STEM disciplines when she explained:

My major and just humanities classes in general feel completely different than science classes. In the humanities I feel like I have a lot of freedom to explore class topics in different ways as long as I back up my arguments with reliable sources. There aren’t really any wrong answers as long as you can make a valid argument. In science classes I felt like there were just facts and all I was supposed to do was memorize what was in the textbooks. I didn’t really feel like it was making me more creative even though I was learning about a new subject. A lot of the topics were really fascinating but still, it’s very fact-based and you just have to memorize stuff.

STEM students also remarked on the differences they noticed between their humanities classes and science classes in regards to fostering PTI. These students also commented on the epistemological rigidity of science classes especially at the lower-division level that did not encourage innovative thinking. According to Jack, a biology major:

Thinking in innovative ways is kind of hard in bio because I do feel like the majority of it was memorization and regurgitation. I’m not saying classes were easy but you’re not really pushed to think outside the box. I think a lot of this is because the content we were learning was more factual and concrete compared to humanities classes.

When asked about how classroom experiences impacted his innovative thinking, Nick a physics student also explained that his humanities courses provided more opportunities:

I would say that there’s just more room for innovative thinking in the humanities classes I’ve taken. The concepts in physics are hard to grasp but a lot of it comes down to memorizing things in my opinion. And there’s always a right or wrong answer generally. But in the humanities classes I’ve taken I felt like I had more freedom to explore ideas and there weren’t necessarily right or wrong answers. It
came down to how well you crafted your argument and how much you could back it up.

Vanessa, a neuroscience major, astutely pointed out that “you have to sort of know what the rules are in science before you can break them.” For Vanessa, she “needed a foundation in science before she could start thinking about things on her own.”

Overall, interviews revealed that epistemological differences between humanities and STEM disciplines may help to account for the differential PTI outcomes between humanities and STEM students. During interviews, many STEM students expressed how the positivist nature of STEM disciplines constrained their innovative thinking, especially during their lower division years, and that their humanities courses provided many more opportunities for PTI development.

**Class structure as a contributing factor**

Interviews with students also revealed the ways in which differences in class structure between humanities and STEM classes may also help to explain why humanities and STEM students experienced differential end-of-college PTI. In terms of class structure, both STEM and humanities students reported that having time for class discussions was an important component in helping them to engage with class materials and also to think in more innovative ways. Discussion periods, as opposed to lecture periods, gave students more opportunities to challenge professors’ ideas in class due to the more casual and collaborative atmosphere it fostered. Discussion periods were also more conducive to innovative thinking compared to lectures because students could also learn from and respond to the opinions of their fellow classmates. Compared to their STEM peers, humanities students more often reported that discussion was a major component of their class time and also explained how discussion helped to positively impact their innovative thinking. According to Wyatt, an English major:
For most classes we come having done the readings and as other people begin to share their ideas it’s very much expected of us to either further the ideas our classmates are putting out there or we’re expected to have some sort of rebuttal or present a contrasting perspective. So in a sense our entire class period which is basically a long discussion, is pushing us to think in innovative ways.

Tony, a history major, also echoed this sentiment when he explained that discussions were extremely helpful in influencing his ability to think in innovative ways because “when someone finds a point in the reading or makes a connection between things that he wouldn’t have thought of, it inspires him to also think of ways to make connections he never would have otherwise.” Tony also explained that discussion periods were much more helpful in keeping him engaged with course materials compared to lecture periods:

My humanities classes have mainly been discussion-based and that has kept me much more engaged. So if a professor is just standing there and lecturing from Power Point I sort of just tune it out but when you come to class and you’re expected to contribute to class discussion then that engages me because it makes me want to make a contribution. College discussion-based classes have definitely been the best way for me to learn. It essentially forces me to come to class prepared and to have engaged with the content before even coming to class and it’s especially effective if there is a balance between the professor and the students each contributing.

All other humanities students also mentioned discussion periods as a contributing factor to their innovative thinking. Many explained that it was during discussion periods that they were able to have the opportunity to challenge a professor in class and to integrate knowledge and skills from other sources and experiences. According to humanities students, discussion periods were a much more viable time to have these academic experiences compared to lecture periods which they considered to be more formal and didactic in nature.

STEM students who had classes with engaging discussion periods also explained that discussions were extremely helpful in impacting their innovative thinking. Vanessa, a neuroscience major explained that having small group discussions was particularly effective:
I definitely think that group discussions keep me more engaged. Sometimes a professor will lecture on diseases and weird abnormalities in biology and physics and being able to talk about this in a small group is really great. We can all contribute our ideas about what is going on and predict what is going to happen. The good thing about talking in small groups is that you get all of these different perspectives, especially if people are coming from different majors. Small groups are also good in the sense of validation. When I have an innovative idea that’s maybe kind of off the wall, it’s a good testing ground for those ideas and when people agree with what I have to say it makes me believe my ideas might have some merit.

Hence, for Vanessa, small group discussions were beneficial because she could learn new ideas from her peers and also gain confidence in her own innovative ideas.

Maggie, a physics major, explained that at Southwestern physics was a “small major” and due to this reason she was able to have classes that had a relatively small student-to-faculty ratio. One class in particular (that only had ten other students) was especially effective in helping Maggie to stay engaged with her coursework because one of the two days that the class met each week was allocated to discussion. The first class of the week was a “normal lecture” where students listened to the instructor and took notes. The second class of the week was a “flipped classroom” where students were expected to have read materials and listened to some digitally recorded lecture content before coming to class and were expected to be able to discuss class materials. In addition, during these “flipped” class periods the instructor provided students with problem sets that they were to complete while collaborating in small groups. After an allotted amount of time, students shared out to the larger group the problem they were presented with and how they solved it. According to Maggie:

Flipped classrooms are great. They really lend themselves well to discussion and give us a chance to talk to classmates and also get some more personal time with the professor. So during the discussion period the professor will write out some problems on the board and we break into small groups to solve the problem we’ve been assigned. Sometimes if we get stuck we can get the professor to help us out. I really like it because there’s no shame if we aren’t able to figure something out.
Also just being able to talk through problems with other classmates really helps because I usually get to see something from an angle I never considered before.

Although Maggie benefitted greatly from the increased discussion that a flipped classroom provided, other STEM students who were interviewed did not have experience with flipped classrooms or classes that devoted very much time to discussion. Maggie explained that this class experience was somewhat unique, although most of her classes did incorporate some amount of discussion especially at the upper-division level. Based on Vanessa and Maggie’s testimonies, it seems that discussions provided a couple key benefits. First, they provided a space for students to collaborate with each other and by doing so, students were also able to learn from new perspectives and ways to solve problems. Second, discussions provided a space for students to test out ideas with each other and this provided them with a sense of confidence in their intellectual abilities.

Coursework as a contributing factor

Interviews with students also revealed the ways that differences in coursework influenced their innovative thinking. In particular, students reported that projects and assignments that were open ended were especially conducive to fostering innovative thinking. As with discussion periods, having course requirements that were open ended was also more frequently experienced by humanities students than by STEM students. According to humanities students, assignments that were open ended in nature contributed to their innovative thinking because it allowed them to be creative with project topics. According to Eddie, a history major, writing papers with relatively open-ended prompts gave him the freedom to “go his own way with a topic, which automatically made him think outside the box.” Kate, a musicology major, explained that she loved prompts that were more opened ended because they allowed her to “use knowledge that
she gained from class and apply it to a topic from outside of class or vice versa.” Laura, an Eastern European studies major, explained that she liked open ended prompts because she could “make her focus more historical, or political, or cultural” and this allowed her to explore topics more creatively.

In addition, prompts that were open ended allowed students to have more of a sense of ownership over their papers and projects. As mentioned in earlier in this chapter, having a sense of ownership over coursework contributed to students PTI because it encouraged them to think for themselves when it came to problem solving and completing assignments. Kate, a musicology major, preferred open ended prompts for papers and projects because they allowed her to rely more heavily on primary sources of her choosing, which she preferred over textbooks from class. Her reasoning for this was that by selecting her own primary sources, she could “interpret them for herself instead of having a textbook interpret them for her.”

STEM students also explained that open-ended project topics were especially beneficial for fostering PTI. However, these experiences often did not arise until they were taking upper division coursework and for some students, the only project that they could think of that required innovative thinking was their capstone project which often was the last project they completed before graduating from college. According to Nick, a physics major, his capstone project was the most impactful academic experience he had in college in terms of fostering innovative thinking. What he liked most about his capstone project was that he could choose his topic and design each step himself. Nonetheless, he did find the open-ended nature of the project to be somewhat challenging due to the fact that it was hard for him to “shake the idea that someone should be telling him what to do” based on his previous experience with lab projects and assignments for his major. Cathie, a bioengineering major, also appreciated the open-ended nature of her
capstone project but wished that such projects had been offered earlier in her undergraduate career. According to Cathie:

We just did our capstone for bioengineering…and it was definitely a bit of a steep learning curve for me because I really hadn’t had that many creative outlets throughout college in terms of my major. I’m glad I had the experience in the end because I got to exercise some more of my creative muscles and also get a better idea of how to apply bioengineering to real life but I do wish that there had been more real-life or hands-on things earlier on. Most upper division courses still just focus on the facts but I’d say the capstone project was my most significant experience where I had to utilize innovative thinking.

