USING STUDENT PERCEPTION OF COLLEGE ENVIRONMENT FOR DEVELOPING ACADEMIC SELF-EFFICACY IN ENGINEERING AND COMPUTING EDUCATION

by

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DEDICATION

Dissertation journeys reflect a lifetime of loved ones. This one is dedicated those threaded through these pages – beginning with those who were gone too soon. Lola Irene Boyer (*Grandma*), William C. Lotti (*Honorary Dad*), Betsy Palmer (*Advisor*), Bobby Roberts (*Honorary Sister*), and Matthew C. Campbell (*Dear Friend*). Your examples of happiness, persistence, courage, love, humility, enthusiasm for life, gracious acceptance, gentle correction, commitment, and resilience live on in those who knew you – I miss you. Grandma, you may have not received the degree you wanted; but you instilled the importance of words, being educated…and spelling. You set the stage for this moment.

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No act of kindness, no matter how small, is ever wasted.
Aesop

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DEFINITIONS

Academically Underprepared (AUP) - students entering STEM majors not ready for pre-calculus (Castro, 2014).

Deficit Thinking – holding a student responsible for environmental circumstances outside their control which influence academic readiness for college or university (Castro, 2014; McKay et al., 2016; Peck, 2021).

Gracious Space - is an emotionally safe, adaptive environment where healthy growth occurs between everyone involved in the experience (Hughes et al., 2004)

Higher Education – any formalized academic experience that includes formal instruction and measurement of acquired knowledge resulting in a degree, credential, license, or other proof of content acquisition (Education USA., n.d.).

Next generation expert (NGE) – a student who hones their talents and interests through engagement with current experts in a higher education or work force environment (Hall et al., 2015; Jahn et al., 2014; Merriam-Webster, 2014; Zhang et al., 2004).

NACOE – Norm Asbjornson College of Engineering

STEM – Science, Technology, Engineering and Mathematics

Work Force – the number of people in a country who are physically able to do a job or are available for work. Also, the total number of people employed by a company (Chubin, D. E., et al., 2005; National Science Board, 2019).

ABSTRACT

Next Generation Experts (NGE) are needed to fill engineering and computing careers. Access to college degree programs in these disciplines has been identified as an important contribution in addressing this problem. Students enter university with varying levels of academic readiness based on environmental circumstances outside their control. In Montana, many communities are limited in their ability to provide advance math and science coursework with even fewer providing engineering or computer science topics. Montana State University (MSU) is the state's land grant institution is charged with educating the sons and daughters of Montana's working class citizens. This problem of practice study considers the experience of academically underprepared (AUP) students interested in engineering or computing with retention initiatives in the Norm Asbjornson College of Engineering (NACOE). Understanding student perceptions of how the college environment influences academic self-efficacy development with engineering and computer science content can provide direction for retention programming.

This qualitative study uses a complex theoretical framework, and phenomenography as a research approach to consider the range of student experience with an AUP retention program in the NACOE. Thirteen students participated in a study version of the AUP retention program which consisted of 6- topic focused, weekly meetings. Eight students provided feedback through a 1:1 interview following a semi-structured interview protocol. Interviews were transcribed, coded, and analyzed using an iterative process introducing a shift in perspective related to the relationship between physiological states and their influence over mastery, vicarious, and social persuasion experiences. Physiological states sit in the space between environmental experiences continually shading engagement between the environment and student.

Findings described how physiological states interact with mastery, vicarious, and social persuasion experiences. Environmental factors, including people, had an influence on the developing relationship between AUP students who participated in a study version of the AUP retention program. Demonstrating the importance of structure, this study showed the value of community in developing relationships between students and academic content. Normalizing the variety of academic readiness levels shifts from deficit thinking to an allowance of gracious space to begin a college degree from any point without a hidden script of expectation. Borrowing from the college athletics' programs, introducing a Redshirt year changes the game. The Redshirt in Engineering Consortium borrowed and implemented this idea to support recruitment and retention in AUP populations. AUP students are also the NGE in engineering or computing. It is the responsibility of current experts to teach them they have potential to be successful in these disciplines through inclusive environments.

CHAPTER ONE

OVERVIEW

Introduction

Question: The International Space Station, Fiber Optics, Highways, Electronics, and Health Technologies are examples of what? Answer: They are a few of the greatest engineering achievements of the 20th Century (Jachimowicz et al., 2018; Somerville et al., 2003). These and other accomplishments informed the development of 14 Grand Challenges for engineers and computer scientists in the 21st Century, identified by the National Academy of Engineering (2017). A review of all these accomplishments and challenges quickly uncovers how closely connected engineering and computing professionals are to the advancements placing countries such as the United States among those known as highly developed, industrialized, *progressive* nations. Now, "as the population grows and its needs and desires expand, the problem of sustaining civilization's continuing advancement, while still improving the quality of life, looms more immediate" (National Academy of Engineering, 2017, p. 2). Reports such as *Rising above the gathering storm* (2007b) and Volkswagon Group's, *Sustainability Report* (2011) are just two voices declaring growing concern regarding an unmet need for experts in STEM fields. These same voices have shined a light on a solution for developing more engineering and computer science experts who understand problem solving practices and have their own area of expertise to contribute to solutions society seeks (Agogino, 2008; Global Development & Environment Institute, 2018; Thomas, 2019; Volkswagon, 2011). The solution to the need for engineers and computer scientists is to focus attention on educating the next generation of expert in these disciplines.

Research by Hill et al. (2010), Corbett et al. (2015), studies by the National Academies of Sciences Engineering Medicine (2007a, 2011), and Seymour et al.'s (1997) landmark study have presented a critical need for educational environments to foster academic development of next generation engineering and computing experts. Revisiting these 1997 findings, Seymour and colleagues found not much has changed in 20-plus years, despite the growing focus on the need to change tactics (Thiry et al., 2019). For example, social culture still lacks widely accessible STEM socialization and preparation practices in under-represented populations. Robust K-12 experiences with advanced math, science, engineering, and computing content such as calculus and physics are limited or missing in less affluent high schools. Combined with college programs using "gate way" practices such as pre-engineering or pre-computer science programs, four - year degrees starting with advanced content; and rising costs of college tuition, the gaps remain in spite of focused efforts (Seymour et al., 1997; Thiry et al., 2019). In her more recent collaborative work, Seymour, in collaborative work with Thiry and other colleagues, notes the need for continued focus and study on this topic. "If new work is not undertaken, commentators are apt to resort to conjecture, unsupported by data, in order to account for STEM switching rates" (Thiry et al., 2019, p. 35). Intentionally stemming the flow of students switching out of engineering and computing disciplines will take new work focused on changing the factors influencing this action. Data supported decision-making provides the evidence to support change rather than speculating about what might work and implementing programs that do not solve the problem.

The *next generation of expert* (NGE) can be described as a student who hones their talents and interests through engagement with current experts in higher education and work force environments (Hall et al., 2015; Jahn et al., 2014; Merriam-Webster, 2014; Zhang et al., 2004). Engaging in challenging experiences to add new knowledge, skills, and experience to existing talents and interests helps to refine students' areas of expertise, which can then be applied to meet society's needs (National Science Board, 2019; Ponton, 2002). In the case of engineering and computing professionals, Figure 1.1 represents three human systems (Students, Higher Education, and Work Force) involved in developing the NGE (American Society for Engineering Education & National Science Foundation, 2013; Meadows, 2008b; Sithole et al., 2017). Work by Ericsson (2009) synthesizes research on the process of reverse engineering how current experts reached their high levels of performance and provides data informing desired outcomes for NGEs. Ericsson's articulation of NGE development provides a perspective to investigate the growth of 21st Century experts preparing to solve complex problems of tomorrow.

Presenting the NGE as an equation, I propose it might look like this: $\boldsymbol{NGE = (T + I + CE) * (NK + NS + NE)}$**.** Where the sum (Σ) of Talent (T), Interest (I) and interactions with Current Experts (CE) multiplied by the sum (Σ) of New Knowledge (NK), New Skills (NS) and New Experiences (NE) leads to an outcome (=) of the NGE; an individual who has become more than the sum of their parts to become the next generation of expert in a particular area. Today's youth are tomorrow's NGE. When they arrive at a college or university their purpose is to develop new knowledge, skill and experience and hone their talents by working with CEs. In a higher education setting, instructors are CE's who need to be ready to spark the NGE's interest in why and how a particular subject is relevant. In a 2012 American Society of Engineering Education (ASEE) report (Yoder, 2012), over 60 strategies and best practices were identified as effective methods of retaining students addressing the shared responsibility of retention between student and institution. This report is an analysis of current retention programs in place at colleges or universities across the country that have demonstrated a successful trend of retaining diverse student populations.

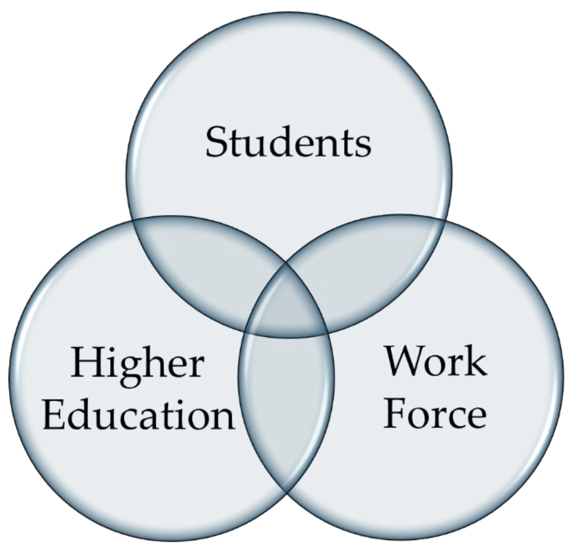


Figure 1.1. Systems Involved in Developing the NGE

Engineering and computer science majors are known for their rigorous coursework and high attrition rates (Ashley et al., 2017; Suresh, 2006). Although 28% of incoming first-year students between 2003 and 2009 selected a STEM discipline, nearly half of these students (48%) either changed to a non-STEM major or exited college altogether (U.S. Department of Education, 2014). This is an alarming attrition rate. In the setting for this study, a similar--albeit not as dramatic-- attrition pattern occurred. Montana State University is a large, public, state university in the U.S. Pacific Northwest. Twenty-two percent (456 students) of new Freshman in Fall 2010, declared their intent to pursue either an engineering or computer science discipline (Montana State University, 2016). By Fall 2011, 38% (174 students) of this cohort had not persisted in their declared engineering/computing discipline. Over half of students not persisting (53%) chose to depart from MSU, see Table 1.1 (Montana State University, 2016). In light of these local and national circumstances, collaborative efforts by the National Science Board (2019) and the Center for the Advancement of Engineering Education (2010) report a need for, and efforts to, initiate research and retention of NGEs in engineering and computing programs.

Table 1.1. Attrition of Freshman Students Declared in a NACOE Major.

Total New Freshman	Fall 2010	Fall 2011			
	NACOE Majors	NACOE Majors Retained	Total Attrition	Changed Colleges	Departed MSU
2042	456 (22%)	309 (68%)	174 (38%)	82 (47%)	92 (53%)

This problem of practice study focuses on a pilot student retention program within an engineering college designed to support first-year students interested in engineering or computer science careers and arrive academically underprepared (AUP), not ready to study advanced math and science, for the STEM content in these majors. This pilot program provides students with specialized academic advising to organize a plan of study unique to their academic readiness. These advising relationships also include conversations aligning career interests with academic programs to begin connecting students with exciting opportunities after college. The scope of this study includes the AUP pilot program and its inclusion of workshops to compel engagement with other programs in the college such as peer mentoring.

Background

There is a critical need for more NGE's within engineering and computing. Industries such as ExxonMobile (2020), Raytheon (2016), Volkswagon (2011), and the National Academy of Engineering (2017) have called for knowledgeable and skilled experts ready to solve 21st Century problems. Studies by the National Academies of Sciences Engineering Medicine (2007a, 2011), the American Association of University Women (2015; 2010), and U.S. Government programs (2014) speak of the alarmingly low number of youths completing STEM disciplines. Education initiatives such as *New Generation Science Standards* for K-12 (2013) students in the United States (Haycock, 2010; National Governors Association, 2010), the National Governing Board's (2014) articulation of academic preparedness indicators, and the National Science Board's (2019) emphasize STEM disciplines in their presentation of standards of career and academic preparedness related to college and job training. Despite the awareness of this critical need, the number of youths interested in STEM fields remains much lower than desired…or needed.