In contrast, humanities students often reported that innovative thinking was expected from the first class they took. This was mainly due to the fact that even in lower division courses, humanities students were expected to write papers as a part of their course requirements. Writing papers required much original thinking and was often the most frequent way that students sought feedback from instructors and integrated knowledge from different sources and experiences. The impact of paper-writing was persuasively expressed by Kate, a musicology major, who explained that:

Writing papers is one of the best ways to get me to think innovatively. For example, I took a class on musical developments from the sixteenth century to present day and how music reflected the culture of the times. For our final paper we could use sources from both inside and outside of class and we had a lot of free reign in terms of how to tackle the topic. I decided to analyze the history of music from a Marxist lens after learning about Marxism in another class. I wasn’t sure if it was the best fit but my professor thought it was a great idea. It was a really great experience and I felt really proud about being able to apply a unique lens to the topic of music. But pretty much all of my humanities classes require papers and usually they all allow me to approach topics from a creative angle.

Although writing papers was not as common of a course requirement for STEM students, those students who did have experience writing papers also expressed that they were particularly helpful for helping them to think in innovative ways. Carl, a chemistry and physics double major, explained that his favorite assignment was the first paper he wrote on the quantum mechanics of
photosynthesis. He explained that the prompt was very open ended and “that helped in terms of
getting him to think in innovative ways.” Carl especially liked writing on that topic because “the
class was in the physics department but he felt like he could also make connections to a lot of
other fields, which was really satisfying.” Vanessa, a neuroscience major, explained that much of
her inspiration to be innovative came from writing research papers. According to Vanessa:

I usually get a lot of inspiration to think in innovative ways from reading
interesting research and from writing research papers. Those papers are tailored to
my analysis of things and things I’m interested in in the scope of the class. And
that kind of forces me to look outside the confines of the class for research that
I’m most interested in. That helps to get my ideas flowing or alters some of my
previously held ideas.

Hence, for humanities and STEM students writing papers was an especially helpful academic
experience in terms of fostering innovative thinking. However, according to students, humanities
courses required written papers much more frequently than STEM courses and began early at the
lower division level. In contrast, STEM students often did not write papers until their upper
division years and sometimes the only significant paper they had to write was for their capstone
project which was usually taken during the last semester of their undergraduate careers.

**Accessibility of faculty as a contributing factor**

During the interview process it also became clear that humanities and STEM students had
very different experiences with faculty members during their earlier years of study. The
quantitative phase of the study revealed that having a strong mentorship relationship with faculty
was highly correlated with stronger PTI at the end of college. However, interviews indicated that
humanities students were able to achieve stronger relationships with faculty members earlier in
their college careers compared to their STEM peers. It is possible that this difference in faculty
accessibility during the early years of college education may contribute to why humanities
students outperform STEM students in regards to PTI. When asked about her relationship with faculty members, Cathie, a bioengineering major, explained that she was somewhat close to one faculty member due to working closely with him on her capstone project, but other than that, she did not have any strong relationships with any other faculty members. She did observe, however, that her peers in humanities majors seemed to have a very different experience. According to Cathie:

I’ve noticed that my friends who are humanities majors seem to have had a deeper relationship with professors from like as early as their first year and that’s just really different from my experience. They’ll have professors who supposedly have asked them to talk with them over coffee or something (laughs) but that would never have happened to me during my earlier years here.

When asked why she felt like it would have been difficult to have had stronger relationships with faculty members earlier on, Cathie explained that she had mainly taken lecture-style courses during her first and second year and that she always felt “like professors were sort of above her and it was easier to talk to a TA or ask her peers for help.” Hence, for Cathie, attending mainly lecture-style courses created a barrier between her and professors.

Other STEM students also echoed this sentiment. Jack, a biology major, explained that during his lower-division years he could “get away with the professor not even knowing his name if it was a larger class.” However, getting somewhat used to being anonymous to professors made it harder for him to connect with them when he was in smaller classes and when his upper division coursework required him to meet with professors during office hours. According to Jack:

I sort of became comfortable not having a strong relationship with faculty members and so in smaller classes I definitely felt more nervous. There were more opportunities to get mentorship from faculty as the years progressed but I guess it was hard for me to feel like I was on equal terms with them since lectures made me feel somewhat intimidated to talk to them. I do wish that could have
been different. That’s probably the one thing I wish I could have changed about my college experience. It’s just hard to switch gears.

As with other STEM students, Jack had opportunities to engage more meaningfully with faculty members as he began his upper division coursework, however, the transition was somewhat difficult because he had grown accustomed to not engaging with faculty members. In addition, Jack reflected the sentiments of other STEM students who felt that the major barrier to developing mentorship relationships with faculty was due to the lecture-heavy nature of lower-division classes. Attending mainly lecture-style courses created a hierarchical division between these students and professors and then made it difficult to transition to more intimate relationships with professors during the latter years of their undergraduate careers.

**Summary of Findings**

The qualitative phase of the study shed much more light on how academic experiences influenced students’ PTI from the perspective of students as well as why humanities students may outperform STEM students in regards to PTI. The interview protocol investigated the third research question of this study, which asked: How do students perceive academic and curricular experiences as impacting their propensity towards innovation? Although students came from a variety of backgrounds and academic areas of study many common themes began to emerge in regards to how the four academic and curricular experiences of interest impacted students’ PTI. In the process it, also uncovered reasons for why humanities students may outperform humanities students in regards to PTI.

In regards to “challenging a professor in class” both humanities and STEM students reported that this experience was crucial in influencing their PTI because the exchange between
faculty and students provided a means for faculty to support budding ideas that students often felt insecure about. When faculty members were receptive to students challenging their ideas and open to having a dialogue with them, this provided students with the confidence and inspiration to further develop nascent ideas and to encourage their innovative thinking. This experience also influenced students’ valuing of innovation by providing opportunities for students to appreciate different perspectives coming from professors as well as other students in class.

“Seeking feedback on academic work” also provided many benefits in regards to encouraging students’ PTI. Multi-stage feedback was particularly helpful because it helped students to push themselves intellectually. Students often submitted drafts of research papers that they felt would meet instructors’ expectations for “good work” but would often receive feedback pushing them to expand or think more deeply on certain aspects. This type of feedback was crucial for challenging students to think in even more sophisticated and innovative ways to improve their projects and papers. Related to this is the process of by which seeking feedback on academic work also influenced students’ PTI because it challenged them to move past “simplistic” or unidimensional ways of thinking. STEM students in particular felt that seeking feedback was particularly helpful for fostering their PTI when instructors would provide helpful tips or “probing questions” that helped them to arrive at conclusions themselves.

“Integrating skills/knowledge from different sources and experiences” was also quite helpful for encouraging students’ PTI. Many students explained that this was due to the process of making connections between seemingly disparate areas of knowledge. When instructors provided opportunities or even encouraged students to draw from sources and areas of knowledge outside of class, these experiences challenged students to be innovative because they
had more ownership over the assignment or project they were working on and were hence forced to “think for themselves.”

Having experiences related to “Faculty interaction/mentorship” was perhaps the most impactful experience for all students. Both humanities and STEM students reported that having relationships with faculty members often led to meaningful and casual discussions that tended to reduce the perceived hierarchical difference between themselves and faculty members. Interactions with faculty members, whom many students considered to be mentors, was crucial for helping them to think in innovative ways because these conversations often gave students the confidence they needed to persistently develop budding ideas. In addition, both humanities and STEM students explained that having relationships with faculty members also influenced their PTI because faculty often acted as role models for innovative thinking. Witnessing the creative projects faculty members were working on and simply absorbing faculty members’ innovative ways of thinking during casual discussions and office hours often encouraged students’ value of innovative thinking and inspired them to also be innovative thinkers.

The qualitative phase of the study also revealed several key findings related to research question 4 which asked: Why might humanities and STEM students experience differential end-of-college levels in PTI? Findings revealed that differential PTI levels between humanities and STEM students could be attributed to several factors including discipline-related differences in epistemology, class structure, coursework, and accessibility of faculty. Interviews with students revealed that the epistemological fluidity of the humanities compared to STEM allowed more humanities students to think in innovative ways earlier in their undergraduate careers. In addition, humanities courses’ emphasis on discussion and open ended paper and project topics also allowed more humanities students to reap the benefits of such pedagogical practices that
help to foster PTI. Lastly, STEM students often spent much of their lower division years in lecture-based courses which tended to impede closer student-faculty relationships while humanities students were able to take smaller seminar-style courses earlier in their undergraduate careers, and this in turn helped to make faculty seem more accessible. All of these factors may contribute to why humanities students tended to outperform STEM students in regards to PTI. A further discussion of these factors will be presented in Chapter 6.
The overarching purpose of this study was to determine if humanities and STEM students leave college with differential levels of PTI and to determine how specific academic experiences impact students’ PTI development. While sources had suggested that humanities and STEM education may differ substantially in their impact on several key student outcomes, there had been no study to date that compared the learning outcome differences between humanities and STEM students in regards to innovation. In addition, no study had addressed the academic and curricular factors that may contribute to students’ PTI development in college. In response to the need for more empirical research on this topic, this study sought to explore and measure what differences, if any, exist between humanities and STEM students’ propensity toward innovation and identified various academic and curricular predictors. In addition, this study explored qualitatively how students perceive potentially beneficial academic and curricular experiences as impacting their propensity toward innovation and shed light on why humanities and STEM students may experience differential PTI outcomes.

The quantitative phase of the study answered the first research question which asked: What differences if any exist between humanities and STEM students’ PTI at the end of college? This phase of the study revealed that humanities students had stronger PTI at the end of college compared to their STEM peers even while accounting for a proxy pretest as well as background and institutional characteristics. Regression modeling using a dummy variable representing students’ area of study indicated that humanities students tended to leave college with stronger PTI compared to their STEM peers. This finding also confirmed the hypothesis that humanities students would leave college with stronger PTI than their STEM peers.
The quantitative phase of the study also answered the second research question which asked: What academic experiences significantly predict humanities and STEM students’ PTI? Regression analysis indicated that the more that students “challenged a professor’s ideas in class,” “sought feedback on academic work,” “integrated skills/knowledge from different sources and experiences” and had stronger mentorship relationship with faculty, the more likely they were to also display stronger PTI at the end of college.

The qualitative phase of the study first shed light on how academic experiences influenced students’ PTI from the perspective of students and answered the third question: How do students perceive academic and curricular experiences as impacting their propensity towards innovation? This phase of the study revealed that in regards to “challenging a professor’s ideas in class” this experience was crucial in influencing students’ PTI because the exchange between faculty and students provided a way for faculty to support budding ideas that students often felt insecure about. This experience also influenced students’ valuing of innovation by providing opportunities for students to appreciate different perspectives coming from professors as well as other students in class. “Seeking feedback on academic work” also provided many benefits in regards to encouraging students’ PTI. Multi-stage feedback was particularly helpful because it helped students to push themselves intellectually and to move past “simplistic” or one-dimensional ways of thinking. STEM students in particular felt that seeking feedback was particularly helpful for fostering their PTI when instructors provided helpful tips or “probing questions” that encouraged them to arrive at conclusions themselves. “Integrating skills/knowledge from different sources and experiences” was also helpful for fostering students’ PTI because it encouraged students to make connections between seemingly disparate areas of knowledge. This experience also challenged students to be innovative because they felt they had
more ownership over their coursework and hence were forced to “think for themselves.” Finally, “Faculty interaction/mentorship” experiences were crucial for helping students to think in innovative ways because these conversations often gave students the confidence they needed to persistently develop budding ideas. In addition, both humanities and STEM students explained that having relationships with faculty members also influenced their PTI because faculty often acted as role models for innovative thinking.

The qualitative phase of the study also drew from student experiences to uncover why humanities and STEM students may experience differential PTI outcomes. Hence, the qualitative phase also answered the fourth research question: why do humanities and STEM students have differential PTI outcomes? Interviews revealed that disciplinary differences contributed to humanities and STEM students’ differential PTI outcomes and specifically that aspects of humanities education and pedagogy helped to encourage more opportunities for PTI development compared to STEM educational practices.

**Limitations**

**Quantitative Phase**

Perhaps the clearest limitation of the quantitative phase of this study is that it relied on secondary data, thereby constraining this study to survey questions that were not necessarily intended to explore students’ propensity toward innovation. In addition, this study was constrained by the limited items on the survey that could be used to create the dependent variable and questions had been framed in ways that could not be fine-tuned or adjusted.

A second limitation is that due to the scarcity of survey questions addressing innovation, several proxies had to be utilized. Instead of being able to measure students’ innovation capacity,
this study was limited to measuring students’ propensity toward innovation. In addition, what is lacking in this study is a true pre-test. Out of the three survey questions that make up the dependent variable, only one question (asking students’ self rating on creativity) was available on the TFS. This question alone had to serve as a proxy pretest in the absence of additional pre-test questions on the TFS. In order to help compensate for the lack of a true pre-test, however, pre-college characteristics known to influence innovation and related cognitive skills were controlled for in the regression model (as discussed in Chapter 3). A true pre-test, however, would have allowed this study to investigate in-college gains. Instead this study was limited to studying students’ end-of-college PTI while controlling for important background and institutional characteristics.

Another limitation of this study is that the dependent variable consisted of one survey question that measured students’ self-reported gains in creativity. Currently, the reliability of student self-reported gains is under debate (Porter, 2011, 2013). Scholars who support the reliability of gains questions point to studies showing that students’ self-reports do not appear to be random, but rather, are consistent with other student characteristics such as disciplinary area (i.e., art students report larger gains on questions asking about their appreciation for art, music and drama compared to non-art students etc.) (Pace, 1985; Pike & Killian, 2001). Perhaps the strongest empirical evidence pointing to the validity of gains questions are studies conducted by Pike (2011) and Pike, Smart & Ethington (2011) which used questions from the National Survey of Student Engagement (NSSE) and applied Holland’s (1973) theory of person-environment fit and found that gains questions had “both construct and criterion validity” (Porter, 2013, p. 204). Those who argue against the validity of gains questions contend that scholars have yet to provide a credible theory as to how students are able to accurately report gains in learning, and more
specifically, argue that students do not have the cognitive ability to provide this information accurately (Bowman, 2010; Porter, 2011).

Another limitation of the dependent variable is that the survey questions on some level may be biased on favor of humanities students. One of the three questions making up the PTI construct asks students to rate themselves in regards to their level of creativity. In addition to the questioned reliability of self-reports, it may be possible that humanities students regard themselves as being more creative than their STEM peers due to social and cultural influences, but may not in fact actually be more creative than their STEM peers. In addition, cultural and social influences may have a stronger impact on humanities students in regards to their value of innovation in the workplace, thereby leading more humanities students to report that opportunities for innovation is an important aspect of their first job after college.

Lastly, it has been argued that statistical modeling in the field of education can often benefit from the use of hierarchical linear modeling (HLM) due to the nested nature of data (i.e., students nested within disciplinary areas that are nested within certain types of institutions etc.). As a result, multiple regression is often viewed as limited in its ability to capture institutional-level effects. However, for this study in particular, prior research suggests that HLM may not be necessary. Mayhew and colleagues (2012), for example, found that institution type did not influence students’ innovative entrepreneurial intentions and thus chose to analyze their nested data using single-level regression techniques instead of HLM. In addition, Heinz, Shapira, Rogers and Senker (2009) also found that creativity did not significantly vary by institution type when other student and environmental characteristics were controlled for. These factors support the justification of using multiple regression for this study. Institution type also did not end up being a significant predictor for PTI during the quantitative phase of this study.
Qualitative Phase

The most evident limitation of the qualitative phase of this study is that the interviews cannot possibly capture the multitude of experiences and perceptions that exist on an entire college campus. Furthermore, because this study focused on the role of deep approaches to learning and teaching on impacting students’ propensity towards innovation, it did not look extensively at other aspects of students’ identities and backgrounds (such as SES, race/ethnicity etc.) that may also influence PTI. Although these facets of students’ identities sometimes came up in interviews and were incorporated into the findings, they were not the focus of this study. Another limitation of the qualitative phase is that it was conducted at a moderately sized liberal arts college in order to reflect the sample used in the quantitative phase. Findings in regards to students’ propensity towards innovation may have turned out differently if interviews were conducted in a different institutional setting. Southwestern College is also a highly selective liberal arts institution and this may also have influenced interview findings as it can be assumed participants may have stronger cognitive and intellectual abilities compared to the national average. Furthermore, in terms of participant recruitment, I was not able to find a student majoring in mathematics, even though that is one of the core disciplines in STEM.