Seymour's landmark study with Hewitt (1997) and more recent comprehensive work with Thiry, et.al. (2019) compare college students' reasons for leaving STEM majors to an iceberg. This descriptive metaphor was helpful to demonstrate their finding that students reported more than a single factor leading to their decision to switch out of STEM majors and careers (Seymour & Hewitt, 1997; Thiry et al., 2019). For example, when looking only at academic performance it may appear a student switched out of a STEM major because of complex content. Closer inspection reveals unseen stories behind students' academic performance. Students expect complex content, but do not anticipate the impact of inadequate high school preparation, poor teaching pedagogy, and/or lack of academic support (tutoring); a few of the factors Seymour et al. (1997) notes as the unseen portion of the iceberg below the waterline. Since 1997, Seymour et al.'s, (1997) work has been cited in literally thousands of studies exploring factors related to retention and attrition in STEM disciplines including race, gender, pedagogy, academic preparedness, and student self-efficacy (Freeman et al., 2014; Hill et al., 2010; Kuh, 2007; Marra et al., 2009).

Students enter university anticipating challenge but hope to quickly figure out how to "do" college (Conley, 2005; Renn et al., 2013). Conley (2012) demonstrated students are also entering college with varying levels of academic readiness which adds barriers to an already complex transition. This reality encumbers efforts to diversify engineering and computing disciplines often using *deficit thinking* frameworks, described by Castro (2014, 2021) as holding the student responsible for environmental circumstances outside their control, such as access to advanced math and science coursework in high school. Castro (2014, 2021), Phillips (2015), and McKay et al. (2016), include populations from extremely rural communities, under-represented groups (URG) in STEM, and/or from low socioeconomic circumstances in student cohorts beginning college with less robust academic readiness levels, but this is not their fault or reflective of their potential. Under-represented groups (URG) in STEM include African American, Black, Hispanic or Latino/Latina, American Indian and other non-White or Asian race/ethnic populations (Estrada et al., 2016; Hughes, 2018; Riley, 2008) as well as women and students who do not identify within the gender binary.

In the last 9 years, 6842 new first-year students have entered the Norm Asbjornson College of Engineering (NACOE) with a declared engineering or computer science major. Traditional, 4-year program flowcharts anticipate students to be academically ready for calculus 1 (Level 5 math), physics, and chemistry. Of the incoming Freshman population, almost 1200 students (17%) began their pursuit of an engineering or computer science degree from a college algebra (Level 3 math) or lower math course, 2 levels or more below where programs begin charting course plans. For the NACOE, students who start at this math level are considered academically under-prepared (AUP) because entering math level is highly determinate of estimated time to degree completion. Table 1.2 provides a description of the AUP population entering the NACOE ready for Level 1, 2 or 3 math courses. Of this population, 406 identified as female or non-binary and/or as American Indian or Alaska Native, Black or African American, Hispanic, Native Hawaiian or Other, Non-resident Alien, or Two or more races which meet the definition of URGs in STEM. Beginning at this level influences a student’s ability to take advanced physics/chemistry, meet 4-year graduation timelines and present challenges related to connecting with an academic community.

Statement of Problem

The case for increasing access to STEM curriculums in diverse populations has been made and demonstrated as valuable for addressing the need for engineers and computer scientists (National Research Council, 2010; United States Government, 2014). Higher education has responded with first-year experience programs and high schools have developed readiness programs, such as Project Lead the Way, to support student readiness for STEM majors (Garcia, 1991; Project Lead The Way, 2020; The National Center for Public Policy and Higher Education, 2009). Since 2011, AUP Freshman students declaring engineering and computing majors at MSU have increased from 21% (in 2011) to 26% (in 2019). Over 30% of the combined AUP cohort identified with one or more underrepresented group(s) in engineering or computer science and over half graduated from a Montana high school (MSU Office of Planning & Analysis, 2020). In response, the NACOE leadership team established programs such as Empower, Women in Engineering, Engineering Peer Academic Leaders, and College of Engineering-Xploration. These programs support access, interest, and retention of all students in the college by meeting the needs of specific cohorts (Clark et al., 2015). The 5% increase in AUP Freshman persisting in engineering or computer science majors is moving the NACOE in a positive direction with retention, but improvement is always a goal and a key component of the ABET accreditation process (ABET, 2019).

Table 1.2. Breakdown of Underrepresented Groups in NACOE AUP Population

All 1st Year AUP	1192					Female	Non-Binary	Male
URG in STEM	406 (Total includes white women)					153	3	1036
American Indian or Alaska Native	Black or African American	Hispanic	Native Hawaiian or Other	Non-resident Alien	Two or more races	No Response	Asian	White
26	6	52	3	92	71	10	14	918

Montana State University (MSU) is the state's land-grant institution, charged with maintaining open access to the state's high school graduates who wish to pursue a college degree. A unique feature of MSU's NACOE is the absence of pre-engineering or pre-computing programs and a singular admission application occurring when students apply to the university. This means students can begin to identify with their college from the moment they have been admitted and claimed a desire to pursue any engineering or computing major offered as their chosen path. Winifred, Montana native, mechanical engineer, and MSU alum Norm Asbjornson (Norm), is a prominent example of identifying early with the college and the power of a learning community from the Freshman year, regardless of academic preparation. Norm arrived at MSU, then Montana State College, intending to pursue an engineering degree only to realize he was unprepared for the academic material (Nickerson, 2018). Citing a variety of contributors to his success, including faculty and peers, Norm recalls the value of being accepted to MSU as a mechanical engineering student even though he needed foundational math and science courses (Montana State University, 2014). Programs supporting AUP students help with their transition into college and programs with high rigor (Johnson et al., 2011; Schreiner, 2012).

More than 50 years after Norm graduated with a mechanical engineering degree, the NACOE continues to use a single admission application and meet students at their academic level. Once accepted, any of the academic programs in the NACOE are open to students without having to complete a second application. Retention programs that support incoming Freshman demonstrate a commitment to fostering a strong learning community within the college. With the intent of inclusion, the NACOE established a program in 2014 to support AUP students matriculating to college. The program, intentionally not referenced by its name in this paper, provides specialized academic advising and discussions to support academic program planning and exploration of engineering and computing career fields. The modest increase in retention indicates a step in the right direction, but a need to assess the retention program supporting AUP students continues to exist. This study responds to evidence of retention program effectiveness and seeks to understand students' perceptions of how its influence affected their academic self-efficacy related to engineering or computing content.

Since its implementation in 2014, the AUP retention program has supported 868 students, 21% of incoming Freshman based on data from MSU's, Office of Planning and Analysis. Table 1.3 presents a comparison between AUP and academically ready (AR) student groups. Compared to their peers who arrive ready for pre-calculus (Level 4) or higher (Level 5+) levels of math; AUP students take longer to complete an engineering or computer science degree; are more likely to use academic coaches, be on academic probation within their first year, and per student, are less likely to attend college events. The NACOE AUP program participants include a significantly higher percentage of

URGs and demonstrate an academic performance at least 0.5 GPA points lower than their academically ready (AR) peers. URGs in the NACOE include first generation, Female, American Indian or Alaska Native, Black or African American, Hispanic, Native Hawaiian, and students who identify with the LGBTQ+ community.

Three interesting observations are presented in this population. First, is the difference between AUP male (87%) and female (13%) students choosing to pursue engineering or computer science degrees and beginning in Level 3 or lower math courses. Their AR peers demonstrate a gender difference of 82% male and 18% female but make up a larger portion of incoming Freshman (83%) suggesting young women with more math experience are more inclined to pursue an engineering or computer science degree at MSU. Second, this data shows AUP men are more likely to attempt an engineering or computing degree than females arriving with the same academic readiness. Looking further a third observation related to URGs was made. Compared to their AR (29%) peers, 34% of the AUP cohort identified with an URG.

Table 1.3. Academically Underprepared (AUP) and Academically Ready (AR) Student Comparison. Data by MSU Office of Planning & Analysis

	All 1st Year Cohorts			GPA	Use of Support Services	Engagement per Student	Academic Probation	Time to Degree
		Under-represented Groups (URG)						
	Male	Female*	All URGs**					
AUP (17%)	87%	13%	34%	2.51	14%	8 visits	24%	4.4 years
AR (83%)	82%	18%	29%	3.06	10%	13 visits	11%	3.9 years
Total Freshman	6842							

* Female population include: White, American Indian or Alaska Native, Black or African groups are included in Female population. American, Hispanic, Native Hawaiian.

** All URGs population includes: Males and females from American Indian or Alaska Native, Black or African American, Hispanic, Native Hawaiian groups; and White females.

Studies by Hill et al. (2010) and Corbett et.al. (2015) present the need for supporting academic identity in under-represented groups, particularly for students who identify as female. Other studies provide evidence that academic identity development is needed to support widening access to diverse populations in engineering and computing (Capobianco, 2006; Walden et al., 2008). Godwin et.al. (2016; 2020) and Komarraju et. al. (2014) present the connection between identity and self-efficacy in relation to academic content. Separating these concepts, this study seeks to understand perception of the sources influencing academic self-efficacy in AUP engineering and computing students.

Conceptual/Theoretical Framework

Investigating this complex problem of practice requires a robust theoretical framework. Vincent Tinto (1987, 2012a), Alan Seidman (2012), Alexander Astin (1999), and other key higher education researchers have shared examples and advice for future research relating to student development and retention. Tinto's work highlighted the need for intentional action from institutions to understand and address attrition by looking at campus environments (Braxton et al., 2012; Tinto, 1987, 2012a, 2017). Seidman encourages application of current theories into robust programs tailored to meet the needs of an institution's student population (Seidman, 2012, 2015; Seidman et al., 2012). Finally, Astin provides the reminder to include regular assessments to ensure programs stay fresh, relevant, and effective (Astin, 2001, 2016; Astin et al., 2012). All this advice informed my decision to combine Urie Bronfenbrenner's *Bioecological Theory of Human Development* (Bronfenbrenner, 1993, 1995a, 1995b) and Albert Bandura's *Theory of Self-Efficacy* (Bandura, 1997b) to investigate student perception of their college environment for developing academic self-efficacy in engineering and computer science content. Bronfenbrenner's theory allows an investigation of the environmental factors and Bandura's theory provides a method to study how the sources impact student development of academic self-efficacy.

Bioecological Theory of Human Development

Bronfenbrenner was clear that his original 1979, Ecological Theory of Human Development needed to be studied extensively and focused research efforts in this direction. This led to the evolution of this model into the 1990's version being used in this study and it is important to clearly note this decision (Bronfenbrenner Center, 1990). Bioecological Model of Human Development looks at the relationships between an individual and the human systems, close or far away, in their environment which contribute to their growth (Bronfenbrenner, 1993, 1994, 1995a, 1995b). Also referred to as bioecological theory, it includes the Proximal Process-Person-Context-Time (PPCT) as part of the model. Tudge et al. (2009, 2016) emphasize the importance of clarifying which version of Bronfenbrenner's theory is being applied as it both informs how a study is structured and maintains the validity of the theory. Improper use can lead to findings not reflective of the theoretical framework.

In the 1990's Bronfenbrenner introduced bioecological theory of human development and imbedded the original constructs within the four components of Proximal Process, Person, Context and Time (PPCT).

1. *Proximal Process* - As the first construct of Bioecological theory, proximal process describes the engagement between a developing person and the surrounding physical or social structures.
2. *Person* - As the second component of the PPCT model, the person influences their development by how they engage, or fail to engage, with their environment. Important nuances to this component are the four attributes making up a person, defined as *developmentally instigative characteristics.* These four characteristics put into motion the physics of engagement between the individual and externally moving systems in their proximity.

a. *Personal stimulus characteristics* – Personal qualities that respond to the environment either inviting or rejecting engagement in a manner that impacts physical growth.

b. *Select responsivity* – An individual's decision to explore their environment in a solitary or socially connected fashion.

c. *Structuring proclivities* – The dispositions influencing the nature of engagement a person has with activities, particularly if they are increasingly more complex in nature.

d. *"Directive belief systems about the relation of the self to the environment" (*(Bronfenbrenner, 1993, p. 13) – An increasing ability and active preference to interact collaboratively with a person's environment.