An additional limitation of the qualitative phase is that innovation and innovative thinking may be conceived of differently by humanities students than STEM students. Participants were informed that for the purposes of this study “innovation” was not defined by more marketplace-driven definitions (i.e. innovation did not have to include producing a deliverable with marketplace value), but other than that participants had the freedom to answer questions based on their own definitions of innovation or innovative thinking. It is possible that humanities and STEM students may think of innovation differently and their answers to
interview questions may reflect what they perceived to be innovation. For example, humanities students may have a tendency to think of themselves as creative thinkers, thereby also thinking of themselves as highly innovative individuals. It is possible that STEM students may have a more narrow definition of innovation and may not consider subtle instances of “thinking outside the box” for problem solving as innovative thinking. It is also possible that a dichotomy in perception could arise from discipline-related socialization. For example, humanities professors may have a tendency to tell students that they are expected to think in creative ways and hence, reinforce students’ belief that they are indeed creative thinkers. This type of socialization may not be as prevalent in STEM classrooms, therefore leading STEM undergraduate students to not think of themselves as innovative.

Another limitation to note is the fact that students had a harder time answering questions that asked about how academic experiences impacted their “valuing of” or “appreciation for” innovation compared to questions that asked about how academic experiences impacted their ability to be innovative thinkers. Since PTI was operationalized in the qualitative phase by asking students the two types of questions mentioned above, it can be argued that the qualitative phase of the study was better able to uncover student perspectives in regards to one aspect of PTI (innovative thinking) and less able to uncover students’ perspectives in regards to the other aspect of PTI (valuing of or appreciation for innovation). In addition, students were asked about their valuing or appreciation of innovation overall, and not specifically about their valuing of innovation in regards to career paths, which is what two of the three survey questions that make up the PTI construct ask. This was done because it was reasoned that it would be quite difficult for students to evaluate the degree to which their academic experiences impacted their valuing of innovation as it relates to a workplace setting versus innovation as a more general concept.
Theoretical Limitations

Although this study is grounded in the theory of student approaches to learning (Marton & Saljo, 1976a, 1976b) and specifically the model of deep versus surface approaches to learning (Biggs, 1988, 1999), which have been widely utilized in higher education research, these theories have also been criticized for several shortcomings. As mentioned in Chapter 2, Marton and Saljo (1976a, 1976b) observed that when learning, students generally fall into two categories, those who take a “deep” approach to learning, and those who take a “surface” approach to learning. Biggs (1988, 1999) and others (e.g. Laird, Shoup & Kuh, 2005; Trigwell & Prosser, 1991) expanded upon this idea and explained that a deep approach, which leads to stronger comprehension, is the more preferred approach to learning as opposed to a surface approach, which leads to a more superficial understanding of course materials. Howie and Bagnall (2013) argue that the model of deep versus surface approaches to learning has been reified by scholars and has been applied by many without any serious critique of the model, leaving the model overused and underdeveloped.

I recognize that the underdeveloped nature of the model of deep versus surface approaches to learning contributes to some theoretical weaknesses in this study. As mentioned by Howie and Bagnall (2013), the model of deep versus surface approaches to learning has lacked refinement and further clarification since it was promoted by Biggs in the late 1980s, leaving the model vague and the terms “deep” and “surface” loosely defined. Due to the lack of clarity on what exactly is meant by “deep” and “surface” approaches to learning, scholars, including myself, have been left to some degree to interpret these concepts for ourselves. For the purposes of this study, I largely followed Trigwell and Prosser’s (1991) interpretation of deep approaches to learning as meaningful engagement with coursework and a surface approaches as those which
rely heavily on memorization. Although still somewhat vague, I felt that Trigwell and Prosser’s (1991) definitions of “deep” and “surface” were understandable and practical. I used my own interpretations to select variables that qualified as “deep” approaches to learning (as defined by Trigwell and Prosser), in the quantitative phase of the study and also used my own interpretation to distinguish between deep and surface approaches to learning in the qualitative phase. As a result of the underdeveloped nature of the model of deep versus surface approaches to learning it is possible that a different interpretation of the model could have led to different findings. I would also argue that the lack of clear definitions for “deep” and surface” has led to a deep/surface dichotomy that can be construed as overly simplistic. However, I have attempted to collect and interpret data with as much acknowledgement as possible to the complexities and nuances inherent to the process of student learning.

**Nuances Regarding Students’ End-of-College PTI**

Although the quantitative phase uncovered that humanities students ended college with stronger PTI compared to their STEM peers and the humanities students in the qualitative phase reported having more frequent academic experiences that are positively correlated with stronger PTI (such as challenging a professor in class, etc.), findings from the qualitative phase revealed that comparing humanities versus STEM students’ differences in PTI is challenging and requires attention to various nuances. While STEM students overall reported that experiences such as challenging a professor in class, receiving feedback, integrating skills and knowledge from different sources and experiences, and having a mentorship relationship with faculty were not very relevant to their lower-division years, STEM students tended to have more of these experiences during their years completing upper-division coursework. Hence, while STEM
students overall did not report having as many PTI-fostering experiences as their humanities peers, findings from interviews suggested a difference in frequency and quality of these types of experiences between lower-division and upper-division years. In particular, opportunities to see professors as creative role models tended to arise while STEM students were completing upper-division coursework rather than lower-division coursework, during which professors were often viewed as lecturers and purveyors of information, rather than as potential collaborators.

Another nuance that was uncovered is the fact that STEM student experiences varied significantly depending on students’ respective majors. STEM students whose majors were either more interdisciplinary in nature or in applied fields reported having many richer experiences in regards to challenging a professor in class, seeking feedback, integrating knowledge and skills from different sources and experiences, and having a mentorship relationship with faculty members. Interviews with students revealed several reasons why these student experiences differed from those of their STEM peers in more “pure” disciplines (Biglan, 1973). Engineering students in particular tended to work more closely with professors and had more opportunities for innovative thinking due to the “trial and error” nature of the projects they worked on. Students whose majors explored where different disciplines intersect, often incorporated knowledge from different disciplines in the research they conducted and also had to rely on strong relationships with faculty members from different disciplines. Students in more interdisciplinary majors also explained that the nature of their majors made it so that they were not able to rely on textbooks or “cookbook” style experiments and had to work closely with faculty members to keep pushing their projects forward. Hence, while humanities students as a whole reported having more frequent academic experiences that are linked to stronger PTI,
STEM student experiences varied greatly by their year of study as well as their respective majors.

As mentioned in Chapter 2, Becher (1994) argued that as a result of overlooking the distinctions *between* disciplines, scholars tend to reach oversimplified conclusions about teaching, learning, and issues related to higher education practice. Becher (1994) in particular was referring to administrative policies that do not acknowledge disciplinary differences, and the disappointing outcomes that result for both HEIs and stakeholders such as instructors and students. Becher’s admonition, while related specifically to administrative policies, highlights the importance of not viewing STEM as a homogenous field for research, teaching, and learning purposes. These findings also support existing studies that espouse the benefits of interdisciplinary education in terms of fostering positive cognitive outcomes. The topic of interdisciplinary education will be further discussed later in this chapter.

**Findings and Connections to the Theory of Student Approaches to Learning**

Perhaps the most significant aspect of the findings from this study is that they provide support for the theory of student approaches to learning which posits that students approach learning by adopting an “understanding approach to learning” or by adopting a “reproductive approach to learning.” As mentioned previously, these two approaches are commonly referred to as “deep” and “surface” approaches to learning, respectively. Trigwell and Prosser (1991) and other scholars have posited that students would experience greater cognitive and intellectual gains if they more frequently utilized deep approaches to learning and had instructors who encouraged deep approaches to learning.
Impact of deep approaches to learning on PTI

Results from this study support the idea that deep approaches to learning contribute to students’ PTI. Students reported during interviews the various ways in which academic experiences such as challenging a professor’s ideas in class, seeking feedback on coursework, and integrating knowledge and skills from different sources and experiences, which can all be considered deep or more meaningful engagement with coursework, all had a positive impact on their innovative thinking or their valuing of innovation. Challenging a professor’s ideas in class not only required that students understand course content, but required that they be able to think critically and creatively about how a different perspective could be taken on an issue. Seeking feedback required students to be invested in their learning experiences and also encouraged more meaningful engagement with coursework. It also provided students with the opportunity to challenge their existing ways of thinking especially if they sought feedback at multiple stages while completing a paper or project. Integrating knowledge and skills from different sources and experiences, much like challenging a professor’s ideas in class, required that students “think outside the box.” This experience impacted students’ PTI because it required students to think innovatively by drawing connections between seemingly disparate areas of knowledge. Lastly, pursuing relationships with faculty members also led to much more engagement with course materials and also pushed students to think in innovative ways by being intellectually encouraged by faculty members.

Related to the theory of student approaches to learning is an idea presented by Laird and colleagues (2008) who argued that differences in approaches to learning, and hence, learning outcomes, could be attributed to students’ academic disciplines in college. As mentioned in Chapter 2, Laird et al.’s (2008) study found that deep approaches to learning were utilized more
frequently by humanities students than by STEM students. Results from this study provide support for this premise and appear to be consistent with Laird and colleagues’ (2008) findings. Not only did the quantitative phase of the study uncover that humanities students tended to leave college with stronger PTI compared their STEM peers but the qualitative phase of the study also revealed the ways in which humanities students more consistently utilized deep approaches to learning and were provided with more opportunities to do so. Humanities students often reported that critical thinking and meaningful engagement with course materials was required very early on in their undergraduate careers while STEM students revealed that their lower-division coursework was dominated by memorization and content acquisition. A deeper analysis of the contributions of discipline to students’ PTI will be discussed in the following section.

**A Matter of Discipline:**

**Reasons for differences in PTI between Humanities and STEM students**

This study aimed to test out the hypothesis that humanities and STEM students would experience differential end-of-college levels in PTI and that humanities students would outperform STEM students in regards to this outcome. The quantitative phase of the study revealed that there indeed was a quantifiable difference between humanities and STEM students’ end-of-college PTI, even when controlling for important background and institutional characteristics, and the qualitative phase of the study explored how academic experiences found to be significant predictors impacted all students’ PTI. As interviews progressed the qualitative phase of the study also began to uncover potential reasons for *why* humanities and STEM students experienced differential levels of PTI.
Epistemological differences as a contributing factor

In addition to using the theory of student approaches to learning as a guiding conceptual framework, this study also centered on how educational environmental characteristics may influence student approaches to learning and ultimately, different learning outcomes. Laird and colleagues (2008) found that compared to their counterparts in hard disciplines, faculty in soft disciplines, such as humanities disciplines, more frequently and consistently utilized deep approaches to teaching that were more likely to encourage deep approaches to learning. The sciences, located at the “hard” end of the spectrum, are characterized by “greater consensus on content and method” and the humanities, located at the “soft” end of the spectrum, are characterized by disciplines wherein “content and method in these areas tend to be idiosyncratic” (Biglan, 1973a, p. 202). In other words, STEM disciplines are typically characterized by a high level of consensus around foundational knowledge, paradigmatic assumptions, and epistemology whereas the humanities tend to be characterized by less consensus around and more recurrent revisions of these areas (Snow, 1959; Biglan, 1973a, 1973b).

Laird and colleagues (2008) attributed discrepancies in teaching methods to the epistemological differences between disciplines at different ends of the hard-soft spectrum. According to Laird and colleagues (2008) faculty in hard disciplines tended to use pedagogical practices, or “surface approaches to teaching” that were more likely to encourage surface approaches to learning. This was mainly due to the epistemological rigidity of these disciplines. These teaching methods included encouraging students to memorize content from textbooks and evaluation methods, such as multiple choice examinations, that tend to reward rote memorization (Laird et al., 2008).
As mentioned in Chapter 5, clear distinctions emerged early in the interview process in terms of the different educational experiences humanities and STEM students had due to the epistemological differences of their respective areas of study. Humanities students often explained that because there were “no right or wrong answers” in their majors, their main objective in class and while completing coursework was to develop a response that could be defended using evidence. Developing responses for papers and for engaging in class discussions was a major way in which humanities students exercised their ability to think in innovative ways.

Results from these findings corroborate Edelstein’s (2010) idea that due to the more frequently evolving and malleable nature of the assumptions and knowledge base undergirding humanities disciplines, humanities courses are able to “demand originality from day one” (Edelstein, 2010, p. 17). While Edelstein (2010) acknowledges that STEM courses at the undergraduate level may require students to be innovative, he argues that these experiences are less frequent and not a major component of most undergraduate STEM curriculum. For these reasons, Edelstein argues that humanities education, at least at the undergraduate level, is better positioned to foster innovative thinking in students. Findings from this study seem to support Edelstein’s (2010) assertion; however, it is important to remember that opportunities to think in innovative ways did begin to emerge much more frequently for STEM students during their upper division years.

Class structure as a contributing factor

Interviews with students also revealed the ways in which differences in class structure between humanities and STEM classes may also help to explain why humanities and STEM students experienced differential end-of-college PTI. In terms of class structure, both STEM and
humanities students reported that having time for discussions was an important component in helping them to engage with class materials and also to think in more innovative ways. Discussion periods, as opposed to lecture periods, gave students more opportunities to challenge professors’ ideas in class due to the more casual and collaborative atmosphere it fostered. Discussion periods were also more conducive to innovative thinking compared to lectures because students could also learn from and respond to the opinions of their classmates. Compared to their STEM peers, humanities students more often reported that discussion was a major component of their class time and also explained how discussion helped to positively impact their innovative thinking.

Based on student testimonies, it seems that discussions provided a couple key benefits in regards to fostering innovative thinking. First, they provided a space for students to collaborate with each other and by doing so, students were also able to learn from new perspectives and ways to solve problems. Second, discussions provided a space for students to test out ideas with the support of faculty and this provided them with a sense of confidence in their intellectual abilities. These findings lend support for existing research that has uncovered the many benefits of incorporating as much discussion as possible into undergraduate classrooms (Kim, Kim, Khera, Getman, 2014; Roehl, Reddy & Shannon, 2013; Strayer, 2012). These findings also support McWilliam (2009) who argues that in order for instructors to teach for creativity, they must master the art of “meddling in the middle,” rather than acting as “sage on the stage” or “guide on the side.” In other words, in order to encourage students to think creatively, instructors need to be able to serve as a conductor for creative thinking, which requires them to walk a middle ground between being a lecturer delivering information (i.e. the “sage on the sage”) and a discussion moderator (i.e. the “guide on the side”). Many participants in this study who reported
having instructors who fostered their innovative thinking essentially described their instructors as “meddlers in the middle” who not only listened to their ideas and facilitated discussions but also encouraged students to build upon existing ideas to reach higher levels of analysis through probing, leading questions, and supporting small-group collaboration. “Meddlers,” as McWilliam (2009) describes them, are also adept at encouraging a learning environment that is “low threat, high challenge,” meaning that students feel safe and welcome to share their ideas but also feel that intellectual rigor is fostered and expected (p. 289).

Findings from this study support the idea that this type of learning environment is much more feasible in the form of a discussion-style classroom rather than through lecture, as many students who attended lectures reported feeling self conscious and apprehensive about raising their hand to ask questions. As mentioned in other parts of this paper, humanities students more frequently had discussion or seminar-style classes and sometimes as early as their first or second year in college. These types of classes were structured in a way to provide safe spaces for meaningful discussion and intellectual growth and humanities students reaped the benefits of this type of class structure more frequently than their STEM peers.

**Coursework as a contributing factor**

Interviews with students also revealed the ways that differences in coursework influenced their innovative thinking. In particular, students reported that projects and assignments that were open ended were especially conducive to fostering innovative thinking. As with discussion periods, having course requirements that were open ended was also more frequently experienced by humanities students than by STEM students. According to humanities students, assignments that were open ended in nature contributed to their innovative thinking because it allowed them
to be creative with project topics. In addition, prompts that were open ended allowed students to have more of a sense of ownership over their papers and projects. As mentioned in chapter 5, having a sense of ownership over coursework contributed to students PTI because it encouraged them to “think for themselves” when it came to problem solving and completing assignments. STEM students also explained that open-ended project topics were especially beneficial for fostering PTI. However, these experiences often did not arise until they were taking upper division coursework and for some students, the only project they reported that was completely open ended was their capstone project which was often the last project they completed before leaving college.

In contrast, humanities students reported that open ended prompts were par for the course even in lower division classes. This of course was mainly due to the fact that humanities courses often require written assignments, which are often more conducive to open ended prompts compared to STEM lower division work which is often dominated by problem sets and other types of homework. According to both humanities and STEM students, writing papers required much original thinking and was often the most frequent way that students sought feedback from instructors and integrated knowledge from different sources and experiences. Although writing papers was not as common of a course requirement for STEM students compared to humanities students, STEM students who did have experience writing papers in courses for their majors also expressed that they were particularly helpful for encouraging them to think in innovative ways.

These findings support extant literature that discusses pedagogical practices that can stimulate creative thinking (Davis, 1991; Fasko, 2000; Feldhusen & Treffinger, 1980; Renzulli, 1992). Feldhusen and Treffinger (1980), for example, provided several recommendations that could help foster creative thinking, including adapting student interests to coursework whenever
possible as well as allowing students to have choices and be able to take part in the control their learning experiences. By providing students with open ended prompts or allowing them to choose the topic that interests them the most, instructors allow students to further explore topics they already have an interest in and also give students the opportunity to have greater ownership over their work, which in turn, according to Feldhusen and Treffinger (1980), help to stimulate creative thinking. At the lower division level, it would seem that written assignments would be the most conducive to these pedagogical practices. However, project based learning could also incorporate these pedagogical practices at all levels of undergraduate education and could be incorporated into both humanities and STEM education.

**Accessibility of faculty as a contributing factor**

During the interview process it also became clear that humanities and STEM students had very different experiences with faculty members during their earlier years of study. The quantitative phase of the study revealed that having a strong mentorship relationship with faculty was highly correlated with stronger PTI at the end of college. However, interviews indicated that humanities students were able to achieve stronger relationships with faculty members earlier in their college careers compared to their STEM peers. It is possible that this difference in faculty accessibility during the early years of college education may contribute to why humanities students outperform STEM students in regards to PTI.