3. *Context* – Interactions between a person and their environment are described as happening within a layered, contextual system. There are four layers to this system, each one further away from the person.

a. *Microsystems* – The human systems an individual engages with daily including school members, roommates, living community members, and work environment locations.

b. *Mesosystem* – The interactive space between the microsystems an individual engages with daily.

c. *Exosystems* – nfluences external to the individual and the microsystems they engage with daily.

d. *Macrosystems* – The cultural and social influences that affect how the microsystems, mesosystems and exosystems interact with each other.

4. *Time* – Also referred to as the *chronosystem*, this final construct accounts for changes to a person and/or their environment over time. This element introduces a dynamic, multi-dimensional perspective contributing to human development.

<u>Self-Efficacy Theory</u>

Bandura's Self-Efficacy Theory investigates how people make sense of their experiences. The mental vision a person has of themselves tells a story of what they believe can be achieved. The ability to act rather than react to stimuli is a synthesis of environmental influences versus a simple summation of experiences (Bandura, 1997b). Bandura describes four sources of efficacy believes that impact a person's interaction with their surroundings (Bandura, 1997c).

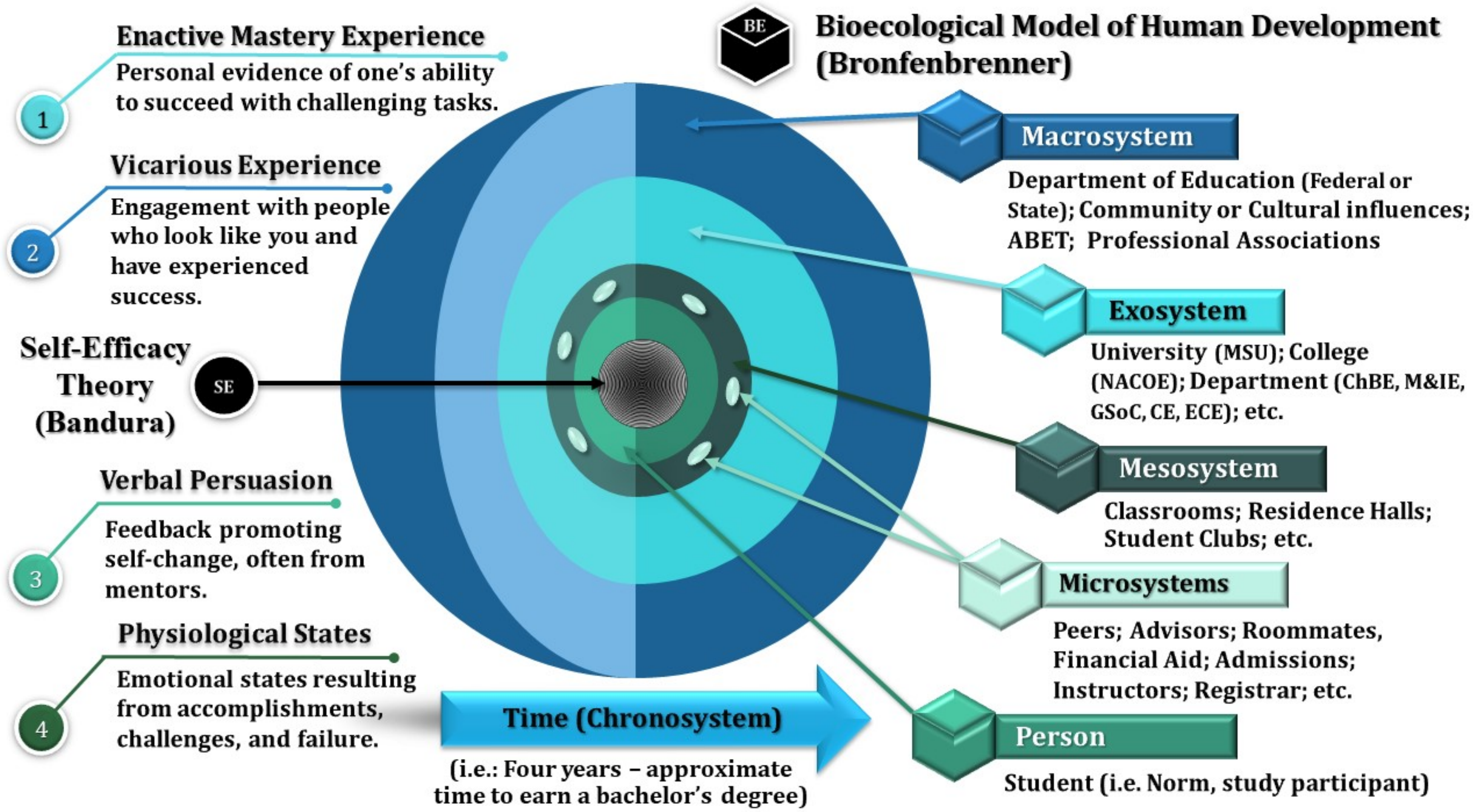
1. *Enactive mastery* – one's perception of their ability to succeed based on their history of completing tasks, especially if they are complicated.
2. *Vicarious Modeling* – engagement with individuals such as experts in the field or peers who have experienced success and developed mastery.
3. *Verbal Persuasion* – External, verbal feedback from the learning environment inspires and sustains an individual's effort. These "persuasive boosts" align with the individual's self-affirming believes and promotes a commitment to acquiring necessary knowledge or skill.

4. *Physiological & Affective States* – The physical status of an individual as they navigate through an experience. This includes psychological bodily states such as stress and emotion.

Conceptual Framework for Study

The intent of this study and conceptual approach is to capture AUP student experience with a program supporting their development of academic self-efficacy. This complex—systems thinking—approach to the student experience is necessary to describe the external environment contributing to internal processing of an academic environment. Bronfenbrenner's model is described visually in Figure 1.2 with the layers of external systems in a higher education explained on the right. On the left and in the center the sources of self-efficacy are detailed, and a spiraling image represents the person and how they internalize their experience with the environment and then choose to interact. One of the harder components of Bronfenbrenner's theory to describe is Time, also referred to as the *Chronosystem*. Figure 1.2 presents this concept as a directional factor influencing every aspect of the student's experience. It is important to note this concept, and the use of spiraling feature in the center also visually describes development as an exchange between the student and their environment. Bronfenbrenner, in a conference presentation noted it was important to recognize development as a continuum and does not end until death (Bronfenbrenner Center, 1990). The program established by the NACOE to support AUP students creates an environment to encourage engagement in an academic community. Over time, the intention is for engagement to promote academic achievement but how the AUP student interprets and responds to their environment determines how these experiences are reflected in their development.

Statement of Purpose: The purpose of this phenomenographic study is to learn the range of perspectives AUP engineering or computer science students experience related to academic self-efficacy while interacting with the AUP program.



Statement of Purpose

The purpose of this phenomenographic study is to understand the range of perspectives among AUP engineering or computing students' experience related to academic self-efficacy, while interacting with the NACOE's AUP program. Using bioecological theory and self-efficacy theory allows a comprehensive lens through which to view the experiences of students within an AUP program cohort who also chose to participate in components added to increase connections with sources of self-efficacy. The AUP program is the NACOE's response to the promise to meet students where they are and help them achieve their goals. Recognizing the increased challenge when AUP students arrive and view their extended academic plans the college believed it was important to support and encourage their goals.

Educating the sons and daughters of the state's working class is the charge of Montana's land-grant institution, as described by Federal legislation, and this purpose is reflected in the NACOE's mission and vision (Norm Asbjornson College of Engineering, 2019; United States Senate, 1996). Additionally, ABET, the college's accreditation agency, notes the importance of supporting student success. When colleges note their efforts to support students, they must also continue to assess and demonstrate how this is being accomplished. Findings from this study will inform programming efforts to support AUP students arriving at MSU interested in engineering or computer science degrees.

Guiding Research Question

The following primary question focusing on the college environment and with four sub-questions aligning with sources in the environment which affect self-efficacy directed this study.

Among students who participated in the AUP modified program, what are their perceptions related to academic self-efficacy development in engineering and computing subjects?

a. What are student perceptions related to their belief they can be successful with engineering and computing content? For example, do they have a history of success with basic concepts suggesting mastery experiences?

b. What are student perceptions related to their interactions with peer mentors in engineering or computing disciplines? Do they have peers who look like them who they can watch or listen to vicariously for clues on how to behave?

c. What are student perceptions related to weekly AUP group discussions with engineering or computing faculty to provide academic encouragement? What sources of persuasion provide feedback (verbal or written) to influence a student's efforts to continue with challenging content?

d. What are student perceptions related to how they have responded physiologically to academic content in engineering or computing subjects? For example, does a student feel sad, anxious, discouraged, determined or resourceful and/or respond emotionally (i.e.: fear, anger, or tears) if they do not understand a concept or earn a low test score or answer?

Research Design

This qualitative study will use a social constructionist paradigm in combination with a phenomenography research approach. Phenomenography is a method of understanding the range of perspectives a phenomenon can be experienced (Marton, 1981, 1986). This method assumes there is a finite number of ways something can be experienced, such as how AUP students may experience a retention program (Marton, 1981, 1986). This study's population is a cohort of 1st-year, AUP students who declared an engineering or computer science degree upon admission to MSU. Math readiness, specifically students whose math level was determined to be at Level 3 or lower defines AUP cohort members. Students will be recruited from the 2020 AUP cohort through email and telephone invitation to participate in a modified version of an existing retention program.

As a problem of practice study patterned after the Carnegie Project for the Education Doctorate (CPED) framework which promotes a scholarly approach in higher education practitioners. A similar framework is found in Cooperative Extension (Extension) where county agents serve as community educators and address the continuing education needs unique to citizens within their region (Franz et al., 2008; Garst et al., 2015; Montana State University, 2017). A variety of methods are used to assess the impact of county agents on their stakeholders including surveying and/or interviewing either formally or informally (Franz et al., 2018; Franz et al., 2008). For this study, data will be collected by recording workshops and conducting individual feedback interviews with program participants. Workshops and interviews were transcribed, coded, and analyzed for themes. It is important to note I am the Student Success Coordinator in the NACOE. In addition to supporting AUP students and program oversight, this position includes a high level of interaction with all NACOE students in an advisor or mentor role. Suzanne Day (2012) and Roni Berger (2015) speak of the complexities of doing qualitative research within a social context. The construction of knowledge is influenced by many factors which requires a researcher to manage challenges including power dynamics and social interactions (Berger, 2015; Day, 2012). In addition, using phenomenography, which allows the researcher to recognize their experience within a range, other practices such as journaling, memoing, and bridling will help manage this researcher's position in relation to the study (G. Åkerlind et al., 2005; Collier-Reed et al., 2009; Creswell, 2013d).

Limitations, Delimitations, and Assumptions

Limitations

Findings from this study reflect the range of perspectives 8 AUP students reported after participating in a modified NACOE retention program designed to support academic self-efficacy development with engineering or computing content. The small sample size presents challenges for generalizing this data to the larger AUP population in the NACOE, but this is not the goal of this study. Furthermore, students in this study are from a College of Engineering at a four-year, research institution in a rural, Northwestern state that does not have a pre-engineering or pre-computing program. As such generalizing these data to colleges in more urban populations may also be challenging. However, findings can be used to provide a contextual perspective of AUP students interested in engineering and computing disciplines.

Next, students both chose to enroll in this modified NACOE retention program and participate in the feedback interviews. They attended six, 1-hour workshops and a 20-60 minute interview with very minimal compensation. This group may be more representative of students who choose to both engage in academic support resources and share their experiences. Two of the participants identified as African American and male, four as female and white, and two as white and male. Their experiences are important but not reflective of the entire range of perspectives UAP students have related to academic self-efficacy and challenging content in NACOE majors. Further research is needed to gather the voices more UAP students who also identify with other URP groups including first generation, Native American and Alaska Native, Hispanic, and with the LGBTQ+ community.