Many STEM students reported that they had opportunities to engage more meaningfully with faculty members as they began upper division coursework, however, the transition was often difficult because many had grown accustomed to not engaging with faculty members on a personal level. In addition, STEM students expressed that the major barrier to developing
mentorship relationships with faculty was due to the lecture-heavy nature of lower-division STEM classes. Attending mainly lecture-style courses created a hierarchical division between these students and professors which made it difficult to transition to more intimate relationships with professors during the latter years of their undergraduate careers.

Findings from this study seem to lend support for Renzulli’s (1992) model for creative thinking which emphasizes the role of the instructor as a mentor and role model as an essential component for fostering creative thinking. Findings also seem to corroborate Chambers’ (1973) findings that certain instructor behaviors tend to foster creativity in students. These behaviors include conducting classes in an informal manner, welcoming unconventional ideas, and being accessible to students and prioritizing mentorship relationships with students.

Implications for Pedagogy

Improving STEM student outcomes

The findings from this study suggest that STEM students may be at a disadvantage compared to their humanities peers in regards to developing strong PTI in college. Findings also suggest various reasons for why STEM students are disadvantaged compared to their humanities peers and that these disadvantages seem to pertain to disciplinary differences in epistemology as well as undergraduate-level pedagogy. These findings support extant research suggesting that instructional approaches are highly related to discipline (Braxton & Hargens, 1996; Neumann, Parry & Becher, 2002). Not surprisingly scholars have also found that students in “hard” fields more often utilized a surface approach to learning and that students in “soft” fields more frequently utilized a deep approach to learning (Biglan, 1973a; Jones et al., 2010; Laird et al., 2008). While differences in epistemology cannot really be helped, findings from this study
provide numerous practical implications in regards to undergraduate pedagogy and how STEM pedagogy in particular could be modified in order to improve student PTI outcomes.

While it is understandable that lectures will remain as a component of STEM undergraduate education, as a substantial amount of time needs to be devoted to teaching foundational principles, findings from this study suggest that it may be advantageous to employ a “flipped” classroom whenever possible—that is a class structure which requires students to watch or listen to pre-recorded lecture materials on their own time and to come to class prepared to discuss lecture content in a collaborative environment. This would allow students to learn vital, foundational knowledge while also devoting more class time to meaningful engagement with course materials, classmates, and instructors. Flipped classrooms also provide opportunities for a broader range of in-class activities such as presentations, project-based learning, peer reviewing, and discussion-based document analysis or critiques. Because flipped classrooms allow for more personalized and less didactic instruction, more time can be spent in class on deep approaches to learning such as problem-solving, teamwork, and critical thinking while constructing knowledge with the help of their instructor and peers (Kim et al., 2014; Roehl et al., 2013; Strayer, 2012).

Findings also suggest that time spent during laboratory sessions can vary greatly depending on discipline and that certain types of lab sessions may be more helpful than others in terms of encouraging PTI. STEM students who were interviewed reported that applied fields such as engineering tended to have lab sessions that encouraged more innovative thinking while fields that were more “pure” in nature (Biglan, 1973a), such as physics and chemistry, employed more “cookbook” style lab exercises that did not foster as much innovative thinking.
Cookbook labs require students to follow step-by-step procedures and record observations and results. Scholars of pedagogy have criticized cookbook style labs for rewarding students for following directions and for not stimulating deeper levels of inquiry and investigation (Germann, Haskins & Auls, 1996; Modell & Michael, 1993). Brownell and colleagues (2012) also found that when undergraduate biology students were exposed to “authentic, research-based lab experiments” compared to traditional cookbook style lab sessions, students in the research-based lab experienced more positive attitudes toward authentic research, higher self confidence in lab-related tasks, and increased interest in pursuing future research compared to students in cookbook style lab courses.

An additional pedagogical implication that can be extracted from the findings is the importance of open-ended projects and assignments for fostering PTI. Although some degree of foundational knowledge is undoubtedly required for STEM students before they can begin to embark on individual or group projects, there are some ways that open-ended assignments can be incorporated earlier in undergraduate education. Some STEM students mentioned that in addition to capstone projects and non-cookbook style lab experiments, article critiques and case studies helped to foster more meaningful engagement with coursework and innovative thinking. Hence, while it may not be reasonable to expect STEM survey courses to include complex written assignments or projects, it would be helpful for instructors to encourage more innovative thinking by assigning article critiques or case studies so that students could begin writing papers at the lower division level and reap the cognitive and intellectual benefits of doing so. These types of assignments would also help to encourage students to seek feedback from instructors and to develop closer relationships with instructors at an earlier point in their undergraduate careers.
In addition, these types of course requirements could help replace evaluation methods that are in the form of multiple choice exams. Such assignments could be designed to test for knowledge acquisition while also encouraging more meaningful engagement with coursework. Reducing the amount of evaluation that is conducted through multiple choice exams would be beneficial as research suggests that multiple choice exams are not an effective measure of learning and may even hinder higher-level thinking and strategies for learning (Dufresne, Leonard & Jurace, 2002; Martinez, 1999; Stranger-Hall, 2012;)

**Importance of Interdisciplinary Education**

Findings from this study also reinforce the importance of interdisciplinary education and suggest that it may play a role in encouraging students’ PTI. Regression analysis revealed that integrating knowledge from different sources and experiences was a predictor of both humanities and STEM students’ PTI at the end of college. During interviews, humanities students especially reported the many ways in which class structure and instructor attitudes encouraged them to incorporate knowledge from disciplines outside of class to their current studies. The process of doing this, as mentioned in Chapter 5, encouraged students to think in innovative ways. STEM students on the other hand did not have as many opportunities to apply knowledge from different areas of study and as a result may have missed out on opportunities to develop stronger PTI. As mentioned previously, however, STEM students in more interdisciplinary programs had more opportunities to incorporate knowledge from different areas of study with positive results.

Many scholars have touted the benefits of interdisciplinary education, especially as a way to foster stronger higher-order thinking skills. In contrast to multidisciplinarity, which involves the additive process of learning multiple disciplines without necessarily integrating disciplinary
components, interdisciplinarity is defined by Knight, Lattuca, Kimball, and Reason (2013) as “marked by a synthesis of disciplinary knowledge and methods that provides a more holistic understanding” (p. 144). Although research on interdisciplinary education has produced some mixed results in regards to student learning outcomes (Lattuca, Voight & Fath, 2004), and has also remained “limited and explorative” (Spelt, Beimans, Tobi, Luning & Mulder, 2009), findings from this study support prior research suggesting that interdisciplinary studies foster a range of positive learning outcomes. Advocates of interdisciplinary programs have found that integrating interdisciplinarity into undergraduate curricula better prepares students for work and for civic participation by facilitating the development of independent judgement (Barnett & Brown, 1981) as well as growth in areas such as general knowledge, critical thinking skills, and preparation for graduate or professional school (Astin, 1993). Findings from this study support the idea that interdisciplinary education may help students to develop independent and critical thinking skills.

On a related note, educators in recent years have also advocated for STEM to be re-conceptualized as STEAM—essentially adding an arts and humanities component to STEM education (the “A” representing “arts and humanities”). Many scholars have criticized introductory STEM courses for focusing too much attention on content acquisition and too little on fostering students’ metacognitive and higher-order skills (Handelsman et al., 2004; Hurd, 1997; Williams, Papierno et al., 2004). DeWitt (2017), a renown science educator whose famous TedTalks advocate for the reconceptualization of science education, argues that traditional science education “stifles both creativity and passion.”

Some scholars have argued that adding arts and humanities in a more intentional way to STEM education could help to improve STEM student outcomes and could help STEM students
become better scientists. While it is beyond the scope of this paper to address the ways in which arts education may enhance learning in STEM students, it is important to note the ways in which humanities education is believed to enhance learning in STEM students. Snively and Corsiglia (2001) for example argue that an understanding of non-Western cultures and how non-Western societies construct knowledge—and even scientific knowledge—may help science students in Western societies recognize the biases that may exist in their process of investigating and interpreting scientific data. Donnelly (2004) argues that humanities education will enhance STEM students’ education by fostering the ability to make independent judgments and interpretations as well as a better understanding of science in the context of human society. In addition, Koblitz (2017) argues that humanities education will aid STEM students by helping them to become better writers. Koblitz (2017) argues that being able to effectively convey scientific procedures and results, and essentially being able to “tell a story”, is fundamental to a successful career as a scientist. Unfortunately, to date, no major empirical study has been conducted on the quantitative or qualitative gains STEM students experience from exposure to humanities education. However, findings from this study suggest that STEM students may benefit greatly from exposure to humanities education, in particular, by enhancing their PTI.