Third, an obvious limitation is the embedded nature of this study and the time between gathering data and analysis. Although this approach is described as valuable in Extension and Education research, on their own findings provide a limited perspective of the questions related to the academic self-efficacy development in AUP students.

Finally, it is important to note the limitation presented by COVID-19 on this study. Restrictions on participant numbers and style of delivery which presented notable challenges throughout the study. Participants themselves noted their Freshman experience could not be translated to last year's Freshman or next year's Freshman. Repeating this modified program with more participants and in-person will add to these findings and broaden the range of perspectives to inform program development and impact more accurately.

Delimitations

The goal of this qualitative study was to understand student perception of modifications to an existing retention program for AUP, first year students in engineering and computing programs. Specifically, changes to the program are intended to externally support academic self-efficacy development with engineering and computing content. Self-efficacy is an internal phenomenon and influenced by sources external to the person. A phenomenographic approach provided a venue for gathering details about student experiences related to program modifications and their perception of the effect on their confidence with academic content..

This study was not meant to explore every nuance. Rather, gathering data related to student experience with external systems provided through the retention program is intended to inform college practices related to program development for the purpose of influencing academic self-efficacy in AUP students. Findings from this study will provide insights related to supporting AUP students pursuing engineering or computing degrees.

Assumptions

The following assumptions inform this study. First, students are complex people entering into a complex network of systems; there is not a one-size-fits all retention approach. Second, students—regardless of their math readiness—anticipate challenges related to engineering or computer science academic content but are inspired by the NACOE's invitation to explore engineering and computer science. Third, high school graduates make three major transitions: first, as an adult with expectations to take responsibility; second, as a student *in* college; and third, as a student *of* a subject (i.e., engineering, computer science, etc.). Fourth, feedback in higher education communities such as 4-year major curriculum flowcharts, financial aid or scholarships requiring a minimum of 15 credits or maxing out after 4 years, and other cues such as university leaders welcoming new Freshman by the year they are expected to graduate (e.g.: "Welcome 2020 Freshman…you are the Class of 2024!") may lead students to feel compelled to complete a bachelor's degree within a set timeframe. The knowledge of being AUP has the potential to present a barrier even if students are accepted to the NACOE if it extends their degree plan past four years. Finally, it is unrealistic to believe every AUP student will transition into college, into an engineering or computer science major *and* persist to degree completion. However, this study begins with the assumption that AUP participants should have an opportunity to learn about their academic college's commitment to them. The NACOE is equally as interested in developing their understanding of STEM career fields, fulfilling the promise to meet students at any academic level with meaningful support, and helping students make informed decisions about an academic path in their first year of coursework.

Significance of Study

Program evaluation is built into the Accreditation Board for Engineering and Technology (ABET) (2017a) accreditation model leading with the expectation engineering and computing colleges consistently review their majors and initiatives to prepare the NGE. Colleges seeking accreditation through ABET (2019) routinely participate in a review process according to criteria set by this organization. Findings from this study will inform the NACOE's next accreditation review, particularly related the declaration that any student desiring an engineering or computing degree regardless of their academic experience or preparation is invited to do so at MSU (Gunnink, 2017). The inclusion of student voices in addition to quantitative data provides a robust way to demonstrate program effectiveness over time. Additionally, these findings will inform program development, funding resources, and support faculty as they present academic content to students from wider, non-traditional backgrounds.

Since 2014, the number of AUP students arriving at MSU seeking an engineering or computing degree has steadily increased. Retention of this population of student remains lower than is desired by the NACOE. Perception of inclusion within this population is significant as it factors into the measurement of success. The NACOE wishes for students to be feel invited to the college and included as valuable contributors to the community of learners.

Chapter Summary

The absence of pre-engineering or pre-computer science programs and the presence of programs supporting student success serve as invitations to the NACOE for high school students intrigued by STEM careers. Increasing numbers of AUP students interested in engineering or computer science disciplines are coming to MSU and the NACOE. The AUP retention program was developed to support this population of 1st year student resulting in a small increase in persistence, but the college believes there is room for improvement. A significantly higher percentage of students in these AUP cohorts, compared to their AR peers, are from underrepresented gender and race groups. Increasing retention and persistence in AUP cohort participants will make the invitation to the NACOE more authentic and demonstrate the college's commitment to diversifying STEM fields. This study uses the bioecological theory of human development and self-efficacy theory as a robust, nested theoretical framework to create a picture of the student experience with a modified version of the NACOE's AUP retention program. As a qualitative research approach, phenomenography provides a method of cataloging the range of experiences modified participants had with the program. These findings will inform the NACOE's support of future cohorts of AUP students.

CHAPTER TWO

REVIEW OF LITERATURE

Introduction

Developing the Next Generation Expert (NGE) compels higher education professionals to recognize the value of existing scholarly research for use in understanding problems of practice (Perry, 2016). In this case, the problem of practice is supporting development of academic self-efficacy in AUP Freshman and Sophomore students pursuing engineering and computing disciplines at NACOE. This chapter first reviews Bioecological Theory of Human Development (Bronfenbrenner, 1995a, 1995b, 1999, 2005) and Self-Efficacy Theory (Bandura, 1997b) . Next a rational for combining these theories into one framework is provided. Finally, using the program objectives for the AUP retention program, a review of empirical literature related to these three themes is provided. Threaded throughout is the example of the NACOE's 1960 alum and namesake, Norm Asbjornson (Norm). Norm is a compelling example of why AUP students are worthy of targeted retention programs. His life story, shared in an intriguing memoire with the assistance of Matthew Nickerson (2018) demonstrates the value of the theoretical framework informing this study.

Bioecological Model of Human Development.

As a preview, the settings of *microsystem, mesosystem, exosystem,* and *macrosystem* combine with components of *Process-Person-Context-Time* (PPCT) to demonstrate the intricately woven tapestry of human development within context (Bronfenbrenner, 1993). Following is an explanation of the constructs of the Bioecological Model of Human Development, also referred to as Bioecological Theory.

Proximal Process

As the first component of Bronfenbrenner's bioecological paradigm, *proximal processes* describe the engagement between a developing person and the physical or social structures surrounding them. More to the point, two sides make up the "coin" of the proximal environment, namely "first, the people present in the setting; and second, the physical and symbolic features of the setting that invite, permit, or inhibit engagement in sustained, progressively more complex interaction with and activity in the immediate environment" (Bronfenbrenner, 1993, p. 11). Like Norm in 1953, today's student who elects to pursue engineering or computing careers apply to attend colleges offering academic programs designed to educate these NGEs. It is in these environments that NGEs develop an identity first as engineering or computing students capable of learning complex content, and then as new experts ready to enter professional fields (Cromley et al., 2015; Koro-Ljungberg et al., 2017; Walden et al., 2008).

Person

The second, interactive, component of the PPCT model is Person. Bronfenbrenner proposed "…the attributes of the person most likely shape the course of development, for better or worse, are those that induce or inhibit dynamic dispositions toward the immediate environment" (Bronfenbrenner, 1993, p. 11). Defined as *developmentally instigative characteristics*, four types of attributes describe the complex nature of the person (Bronfenbrenner, 1993). First, *personal stimulus characteristics* are personal qualities that respond to the environment either inviting or rejecting engagement in a manner that impacts psychological growth (Bronfenbrenner, 1993). Characterized by an individual's decision to explore their environment, *select responsivity* is second, speaking to the solitary or socially connected nature of engagement (Bronfenbrenner, 1993; Evans et al., 2010). *Structuring proclivities* relates to the dispositions that influence the nature of engagement a person has with activities, particularly if they are increasingly more complex in nature (Bronfenbrenner, 1993). Finally, an increasing capacity and active preference to interact collaboratively with their environment is called "*directive belief systems about the relation of the self to the environment"* (Bronfenbrenner, 1993, p. 13). In combination, these characteristics put in motion the physics of engagement between the individual and the various moving systems external to them (Bronfenbrenner, 1993; Lewin, 1935a). While not deterministic in nature, together these systematic forces influence the internal development of a student (Bronfenbrenner, 1993; Lewin, 1935b).

An example of developmentally instigative characteristics within NACOE's retention efforts lies in the AUP student response to program features, such as peer mentoring. Designed to connect Freshman with each other and their Junior and Senior college peers, peer mentoring strives to efficiently establish an academic community, especially with students who have similar experiences and have learned to navigate STEM disciplines successfully. The mentor-mentee relationship is influenced by a mentee's overall response to this external support structure and demonstrates Bronfenbrenner's instigative characteristics. A student's perspective (*personal stimulus* *characteristics*) related to establishing relationships, or network, in a new environment influences how they engage with a program that includes peer mentor support (Attarzadeh et al., 2011; Tenenbaum et al., 2014). Choosing to repeatedly engage (*select responsivity*) with college retention efforts is a response to the environment. The nature of engagement between peer mentee and mentor is shaped by the value a student places on the external influence (*structuring proclivities*) and evolves over time as the college experience becomes more complex (Evans et al., 2010).

Combined, instigative characteristics influence how a student puts into motion their own belief systems. Environmental influences determine student commitment of time to an external phenomenon (peer mentoring) and is the application of Bronfenbrenner's fourth instigative characteristic (Tenenbaum et al., 2014). In the case of this study, a student's belief that engagement with NACOE's community and its retention programs, including peer mentoring, will increase their ability to learn complex academic content related to their professional interests informs their decision to participate and to what degree. The instigative characteristics Bronfenbrenner describes link to the intrinsic nature of a person's development of self-efficacy (Bandura, 1997a; Bronfenbrenner, 1993, 1995a, 1995b). In the case of developing academic self-efficacy, Bronfenbrenner notes the environment (context) students engage with supplies dynamic elements contributing to how a person synthesizes their belief systems which is described in the next section (Bronfenbrenner, 1993; Elder Jr., 1995).

<u>Context</u>

Bioecological Theory presents a logical means of understanding the complex interactions between a person and their environment. Figure 2.1 is a general representation of these contextual, layered systems making up the life of an individual. From this perspective the influences of what might seem far away take shape. Much like a beautiful tapestry is not woven from a single thread, but thousands of colorful threads coming together to become more than the sum of their parts representing a scenic image. Similarly, a person's development reflects many influences and experiences intertwined together. Bronfenbrenner's work suggests we do not exist in isolation but engage – or not – in context with proximal and distal systems around us (Bronfenbrenner, 1993).

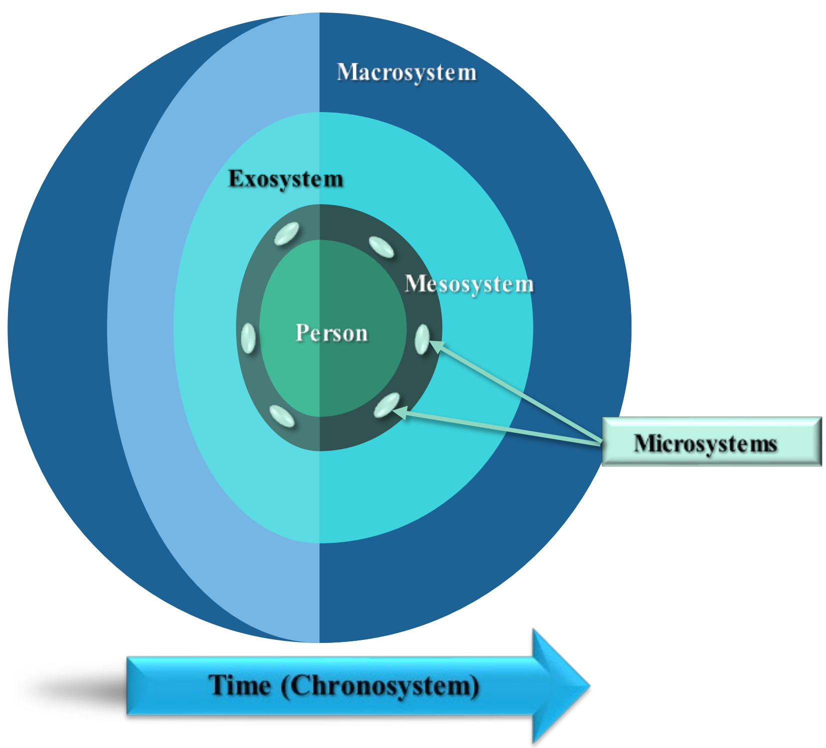


Figure 2.1. Bioecological Model of Human Development

Speaking of the environments supporting his development as a mechanical engineer student at MSU, Norm Asbjornson (Norm), the College of Engineering's namesake, described the influences supporting his success (Nickerson, 2018). In addition to Bronfenbrenner's voice (1993), life historians Cole et al. (2008), and Nickerson (2018) note the contextual experiences leaving us forever changed by the flow of information between interacting systems and demonstrated through reviewing life stories. *Survival and Success,* the life history of Norm Asbjornson (Nickerson, 2018), serves as one example of how complex systems designed to support students' academic success are woven together in a demonstration of bioecological theory (Bronfenbrenner, 1993, 1995a, 1995b, 1999). Four contextual layers formulate the world of an individual, specifically: *microsystem, mesosystem, exosystem, and macrosystem* (Bronfenbrenner, 1993). Following is a description and definition of each system.

Microsystem

Bronfenbrenner defines microsystems as a

> pattern of activities, roles, and interpersonal relations experienced by the developing person in a given face-to-face setting with particular physical, social, and symbolic features that invite, permit, or inhibit, engagement in sustained, progressively more complex interaction with, and activity in, the immediate environment. (Bronfenbrenner, 1993, p. 15)

Bronfenbrenner describes these immediate interactions between the person and activities, organizations, or other individuals as places where cognitive development occurs (Bronfenbrenner, 1993).

Like Norm, the NGE of 2020 interacts with a variety of microsystems within the NACOE including peers, college staff, course instructors and tutors. Research by

Amelink et al. (2010; 2011); Anderson et al. (2015; 2014); Hill et al. (2010), and Corbett et al. (2015), demonstrate both the need for and success of retention programs which include peer mentoring, research experiences, and other strategies supporting under-represented groups in engineering and computing disciplines. The NACOE's AUP retention program structure utilizes these microsystems to create a network of support.

In context, there are many microsystems that make up the environment of the developing person and evolve as they grow and change physical locations. Figure 2.2 demonstrates this context for Norm and today's NGE in the NACOE at MSU (Bronfenbrenner, 1993). These systems may be near the student, such as academic classes, instructors, peers, or campus living and interact directly with the student (Bronfenbrenner, 1993).

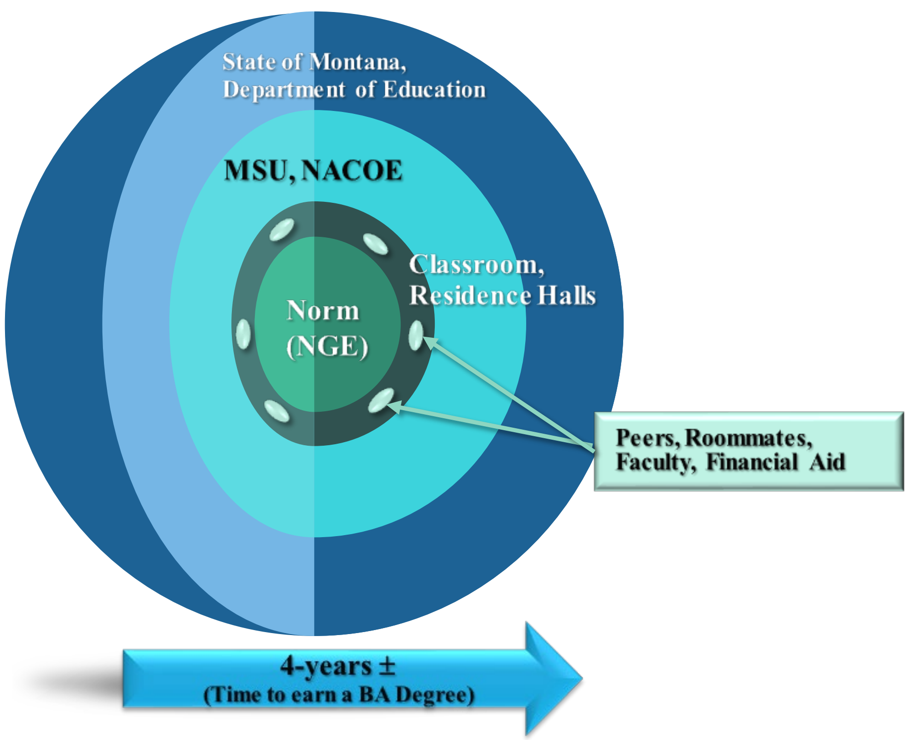


Figure 2.2. Bioecological Theory of Human Development

Mesosystem

The *mesosystem* comprises “the linkages and processes taking place between two or more settings containing the developing person. Special attention is focused on the synergistic effects created by the interaction of developmentally instigative or inhibitory features and processes present in each setting” (Bronfenbrenner, 1993, p. 22). The space directly surrounding the student acts as a proximal boundary for those microsystems engaging with the individual (Bronfenbrenner, 1995a; Elder Jr., 1995).

Like an ocean, the mesosystem acts as the fluid space between the student and microsystems they engage with during their academic experience. In the case of program components supporting AUP students, the microsystem of peer mentors proactively engages with the student, facilitating their engagement with other microsystems. The peer mentor’s efforts to draw new students into faculty-peer led discussion groups, academic content support centers, and student-led clubs could be compared to the way marine life functions together. Fish utilize each other, their environment, and other elements to maintain balance in their population; existing within the same fluid space as other marine life.

Exosystem

Formally defined, the *exosystem* “comprises the linkages and processes taking place between two or more settings, at least one of which does not contain the developing person, but in which events occur that indirectly influence processes within the immediate setting in which the developing person lives” (Bronfenbrenner, 1993, p. 24).

While not directly connected to an individual, the exosystem plays an influential role in cognitive development.

In college, the distal systems of the exosystem first have a connection through microsystems near the student, such as an admissions committee or a department's curriculum committee which determines college acceptance or required courses for an academic degree (Meadows, 2008b). Second, relationships between these more distant systems, such as parent finances of a dependent student or a professionally employed adult student, may influence the interactions with microsystems related to an academic setting (Evans et al., 2010). Other exosystems influencing a college student may include a faculty curriculum committee which influences courses required for a degree path and college's admissions committee that sets entrance standards for incoming Freshman. These systems are important as they involve "significant others" (Lerner & Bronfenbrenner, 2005, p. 46) who have a distal influence on a student's college experience.

Macrosystem

Finally, *macrosystems* have influence in establishing meaning over a larger context, informing culture, belief systems, laws, or policy (Bronfenbrenner, 1993, 1995a). Consisting

> of the overarching patterns of micro- meso- and exosystems characteristic of a given culture, subculture, or other extended social structure, with particular reference to the developmentally instigative belief systems, resources, hazards, lifestyles, opportunity structures, life course options and patterns of social interchange that are embedded in such overarching systems. (Bronfenbrenner, 1993, p. 25)

Ethnic backgrounds, belief systems and/or social organizations such as countries, cities, neighborhoods produce patterns in systems closer to the individual resulting in similarities within cultures, communities, and other environments (Bronfenbrenner, 1993, 1995a; Lerner & Bronfenbrenner, 2005).

In the case of engineering or computer science students, macrosystems such as national program accreditation organizations and cultural climate interact with the student from a distance (Bronfenbrenner, 1993). Engineering or computing students' choices and degree requirements are influenced by the minimum standards set by ABET, the national accrediting body for college programs (ABET, 2019). Rice et al. (2014), Villanueva et al. (2018), Hughes (2018), Riley (2008) and more have described the need to diversify STEM disciplines. They have also shown the current cultural climate is not warm and inviting to non-traditional populations (i.e.: Female, Latino/a, Black/African American) interested in STEM disciplines. In the case of ABET standards, the benefit is NGE's completing academic programs in engineering or computer science disciplines with similarities in minimum levels of knowledge, skills, and experiences (ABET, 2017a). Cultural climate, on the other hand, can prevent the ability to meet the demands of both experts and diverse perspectives needed to solve 21st Century problems.

Chronosystem or Time

The *chronosystem* or *time* factor "encompasses change or consistency over time not only in the characteristics of the person but also of the environment in which that person lives" (Bronfenbrenner, 1994, p. 40). Building off the idea that human development does not happen in isolation this element of Bronfenbrenner's theory introduces a dynamic, multi-dimensional perspective. Figures 2.1 and 2.2 present the time factor in a directional sense, such as a flowing river. Conceptualizing time as an influential factor is important because of the development process an individual goes through is complex. A student's progress from past, to present, to future is influenced by a variety of environments and events which impact the direction, speed, or rate they move through a college experience. An example is the anticipated 4 years to earn a bachelor's degree in engineering or computer science could be shortened or extended depending on environmental factors or events. Students entering college the fall term after graduating from high school with many advanced placement credits versus those from military service or the work force, academically rusty and without a similar jump start, may take longer than 4 years to complete a degree.

Engineers and computer scientists of the 20th Century transformed our lives through city and state infrastructure; automobiles, planes, and spacecraft; household technologies; electronics; and the list continues (Somerville et al., 2003). The 21st Century NGE has been charged to respond to challenges resulting from 20th Century innovation now requiring improvement (sources of energy), repair (city infrastructure), or more recently, advances in medical practices to combat global pandemics (like COVID-19 Coronavirus) (Allan, 2010; Augustine, 2020; Centers for Disease Control and Prevention, 2020; National Academy of Engineering, 2017). Although not declared one of the 14 Grand Challenges by the National Academy of Engineering (2017), retention of students interested in engineering or computer science disciplines is a worthy of 21st Century focus and innovation (E. Cech et al., 2011; Muthukrishna, 2020). Students who identify with URG and/or begin their degrees AUP are also interested in creating solutions for society. The National Academies of Sciences, Engineering, Medicine (2011) organizations supporting our national defense such as Raytheon (2016), and researchers like Chubin et al. (2005) all speak to the critical need for retention, widening access, and retaining the diverse contributions of our 21st Century youth.

Bandura (1997b), Usher et al. (2008a), and Pajares (1996) provide a foundation for the broad and deep research related to student perception of academic self-efficacy influences and the value persistence with challenging material. Higher education research by Renn et al. (2003) frames an understanding of larger social structures and the influences of shaping conditions and events within the proximity of students. Norm's life story, for example, demonstrates the benefits of the college environment on academic self-efficacy development. In his experience, the proximity of MSU with its academic resources, peers, faculty and living environment paired with the belief that he could solve problems through hard work were instrumental to his eventual success in completing an engineering degree (Nickerson, 2018). While this may seem to be a personal characteristic, the next section presents Bandura's self-efficacy theory which picks up where Bronfenbrenner ends with his concept of instigative characteristics.

Theory of Self-Efficacy

The life work of Urie Bronfenbrenner focused notably on the development of children during their early years, with the more contemporary version of his theory including the concept of developmentally instigative characteristics and their role in the complex nature of human development (Bronfenbrenner, 1979, 1994, 1995a; Rosa &

Tudge, 2013). Turning to the intrinsic development process not entirely explained by Bronfenbrenner's theory, the work of social psychologist, Albert Bandura (1997b) provides a useful perspective. Grounded in social cognitive theory, but with its own structure the *Theory of Self-Efficacy* complements bioecology theory by providing a glimpse into how individuals process their interaction(s) with their environment (Bandura, 1997b). Bandura explains, "self-efficacy plays a pivotal role in the multifaceted social cognitive theory, but it is not the sole determinant of action" (Bandura, 1997b, p. vii). Briefly, *social cognitive theory* is the idea an individual can contribute to their circumstances, on purpose; rather than being solely a product of their surroundings (Bandura, 2005). Social cognitive theory was first introduced as *social learning theory,* which is the ability to learn from others within social settings (Bandura, 1971). Like bioecology theory, Bandura's theories evolved through decades of research and application, becoming more nuanced and complex. The use of self-efficacy theory acknowledges the influence of social structures but seeks to gain a better understanding of the intrinsic influences related to the belief that one *can* learn. The spiraling influences of the sources of self-efficacy on a person are depicted in Figure 2.3. uses a common optical illusion with the person at the center. Self-efficacy influences student development and plays a pivotal role in academic success overall, including in engineering and computing disciplines (Corbett et al, 2015; Hill et al., 2010; Marra et al., 2012; Marra et al., 2006). The complementary way self-efficacy theory nests into bioecology theory is presented in Figure 2.4.