**Implications for Research**

Findings from this study suggest that a small student-to-faculty ratio is important in helping to foster students’ PTI since having more opportunities to receive academic feedback and having a strong mentorship relationship with faculty were predictors of students’ PTI at the end of college. It is reasonable to assume that a small student-to-faculty ratio would greatly aid in providing students with more opportunities to have both of these important experiences. The
regression model for this study utilized a dummy variable comparing liberal arts institutions to all other institutions. As mentioned in Chapter 4, this dummy variable did not end up being a significant predictor of students’ PTI even though liberal arts institutions on average have a lower student-to-faculty ratio compared to other types of four-year institutions (Astin, 1999). Future research ought to investigate this issue further especially since scholars have suggested that liberal arts institutions produce an array of positive student outcomes. According to Astin (1999), “residential liberal arts colleges in general, and highly selective liberal arts colleges in particular, produce a pattern of consistently positive student outcomes not found in any other type of American higher-education institution” (77).

On a related note, follow-up studies ought to investigate the qualitative experiences of humanities and STEM students who attend comprehensive, four-year as well as large research universities. The participants in this study attended a selective consortium of liberal arts colleges, but students’ qualitative experiences could vary widely depending on institution type as well as institution size. Geographic region could also play a role in the qualitative experiences of students at liberal arts colleges as the experiences of students attending a liberal arts college in a metropolitan area may differ from those attending a liberal arts college in a rural area.

Future research might also explore reasons for why Asian students tended to outperform White students in regards to PTI. In the regression model, race dummy variables were created by comparing racial minority students to White students as the reference group. As mentioned in Chapter 5, the only race variable that ended up being significant was the dummy variable comparing Asian students to White students. To date, no studies exist on comparing different student racial or ethnic groups in regards to innovative thinking. However, students from different racial groups have been compared in regards to creativity, which is conceptually similar
to innovation. A seminal work on creativity by Kaltsounis (1974) compared low-SES White and Black middle school students and found that Black students performed significantly better than White students on the Torrance Creativity Test. A more recent study on creativity assessment by Kaufman (2006) found that Black and Native American high school students tended to rate themselves as more creative than students from other ethnic groups. Future studies ought to investigate whether or not Black and Native American students maintain their higher self-reports on creativity in college. In addition to testing for creativity, future studies ought to investigate PTI as it relates to students’ racial or ethnic backgrounds. Although race was not ignored in this study, future investigations ought to examine in more detail how background characteristics such as race, culture, and ethnic identity may play a role in students’ innovative thinking and valuing of innovation.

In regards to the disparity in PTI between humanities and STEM students that was discovered in the quantitative phase of analysis, future studies ought to investigate whether or not certain academic experiences impact humanities and STEM students differently. Interaction terms could be used to determine whether or not one group of students was more strongly influenced by specific experiences compared to their counterparts. This would be beneficial as it could help to determine what academic experiences ought to be fostered or emphasized in discipline-specific environments in order to potentially enhance positive PTI outcomes.

**Implications for Policy**

As mentioned in Chapter 2, the theory of planned behavior (Ajzen, 1991, 2002) argues that individual behavior can in part be attributed to attitudes towards, or value of, certain behaviors. In other words, individuals who value a certain behavior will be more likely to act out
that behavior compared to individuals who do not value that behavior. The theory of planned behavior was used in part to create the outcome variable, PTI. I argued that students who valued innovation would be more inclined towards being innovative, or in other words, have a stronger propensity towards innovation. Applying the theory of planned behavior to the quantitative findings from this study, it seems that humanities students may be more likely than their STEM peers to be innovative in the workplace due to their greater valuing of opportunities for creativity and innovation in regards to their first job after college.

This finding has several policy-related implications. Since the 1980s, the U.S. has increasingly turned its focus toward funding and improving STEM education at the K-12 and undergraduate level, with the major justification being that the national economy needs more workers with STEM degrees (Canaan & Shumar, 2008; PCAST, 2012; The White House 2009). At the same time, U.S. federal funding for the humanities has continued to decline since the late 1970s. As of 2012, the federal government provides 74% of the funding for STEM research that occurs in HEIs while it only provides 20% of the funding for humanities research (AAAS, 2014). While increasing support and funding for STEM education is undoubtedly a worthwhile endeavor, findings from this study suggest that funding for the humanities is also of national economic importance. Employers of the 21st century from all different sectors have indicated that innovative thinking is among the most valued characteristics they look for in recent college graduates (AAC&U, 2013). This is especially important to note since the humanities has come under attack during the Trump administration’s unprecedented proposal to dismantle the National Endowment for the Humanities (NEH) which provides funding for humanities scholars (Deb, 2017). Shrinking or eliminating the NEH may also affect undergraduate students because as university professors receive less funding for projects, it is likely opportunities for students to
engage in research with faculty mentors will also diminish. In addition, it is reasonable to assume that proposals to eliminate the NEH sends a message to students that the humanities are not valued.

Findings from this study also have implications in regards to institutional-level policy. Studies shows that due to STEM and pre-professional programs’ stronger revenue-generating potential, these programs have received increased institutional support while humanities programs, which generally have weaker revenue-generating potential, have become increasingly deprioritized (Brint, 2002; Brint et al., 2005; Taylor et al., 2013). Slaughter and Rhoades (2004) call this new economic paradigm “academic capitalism” and posit that due to growing neoliberal policies that favor revenue generation, U.S. HEIs have begun to conform to a “knowledge-learning regime” that privileges forms of knowledge that have closer ties to the market economy. As a result, STEM and pre-professional programs that are more aligned with the market economy have received more institutional support in the form of program, personnel, and operational development (Brint et al., 2005; Taylor et al., 2013). Findings from this study, however, suggest that while humanities programs in general are not revenue-generating, institutional leaders ought to consider the importance of the humanities in regards to students’ workplace preparation. While the humanities have traditionally been defended as fostering important skills such as critical thinking and civic engagement, findings from this study add yet another reason for why institutional leaders ought to carefully consider the growing evidence of the benefits of humanities education when making funding allocations and providing other forms of institutional support.

Results from this study also provide some level of evidence-based support for the need for more interdisciplinary education. A review of recent policy documents from the U.S.
government by Knight (2013) revealed a consistent call for greater investment in interdisciplinary education (e.g. National Academy of Sciences, 2004; National Institutes of Health, 2006). However, these calls are based on the assumption that interdisciplinary educational approaches foster innovation more effectively than do discipline-based educational programs. According to Knight (2013), shifting towards interdisciplinary education is also presumed to promote global competitiveness, national security, and economic prosperity (e.g. National Academy of Engineering, 2004; National Science Board, 2010; U.S. Department of Education, 2006). Findings from my study help to provide some measure of evidence-based support for policy measures that promote interdisciplinary studies.

Although interdisciplinary education programs at the undergraduate level have increased in recent years, many barriers to interdisciplinary education still remain (CIC, 2015). Some of these barriers include “institutional inertia, evaluation challenges, the strong commitment of faculty members to the disciplines in which they were trained, and the role of discipline-based departments in curricula and faulty rewards” (p. 1). From an institutional policy standpoint, one way that interdisciplinary studies could be encouraged is by rewarding faculty members and academic departments for interdisciplinary teaching. Another option would be to create programs that are devoted to interdisciplinary studies and the creation of majors that award degrees in interdisciplinary studies. Miami University in Ohio, in particular, serves as a good model to follow as its pioneering School of Interdisciplinary Studies has received recognition by many scholars for the quality of its learning community (Newell, 1992). While it may not be feasible for many HEIs to create a school dedicated to interdisciplinary studies, smaller steps can be taken by providing funding for interdisciplinary symposia or training for faculty to encourage
them to allow more integration of knowledge from other disciplines or related disciplines into their classrooms.

**HEIs and the Next Generation of Innovators**

Findings from this study revealed that humanities students tend to leave college with a stronger propensity towards innovation compared to their STEM peers. This finding may come as a surprise as STEM education has often been more strongly associated with innovative thinking (Williams, 2013). Many students and parents favor STEM degrees because of what is perceived to be their closer alignment to the economy and to post-graduate employment (Williams, 2013). This narrative has begun to change in recent years as studies have revealed that employers actually care more about *how* students think than what they know (AAC&U, 2013; Bennet, 2014). In fact, employers from different sectors have in recent years made more efforts to recruit and hire humanities students due to the idea that students from these disciplines bring with them a host of transferable skills that are important in the 21st century workplace (Bennet, 2014). Findings from my study provide evidence that employers’ instincts may be correct. They indicate that as far as entry-level, post-graduate jobs are concerned, humanities students may be more likely to have a stronger propensity towards innovation.