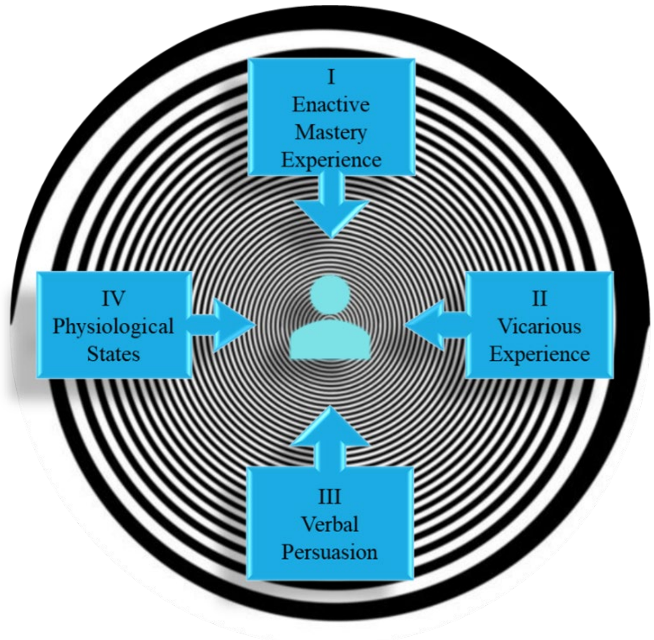


Figure 2.3. Self-Efficacy Theory: Four Sources

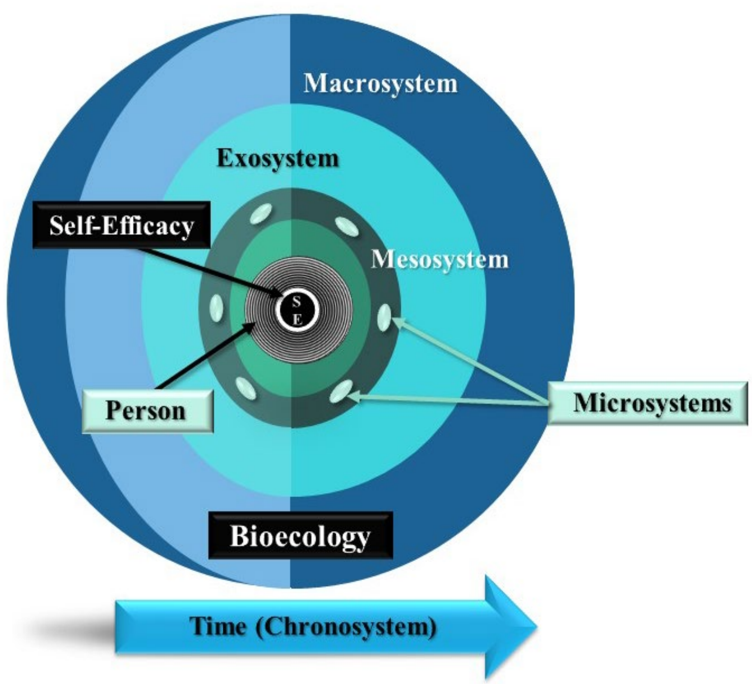


Figure 2.4. How Self-Efficacy Theory Nests into Bioecology Theory

An individual's perception, or belief, in their ability to achieve a goal is the basis of Self-Efficacy Theory (Bandura, 1997b; Kassaee & Rowell, 2016; Shaulskiy, 2016). Our minds have the powerful ability to regulate our actions, informing whether we try or give up, and even how long we persist, when working on tasks or skills (Bandura, 1997a; Kassaee et al., 2016). Bronfenbrenner echoed this concept through his articulation of *developmentally instigative characteristics* and the notion that an individual has an ability to *act upon* their environment (Lerner et al., 2005). But self-efficacy is not fixed, it can be increased with four methods influencing its development. Following is an explanation of *enactive mastery experience, vicarious experience, verbal persuasion,* and *physiological and affective states* (Bandura, 1997b).

Enactive Mastery Experience

Individuals are a culmination of knowledge, skills, and experience that synthesizes with their natural abilities and is the most authentic demonstration of capability. *Enactive mastery experiences,* by definition, act as evidence in one's ability to achieve success and are the most influential sources of building self-efficacy (Bandura, 1997b). Work by Loo et al. (2013), Chen et al. (2013), Booth et al. (2012), and Lishinski et al. (2019), demonstrate mastery experiences alone were statistically significant predictors of students' confidence in their success with engineering or computer science content. Their work shows how opportunities to engage in activities related to applying engineering or computing concepts early in an academic experience allows students to assess their ability with concepts. Hutchison et al. (2006), highlighted factors influencing self-efficacy development in first-year engineering students. Other research has shown students who believed they had mastered the concepts were excited about the material they learned while those who struggled reported being frustrated with problems presented on assignments (Booth et al., 2012; Chen et al., 2013; Hutchison et al., 2006). Building off Hutchison's work, Booth et al. (2012), found mastery experiences during first-year led to students reporting a stronger sense of confidence with material, and increased student involvement and their sense of belonging to an academic community. Mastery experiences include interactive coursework (Litton et al., 2018), involvement in research (Pierce et al., 2013; Tsui, 2007), and opportunities to see where course content may be applied in the real world (Bandura, 1997a). Findings by Garcia (1991) and Dennehy et al. (2017) support developing a retention program for AUP students to discuss experiences, articulate where engineering or computing concepts may be applied in the work force and explore personal interests to support learning in entry level coursework.

Vicarious Experience

Vicarious experience occurs when individuals engage with established experts within an environment and use cues from interactions as a road map to navigate new material or events (Bandura, 1997b). When individuals perceive shared or similar characteristics with the experts this can serve as an effective tool for developing academic self-efficacy (Bandura, 1997b). Usher et al. (2008a), Chen et al. (2013), and Bandura (1997c) note vicarious experiences can happen inside and outside the classroom, and through post-20th Century media avenues like television and now social media. Chen et al. (2013) expanded on how women and girls tend to find vicarious experiences more valuable than an initial experience with new content. If female students find peer or faculty role models within their disciplines who look like them and have shared similar experiences, this supports engagement, learning strategies for complex content, and provides social feedback that encourages persistence (Chen et al., 2013). Relating to first-year programs, Booth et al. (2012) found group engineering design projects supported students with limited direct experience with unfamiliar content. In Litton et al.'s (2018) qualitative study looking at an undergraduate research program, students reported the support of mentors provided insight, shared knowledge or skills while improving their learning ability and confidence with research content. Threading back to Bronfenbrenner's work Melius (2011) speaks to important influence of student environment particularly for low-income, first-generation, and minority populations because it cares for both cognitive and non-cognitive needs. Gándara et al. (1999) and Tsui (2007) found some populations benefit from a form of organized mentoring and may find *within group* mentoring effects more influential that *between group*. For example, if a Freshman African American engineering student is matched with a Junior or Senior engineering student *within* a similar identity group, the impact of the mentoring was found to have a greater impact. Pierce et al. (2013) speaks similarly but about teaching practices and supporting learning through using multi-dimensional perspectives. Looking specifically at supporting AUP students in their first year, including peer mentors, teacher assistants, or faculty with a similar background would support learning complex content in ways other than verbal instruction.

Verbal Persuasion

Bandura (1997c) referred to feedback either directly or indirectly from people such as peers, mentors, or instructors as sources of *verbal or social persuasion* and noted the potential to foster self-change. Schunk et al. (2002) and Ponton (2001) add to Bandura's (1977) guidance for interactive feedback by demonstrating the importance of styles and timing of advice, such as interactive responses that correct understanding of complex content. This form of feedback as a singular approach is limited, as noted by Bandura (1997b), Hutchison et al. (2006), and Chen et al. (2013), but in combination with other sources supports self-efficacy development. Finally, Bandura (1977), Pierce et al. (2013), Usher et al. (2008b), and Tsui (2007), found the impact of this source of self-efficacy is also influenced by the credibility of the source, trusting relationships, and how this information aligns with a person's own belief of their capability. Considering these findings and Bronfenbrenner's (1993) theory, it is important to consider the role individuals (microsystems) in the AUP program (mesosystem) play for the student participants.

Physiological and Affective States

Bandura's (1997c) final source of self-efficacy is *physiological and affective states* which are feelings or emotional responses to stressful or challenging experiences or environments. People use emotional arousal as an indicator of their ability to respond to stress which influences their mindset as they engage with their environment (Bandura, 1977). Bronfenbrenner's (Bronfenbrenner, 1993, 1995a, 1995b) concept of developmentally instigative characteristics provides a framework for how individuals negotiate engaging with their environment. Litton et al. (2018) found students participating in undergraduate research opportunities reported higher levels of confidence in their own ability to engage in research after working through a project with mentors. Marra et al. (2010; 2006) found peer support to be a benefit to developing academic self-efficacy. However, Strayhorn et al. (2013) found lack of same race peers and faculty to influence URG perception of unspoken expectations in academic performance. In a first-year design course, Hutchison et al. (2006) found enjoyment, interest, and satisfaction to be key factors in student self-efficacy with engineering concepts. A study by Loo et al. (2013), however, presented physiological states as having minimal effect on academic achievement in engineering students. In a literature review, Usher et al. (2009) explains this is a difficult source to measure with consistent results and considers how different age groups reflect on experiences or are influenced by the style of assessments constructed by researchers. These findings inform the organization of retention programming for AUP students. Specifically including methods of teaching awareness and coping strategies for physical and emotional responses to situations such as failing an exam, missing an assignment, navigating bias, or setting realistic expectations for academic performance.

Rational for Theoretical Framework and Intervention

Theoretical Framework

External and internal sources influence human development as defined by both Bandura (1997c) and Bronfenbrenner (1993, 1995a, 1995b). In children, Schunk et al. (2002) describe how experiential knowledge contributes to the increase in academic confidence and which can lead to persistence. A study by Alias et al. (2009) presents the effect external stimuli (positive feedback) can have on academic confidence (cognitive performance). Teaching approaches such as relational reasoning (Alexander, 2017), structuring immersive learning environments (Pierce et al., 2013), and first-year design projects (Booth et al., 2012) are examples of how faculty work to build academic confidence in the classroom. An ASEE report by Yoder (2012) provides a robust review of retention programs such as Bridge programs (Ashley et al., 2017), peer mentoring (Craig, 1998; R. Marra et al., 2010), and learning centers (Topping, 1996), and their impact on increasing persistence in STEM. These efforts speak to the need of using a complex theoretical framework to describe the dynamic nature academic self-efficacy development.

Within STEM education research, either Bronfenbrenner's theories *or* Bandura's theories have been used, but there was no evidence of their combined application. This observation was a conversation topic with Anders Berglund, Aletta Nylén, and Arnold Pears, members of the UpCERG research group at a STEM education research conference (UpCERG; Eckerdal, 2018). All recognized Bronfenbrenner and Bandura's work as complex and comprehensive on their own and possibly the reason why they had not been used together. If these two complex theories were to be used together, the consensus was it would be challenging and should be carefully considered. Tudge et al. (2009, 2016), echo this voice of caution in their work noting the appropriate use of Bronfenbrenner's work because of the evolution his original theory since its original publication in 1979. Bronfenbrenner's work focuses on early childhood development, but its systems approach and bioecological model established in the 1990s are useful in studying development in context at the college level (Mayhew et al., 2016; Renn et al., 2003; Tudge et al., 2009). It was the decision of this researcher to use these complex theories together as they complement each other and provide a comprehensive picture of academic self-efficacy development within a university setting.

Advice from Tudge et al. (2009, 2016) describes the importance of clarifying which version of Bronfenbrenner's theory is being used to ensure appropriate application. Individuals live in contextual settings versus isolation, with layers of influences they must process and determine how to engage (Bronfenbrenner Center, 1990). The evolution of Bronfenbrenner's original 1979 ecology theory led to the PPCT model and defining *developmentally instigative characteristics,* which is the internal filter a person uses to make sense of their environment and determine how they respond (1979, 1993, 1995a, 1995b). Using Bronfenbrenner's (1994, 1995a, 1995b) 1990's bioecological systems approach to explain the processes and influences on academic development aligned well with this researcher's questions.

While bioecology theory describes the external factors involved, Bandura's self-efficacy theory picks up where Bronfenbrenner's developmentally instigative characteristics leave off to describe the internal workings of self-efficacy development (Bandura, 1997a; Bronfenbrenner, 1994, 1995a, 1995b). A popular spiraling optical illusion best represents the fluid nature between a person and their environment (Macphersonet al., 2017). Depending on one's perspective, the spiral is either spinning inward or outward, see Figure 2.5. This imagery explains student perception of external factors on internal development of academic self-efficacy and the requirement for selecting a robust theoretical framework to provide a way of articulating what happens. Nesting Bronfenbrenner's bioecological model of human development with Bandura's self-efficacy theory in a single study provides a framework to demonstrate the complex nature of how external factors influence student perception of their academic self-efficacy.

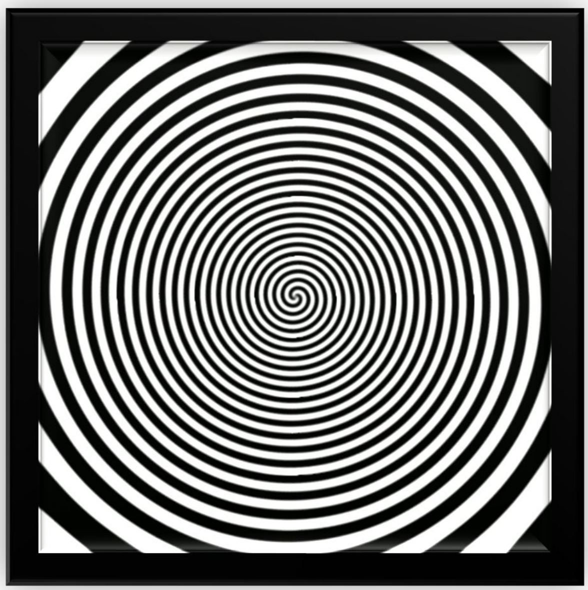


Figure. 2.5. Optical Illusion

Other contributions to higher education literature, including Vincent Tinto (2012b), Alan Seidman (2012), and Alexander Astin (1999), provide additional rationale for using multiple approaches to consider program design. Supporting access to STEM disciplines for the NGE includes consideration of the academic foundation students bring (Fields, 2014; Worley et al., 2010), the environment students will be engaging (Melius, 2011; Micari et al., 2016), and the intentional design of programs to support developing academic self-efficacy (Schneider et al., 2015; White et al., 2008). This study seeks to understand student perception of a retention program for AUP students in engineering and computing disciplines. The existing program was designed to provide targeted academic advising resources to support students as they develop ability with challenging engineering or computing content. Using Norm as an example, his arrival on MSU's campus in 1953 was met with an immediate recognition of not being academically prepared for this new learning environment (Nickerson, 2018). His internal response to this new, external challenge was filtered through experiences throughout his childhood solving hard problems and informed Norm's decision to work hard and learn the material (Nickerson, 2018).

Development of Academic Self-Efficacy with Content

High school students may be aware of engineering or computer science conceptually; but Norm's confession of believing *"mechanics work was engineering"* is still common today. A Google search with the prompt *"What is engineering"* presents definitions about using math and science to solve problems or present images such as gears, electronics, people in hardhats, blueprints, and tools. A similar search with the prompt *"What is computer science"* presents an equally broad response only definitions include the terms computational systems and software while the images present computer screens with lines of programming code. Clive Dym (1998, 2013; 2005), a prominent engineering education researcher and former chair of Harvey Mudd College's engineering department, is remembered for promoting *design thinking* as the systematic process leading to thoughtful, intelligent solutions at the heart of engineering. More recently Guru Madhavan (2015, 2016), National Academy of Engineering senior scholar and program director, has promoted the concept of *engineering mindset* to inspire modular systems thinking to breaking down problems. As a recognized expert within computing education Carnegie Mellon University's, Jeanette Wing (2006, 2008) defines *computational thinking* as an analytical style of problem solving encompassing designing systems, human behavior, and computing concepts. Of note by the engineering and computing education researchers, including Donna Riley (2017, 2021), Erin Cech (2011; 2014), and Mark Guzdial (2008, 2019) is the continued need within engineering and computing education research for exposure and experience in K-12 experiences.

Although opportunities for high school students to take engineering or computing courses are increasing, the critical need to recruit NGEs remains as even government programs fall short of their goals to improve exposure to STEM disciplines and careers in K-12 education (Burke et al., 2011; Casey, 2012; Department of Education, 2015). Marks et al. (2014), Reid et al. (2018), Guzdial et al. (2019), and Booth et al. (2012) are a few researchers in engineering and computing disciplines calling for more K-12 and first-year, higher education program to introduce these topics early and clearly to student populations.

First year, post-secondary education programs including a method of explaining design and computational thinking have potential to establish an engineering mindset in the NGE (National Governors Association, 2007). Supporting student development of academic paths aligning with their career goals is an important contributor to retention as noted by Cromley et al. (2015), Barker et al. (2015), and in Lishinski et al.'s (2019) chapter on student motivation, attitude and disposition. When students understand why content being learned is an important contribution to their career goals, they are more likely to identify as students of a discipline and persist through challenge (Daniels et al., 2004; Peters et al., 2012).

Academic Self-Efficacy and Academically Underprepared NGE

Reflecting on his arrival at MSU in 1953, Norm shares the emotion-clouded moment when he realized two unexpected pieces of information. First, engineering was not the "mechanics work" he had imagined it to be and, second, he was academically underprepared for the advanced math and science the coursework required (Nickerson, 2018). As a defining moment, Norm details the resulting worry and doubt about his decisions followed by the resolve and tenacity to work through problems as they came to find solutions (Nickerson, 2018). However, intrinsic motivation and confidence he could do hard things were not enough. Recalling the relationships with peers, faculty, and staff, Norm spoke about their value to his ability to learn the math and science he needed as a foundation for understanding complex mechanical engineering concepts (MSU News Service, 2014a). The support systems in place within the university environment were as important to Norm's success as his belief that engagement would result in a favorable outcome.

College readiness is a set of knowledge, skills, experience, and behaviors expected in new Freshman students and anticipated as a product from high school programs (Conley, 2005; G. Kuh, 2007). A prolific body of research presents challenges for the 21st Century NGE in any discipline, but also in STEM subjects (Conley, 2005; Corbett et al., 2015; Schreiner, 2012; Tinto, 2000). Academic readiness for STEM disciplines is not as simple as choosing to take math and science in high school. Contributions by Geisinger et al. (2013), Strayhorn et al. (2013), Cole et al. (2008), identify limited access to advanced math and science topics among additional challenges underrepresented groups experience. Empirical research contributions from Sax (2001), May et al. (2003), Crisp et al. (2012; 2010), Hill et al. (2010), and Corbett et al. (2015) are only a small sample demonstrating the how K-12 experiences prepare NGEs for STEM majors in college. They along with many other speak to the importance of repeated exposure to math, science, engineering, and computing topics in high school. These experiences contribute to academic self-efficacy development and college readiness for STEM majors (Hutchison-Green et al., 2008; Loo & Choy, 2013).

Over half of the AUP cohort population were students from Montana communities, like Norm (MSU Office of Planning & Analysis, 2020). Known for its low population, remote communities, and extreme weather patterns over 80% of Montana cities and towns are defined as frontier (National Center for Frontier Communities, 2014). Meaning their access to robust resources available in more urban settings are limited. Additionally, the NACOE is an attractive option for out-of-state and international students because of its single application process which happens admission to MSU. For the last 5 years the Fall AUP cohorts have grown suggesting the NGE is inspired to consider an engineering or computer science career. Both history—in the form of Norm—and research demonstrates a reality that the NGE in engineering or computer science exist in AUP student cohorts. Geisinger et al. (2013), note six factors contributing to student decisions to leave engineering: classroom and academic climate, grades and conceptual understanding, self-efficacy and self-confidence, high school preparation, interest and career goals, and race and gender. Retention can be positively affected when colleges address at least one of these factors.

Academic Environment and the NGE

Norm's life story is an example of bioecology theory of human development in action and the impact of a student's academic environment (Nickerson, 2018). Describing his academic development as an NGE in mechanical engineering, Norm cites many factors contributing to his success. His description of the college environment found at MSU in the 1950s is bioecological theory in action where Norm was able to practice academic mastery, learn through the example and experience of others, receive timely feedback, and manage the emotions, stress, and worry of pursuing a challenging college degree (MSU News Service, 2014b). In the AUP retention program established to support development of the NGE, included strategies included in Yoder's (2012) ASEE report highlighting best practices for retention. The four, research-informed strategies identified retained the specialized advising support in place to help students systematically narrow down their academic direction by considering talents, interests, and the new knowledge, skills and experiences needed to direct their development. Three additional methods included hosting topic specific workshops to develop a peer and staff/faculty network as well as name unexpected emotions or responses to challenging material and provide strategies to manage responses. Second, connecting the NGE with student clubs or professional organizations actively working on real world problems provides a contextual means of visualizing themselves in a particular industry, such as product design in aerospace, big-data management for risk assessment firms, or structure design, or designing power or water usage modification. Finally, peer mentoring supports vicarious experiences and real time feedback from the NGE's environment. Several of these topics were selected because of the rich research informing the success and refinement of practices broadly and within STEM disciplines.

Specialized Advising

As early as 1972 with Crookston's look at academic advising as teaching, in and out of engineering and computer science disciplines, academic advising is a well-researched, recognized profession, and valued resource for supporting student persistence across higher education (Crookston, 1972; Gordon et al., 2008; Thurmond et al., 2006). Seymour et al. (1997) identified academic advising as an important factor in engineering retention and these findings were confirmed by Marra et al. (2012), Geisinger et al. (2013), Meyer et al. (2014) and many other researchers working to address retention in STEM. Villanueva et al. (2018) also found advising to have a low level impact in transmitting the hidden curriculum of higher education. Shifting the focus to why advising is important, Brooke et al. (2019) presented academic advising helpful in onboarding first-year engineering students. Morton et al. (2017) found women in STEM benefited from integration into the academic environment and community adding to May et al. (2003) and Chubin et al.'s (2005) earlier work focusing on URGs in engineering.

As a strategy for supporting career alignment, Rodgers et al. (2014) and Eastman et al. (2017) implemented advising approaches as part of retention programming with some success. Morton et al. (2017) and Marra et al. (2009) note academic advisors are a source of self-efficacy, supporting integration into the academic community. As a strategic planner, Chen et al. (2020)'s work noted the value advisors are as a support for career planning. Specialized academic advising which includes encouragement, support finding help with challenging content, and career alignment for engineering or computing majors touches on at least two sources of self-efficacy: verbal feedback and an opportunity to talk about affective states related to academic or social experiences (Bandura, 1997a; Brooke et al., 2019).

<u>Topic Specific Workshops</u>

Conley's (2005) work is one example of broad college knowledge research and exploring the *hidden curriculum* associated with readiness. In engineering research, Villanueva et al. (2018) was a multi-institutional review of the need to study this phenomenon in engineering and develop methods of research with self-efficacy being noted as an important tool. Gelles et al. (2019) challenged the common nature in engineering to ignore emotions demonstrating that they are present and should be factored into the retention equation. Nudelman (2020) looked at the hidden curriculum graduating engineering professionals find as they are transitioning from college curriculums into the professional world. In each of these the common thread is acknowledging there is a hidden curriculum followed providing training to teach the missing information or skills and practice implementing methods.