Findings from this study also challenge the idea that innovative thinking is an inherent characteristic. In the mid 20th century, innovative thinking was often conceptualized as an attribute reserved for “great minds” such as Albert Einstein or Walt Disney. More recent conceptualizations of innovation have led many to view innovative thinking as something even “ordinary” individuals can achieve given the proper environment and encouragement.
Findings from this study also support the idea that innovative thinking can be fostered given the right academic environment and educational opportunities.

It will certainly be interesting to see how the relationship between the humanities and STEM unfolds in the years to come. As mentioned previously, signs point to an increasing appreciation for the ways in which both areas of study can complement and enhance one another. In addition to a push for STEAM, some colleges and universities are merging humanities with other areas of study such as medicine, public health, and urban studies. In terms of degree-granting programs, Baylor University offers a four-year degree in medical humanities and institutions such as Washington University in St. Louis and University of Nebraska Omaha each offer a minor in medical humanities. Other examples include Stonybrook University, which offers a four-year degree in environmental humanities and the University of Rochester which offers a minor in environmental humanities. The increasing number of programs such as these indicate a growing interest in merging aspects of the humanities into STEM education and vice versa.

In addition to discussing how combining the humanities and STEM can foster positive student outcomes, public discourse has even shifted to how combining the humanities and STEM can impact positive marketplace outcomes. In recent years, several CEOs running companies at the forefront of technological innovations have paid homage to the humanities education they had received as undergraduates and how their education has impacted their work and entrepreneurial vision (Lishing, 2015). Before his death in 2011, Steve Jobs, the CEO of Apple, Inc. revealed how his exposure to the humanities shaped his vision for his products (Lehrer, 2011):

I learned about serif and sans-serif typefaces, about varying the amount of space between different letter combinations, about what makes great typography great.
It was beautiful, historical, artistically subtle in a way that science can’t capture, and I found it fascinating. None of this had even a hope of practical application in my life. But ten years later, when we were designing the first Macintosh computer, it all came back to me. And we designed it all into the Mac. It was the first computer with beautiful typography. If I had never dropped in on that single course in college, the Mac would never have had multiple typefaces or proportionally spaced fonts.

In 2011, Jobs was also quoted as saying (Lehrer, 2011):

> It’s in Apple’s DNA that technology alone is not enough—it’s technology married with liberal arts, married with the humanities, that yields us the result that makes our heart sing and nowhere is that more true than in these post-PC devices.

The beneficial relationship between STEM and the humanities, however, is not one sided. While sources point to the myriad ways in which STEM can benefit by drawing from the humanities, it can be argued that the humanities have also benefitted by drawing from aspects of STEM. The digital humanities, for example, serves as a powerful illustration of how the utilization of technology has helped to bolster the humanities and help to ensure its continued relevance in the 21st century. By using digital resources to enhance the study and teaching of the humanities, the digital humanities has in some ways transformed the humanities landscape by moving past the reliance of the printed word as the main medium of knowledge production and distribution. Some examples of how the digital humanities has achieved this is by using visualizations for data, 3D modeling of historical spaces and artifacts, as well as digitally based dissertations (Klein & Gold, 2016).

Findings from this study come at a time when there has never been more interest in the role of the humanities and STEM in the 21st century. Both fields of study have been criticized for how they fall short in regards to meeting the needs of students and society. Scholars and social commentators alike have criticized the humanities for being out of touch with a changing global economy and as a result, many expressed concerns that the “humanities crisis” would lead to a
slow and intractable decline (Hanson, 2014; Leach, 2010; Winterhalter, 2014; Zuckerman & Ehrenberg, 2009). Some have also been critical of STEM and STEM education in particular for its inability to foster critical and creative thinkers and have labeled society’s growing preoccupation with STEM education as “dangerous” (Zakarah, 2015). Critics have also raised concerns about how science can solve social problems such as social inequality when they are in many ways a part of the problem. Smallman (2016) for example, argues that science and technology has always been a fundamental component of the “neoliberal dream” and that in developed nations the rich often maintain and grow their wealth due to the “grip they have on the capital that funds science and innovation.”

The wealth of scholarly and social commentary on the role of the humanities and STEM in the 21st century is a clear indicator that this, and related issues will continue to be debated and discussed for years to come. In many ways, it is a continuation of a long-standing discussion that began when colleges and universities introduced the “practical arts” into their curricula in the 19th century. Solutions to many of these issues remain elusive and the road ahead for both areas of study seem uncertain in some respects. While distinctions between disciplines and areas of study have been a time-honored concept and a form of organizational structure in academe, perhaps blurring some of these disciplinary barriers is the way in which both of these fields of study can help to push each other forward in the decades to come.
## Appendix A – List of Majors

<table>
<thead>
<tr>
<th>Humanities</th>
<th>STEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>American and area studies</td>
<td>Aerospace sciences</td>
</tr>
<tr>
<td>Archeology</td>
<td>Biological sciences</td>
</tr>
<tr>
<td>English language and literature</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Ethnic, gender, and cultural studies</td>
<td>Computer and information sciences</td>
</tr>
<tr>
<td>Foreign languages and literature</td>
<td>Engineering</td>
</tr>
<tr>
<td>History</td>
<td>Environmental sciences</td>
</tr>
<tr>
<td>Jurisprudence</td>
<td>Mathematics and actuarial science</td>
</tr>
<tr>
<td>Philosophy</td>
<td>Plant and agricultural sciences</td>
</tr>
<tr>
<td>Religious studies</td>
<td>Physics</td>
</tr>
<tr>
<td>Selected studies in art and music</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix B – List of Participants

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Area of Study</th>
<th>Major(s)</th>
<th>Race/Ethnicity</th>
<th>Gender</th>
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<tbody>
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<td>Amy</td>
<td>Humanities</td>
<td>Gender Studies</td>
<td>White</td>
<td>Female</td>
</tr>
<tr>
<td>Eddie</td>
<td>Humanities</td>
<td>History</td>
<td>White</td>
<td>Male</td>
</tr>
<tr>
<td>Erin</td>
<td>Humanities</td>
<td>East Asian studies</td>
<td>Asian/Asian American</td>
<td>Female</td>
</tr>
<tr>
<td>Kate</td>
<td>Humanities</td>
<td>Musicology</td>
<td>White</td>
<td>Female</td>
</tr>
<tr>
<td>Lauren</td>
<td>Humanities</td>
<td>Eastern European studies</td>
<td>Black/African American</td>
<td>Female</td>
</tr>
<tr>
<td>Melody</td>
<td>Humanities</td>
<td>History</td>
<td>White</td>
<td>Female</td>
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<td>History</td>
<td>White</td>
<td>Male</td>
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<td>Wyatt</td>
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<td>Carl</td>
<td>STEM</td>
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<td>Latino/a</td>
<td>Male</td>
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<td>STEM</td>
<td>Bioengineering</td>
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<td>Female</td>
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<td>Engineering</td>
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<td>Neuroscience</td>
<td>White</td>
<td>Female</td>
</tr>
</tbody>
</table>
Appendix C – Interview Protocol

1. Briefly describe the journey you took to choosing your major

2. What has been your overall experience with your major?

3. Tell me about how classes in your major are structured. What happens in a typical class period?
   a) In what ways (if any) have your classroom experiences influenced your desire to think in innovative ways?
   b) To what extent do classes in your major provide you with opportunities to challenge a professor’s ideas in class?
   c) Have you ever challenged a professor’s ideas in class? If so, how did this experience encourage you to think in innovative ways (if at all)?
   d) What kinds of teaching methods make you more engaged in the class material?

4. Tell me about the classes you are taking for your major and describe some typical class requirements and assignments
   a) In what ways (if any) have class requirements/assignments influenced your desire to be innovative?
   b) To what extent do classes in your major provide you with opportunities to seek feedback on your work?
   c) What kind of feedback has been the most helpful in terms of encouraging you to think in innovative ways?
   d) Do classes in your major encourage you to integrate skills or knowledge from different sources/experiences?
   e) How has this influenced your desire to be innovative?
5. Tell me about the relationships you have built with the professors/instructors in your major

   a) In what ways (if any) have they influenced your desire to be innovative or to think in innovative ways?
Humanities & STEM Students Needed for UCLA Research

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Research examines the classroom and academic experiences of humanities and STEM students with a particular focus on how class structure and teaching influence innovative thinking.

Details:

- **Length**: 45 to 60-minute individual interview
- **Eligibility**: 3rd and 4th year students
- **Compensation**: $15 Starbucks, Peet’s or Target giftcard
- **Location**: Conducted on or near campus

Please contact Principal Investigator:

**Tiffany Lee Tsang, M.Ed.**

Email: tiffany.tsang24@gmail.com


Association of American Colleges and Universities (AAC&U) (2013). *It takes more than a major: Employer priorities for college learning and success*. Survey conducted by Hart Research Associates on behalf of the AAC&U.


Jackson, N. (2006). Imagining a different world. In Jackson et al. (Eds.), *Developing Creativity in Higher Education*.


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