The inclusion of topic specific workshops is informed by this research. Developing a topic-specific workshop series serves as a way of providing four sources of self-efficacy for participants. First, drawing on previous experiences, teaching a new concept, and then providing an opportunity to practice implanting the new information fits with mastery experiences. Second, bringing a group of AUP students together with a more experienced peer mentor provides vicarious experiences as participants observe interactions within group members and the topic. Third, social persuasion comes from multiple sources including the workshop presenter, AUP program moderator, AUP peers, and peer mentor. Finally, physiological states and the discussion of emotions can be workshop topics which include methods of management. By not having a graded component to the workshops, they become a low-stakes way of engaging with peers with the potential for a beneficial impact. A workshop topic example could be asking what first-year, AUP students know about engineering or computer science, teaching them about the Grand Challenges for the 21st Century Engineer, and then using this to explore areas of interest.

Engineering/Computing Club & Group Connection

Student engagement is another deeply researched topic and tied to success in higher education environments. A small sampling includes Kuh et al. (2010) who identified engagement as a key factor of student success, Strayhorn (2008) noted its relevance for personal and social learning outcomes, and Melius' (2011) findings showed increased academic achievement in engaged students. Within engineering and computing, Bhaduri et al. (2017) demonstrated the value of connecting classroom learning to an applied experience with a student organization in increasing understanding of course content. In computing education, Ortiz-Rojas et al. (2017) identified similar finding related to using gamification to develop programming skills and increase student engagement. Ohland et al. (2008) found engineering students reported more frequent engagement and Wilson et al.'s (2014) multi-institutional study demonstrated the effects on self-efficacy development were significant. More recent work by Simmons et al. (2018; 2014) showed students were selective of their out-of-class participation choices weighing their options against personal interests, organization, and personal goals alignment, and gaining experience. Barriers to participation included lack of time, scheduling conflicts, need to maintain a job (Simmons et al., 2018). These studies did not focus on AUP students but did indicate limitations of their studies included poor representation of URG which might have modified their findings.

Like workshops, AUP student connection with clubs or organizations has potential to influence self-efficacy development through Bandura's (1997a) four sources. These groups focus on projects and host event within a particular discipline providing opportunity for new skills and concepts to be seen in action. Not only would this influence mastery experience, but also provide vicarious examples of how to learn and apply engineering or computing content (Bandura, 1997a; Purzer, 2011). Watching and being coached (social persuasion) by peers on how to manage disappointment, challenge, conflict, or other emotions (physiological states) influences self-efficacy development as demonstrated in work done by Ohland et al. (2011), Loo et al. (2013), and Marra et al. (2005, 2009).

Peer Mentoring

Along with academic advising, peer mentoring has also been identified to benefit student persistence in STEM disciplines. Some critiques include failure to provide systematic, required training for peer mentors (Colvin & Ashman, 2010) and monitoring mentor-mentee relationships (Attarzadeh et al., 2011). In answer to these critiques, Leidenfrost et al. (2011, 2014) determined in their studies that any mentoring is better than no mentoring, but relationship development should be supported by the college and not left to chance. These critiques and many examples of successful peer mentoring approaches including Johnson et al.'s (2011) program supporting transitioning students, Kisch's (2012) use as a method of helping international students adapt to life at a U.S. university, and Anderson et al.'s (2015) Near-peer mentoring model supporting new undergraduate students and research interns.

Student success research in post-secondary education has discussed the importance of the environment to development, persistence, and retention making using Bronfenbrenner's contextual, systems approach a key component to this study (Mayhew et al., 2016a; Pascarella & Terenzini, 2005a, 2005b). The nature of peer mentoring as a self-efficacy source allows it to be used vicariously and as social persuasion.

Summary

Choosing a theoretical framework to analyze a problem of practice involving the influence of external factors on an internal phenomenon related to human development was challenging. In 1979, when Bronfenbrenner presented his original Ecology of Human Development theory his colleagues challenged the ability to really study a complex and seemingly ambiguous process outside of clinical settings (Bronfenbrenner Center, 1990). The evolution of Bronfenbrenner's ecology theory (1979) into Bioecological Model of Human Development (1995a, 1995b, 1999) over the course of his research career is evidence that the study of humans in context is necessary for a robust understanding what is happening. Seeking to understand the student's perspective of an external influence designed to support their internal development of academic confidence with challenging topics requires not only an external framework, but the internal framework through Bandura's self-efficacy theory (1997a). This is particularly important when the purpose is to increase student retention in underrepresented populations which include academically underprepared high school graduates seeking to enter engineering or computing disciplines and careers.

CHAPTER THREE

METHODS

Introduction

When students are accepted to MSU any major in the NACOE is available to them without requiring a second application. Aligning with the land-grant mission of the university, the NACOE believes there is a responsibility to meet students at their academic preparation level (Norm Asbjornson College of Engineering, 2019). The college's namesake, Norm Asbjornson, arrived on the MSU campus, then Montana State College, in 1953 wanting to earn a mechanical engineering degree (Nickerson, 2018). Very quickly he learned his high school education in Winifred, Montana did not provide the academic preparation in math and science he needed to begin the engineering content (Nickerson, 2018).

Although efforts have been made to increase academic college readiness, it is different from academic preparedness as described by Barnes et al. (2010). College readiness is presented by Barnes et al. (2010) as understanding the structure of a new learning environment such as enrollment processes, financial aid, college campus structure (i.e.: student accounts, "Registrar," campus housing, student union, bookstore, etc.), and student service resources. Academic preparedness, being ready for what a student is coming to learn, is introduced as a separate component from college readiness by Barnes et al. (2010), deviating from extensive research by Conley (2005, 2007, 2012) which places them under the same umbrella. Students coming to study engineering or computing disciplines are considered academically ready when they are prepared for calculus, physics, chemistry, and/or computer programming in their first year (Dickerson et al., 2014; Llewellyn et al., 2018). Many students from Montana high schools, particularly from small and remote communities like Winifred, arrive on the MSU campus AUP just as Norm did in 1953 without the expected academic readiness AND missing the knowledge to support success in a new environment. In 2014, the NACOE established a retention program to support AUP students in their first year. The purpose of this problem of practice study is to discover student perceptions of their experience with a structured version of the established retention program for AUP cohorts in NACOE majors.

As Montana's, land-grant university, MSU provides opportunities for higher education *and* continuing education in counties across the state – serving as a portal between new research and innovation (the university) and citizens of the state (Montana cities and towns) (Rydell et al., 1992). A key feature of Cooperative Extension (Extension) is its pracademic approach to programming and assessment (Walker et al., 2013; Wilson et al., 2014). Borrowed from the work of Walker et al. (2013) and Wilson et al. (2014), a pracademic is a practitioner who uses scholarly research to inform their practice. Extension Specialists are education practitioners who use a scholarly approach to organize programs to meet the needs of their community and assess their impact (Franz et al., 2008; Koundinya et al., 2020). Extension programs are developed by county agents and aligned with core competencies requiring forms of embedded assessment (Franz et al., 2018; Maddy et al., 2002). These can include needs assessments which inform program development or allowing program participants to select content they wish to cover related to subject (Garst et al., 2015; Taylor-Powell et al., 2008). Because the academic topic needs of county residents are fluid, and county agents must demonstrate their effectiveness as community educators, their programs tend to include an embedded, informal assessment approach. These assessments are often administered in paper format but can also include a small group or 1:1 interview after each event. This feedback is used both to direct future topics, but also to include in annual employment reviews (Montana State University: Extension Service, 1999).

Comparatively, this aligns with the Carnegie Project of the Education Doctorate (CPED) developed to foster a scholarly approach to higher education practices (Hoffman et al., 2016). Supporting student populations is much like working with a community whose members have dynamic and evolving academic need. The need to assess the NACOE retention program for AUP students was an immediate problem of practice aligning with the CPED structure (Hoffman et al., 2016). However, the timing of program assessment aligned more with Extension's framework for gathering data as a program is running in the event it is not repeated (Franz et al., 2018; Garst et al., 2015). Program development and improvement occurs after data assessment (Franz et al., 2008; Montana State University, 2017). This practice allows for participant feedback to be captured in real-time, reviewed later, and the findings and/or program structure shared with agents in other locations.

Research Design

Exploring the qualitatively different ways AUP students experienced a retention program organized to influence their academic self-efficacy related to engineering or computing content was the primary goal of this study. Managing researcher bias was a secondary goal given the author's relationship and proximity to both the topic and study participants. Maxwell (2013a) noted the value of structuring qualitative approaches aligning with study goals. Using a qualitative research design for this study supports an interpretivist theoretical approach, acknowledges the relationship of this author to the topic, and understands the range of experiences as individuals live it; all important considerations for ethical research (Creswell, 2013a; Maxwell, 2013; Savin-Baden et al., 2013). Adopting phenomenography as the research approach combines well with a social constructionist paradigm to explore student perceptions related to academic self-efficacy and is designed to manage researcher bias (Åkerlind et al., 2005; Booth, 1997; Marton, 1986).

Phenomenographic Approach

As a researcher seeking to understand the higher education experience for students in engineering or computing majors, this qualitative study used *phenomenography* as its research approach. First introduced as a concept by Sonnemann in 1954, Ference Marton et al. (1981, 1986, 1992) at the University of Göteborg in Sweden developed phenomenography to study student experience within the classroom (Marton, 1981, 1986). As a research approach, Tight (2016) pointed out it is the only one developed by higher education researchers to study higher education. Hasselgren et al.

(1997), described the origin and historical roots of the term "Greek *phainomenon* (appearance) and *graphein* (description), rendering *phenomenography*, a description of appearances." Marton (1981, 1986) explained Phenomenographers seek to understand the spectrum of perceptions within a natural environment as perceived by people experiencing the phenomenon, such as a retention program focusing on AUP students in engineering or computing majors. As its own perspective, this approach was designed to sit in the space between the natural and social sciences to provide a language to communicate human conception of their experience (Marton, 1981, 1986; Svensson, 1997; Yates et al., 2012). Figure 3.1 visually represents where phenomenography sits between the natural and social sciences.

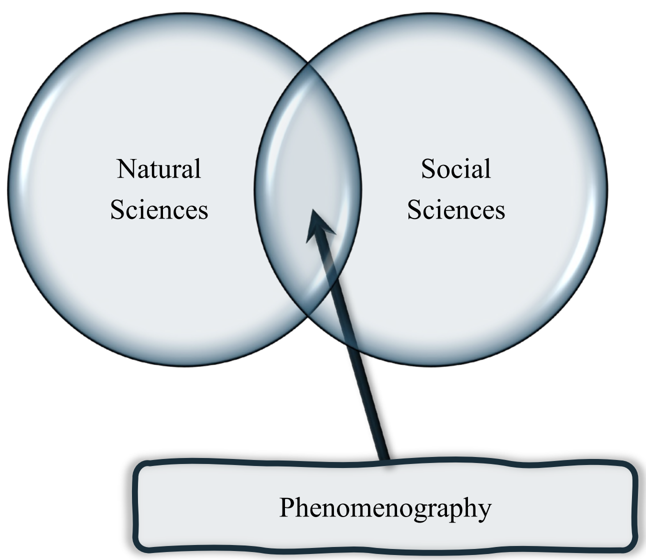


Figure 3.1. Language of Phenomenography

Marton (1981, 1986), Hasselgren et al. (1997), Assarroudi et al. (2016), and others confirm phenomenography as a standalone research approach and not a variation of phenomenology as it is sometimes presented. The differences are many, beginning with the origin of phenomenography from empirical education research compared to phenomenology's theoretically philosophical background (Marton, 1981, 1986). Marton (1981, 1986) described the need for a more autonomous, second-order perspective to understand the content related to a human experience. Meaning the researcher wants to understand *how* a population views something versus *why* they think a certain way as explained by Kaapu et al. (2006). This method seeks to record the number of different ways a phenomenon can be experienced, assumes a finite number of perspectives exist, and is focused on understanding every perspective (Marton, 1981, 1986). Phenomenology provides a first-order perspective of an experience, seeking to reach a consensus related to a phenomenon, and does not depend on the interpretation of an observer (Marton, 1981). For example, this study sought to understand the qualitatively different ways a retention program supporting academic self-efficacy development was experienced by participants. A phenomenological approach would seek to understand the retention program, how students interpret their experiences with the program, and the range of variation within those events (Dahlberg, 2006; Kaapu et al., 2006).

A key premise of phenomenography is the idea that there are a finite number of ways people can experience a phenomenon. This is a third distinction further separating this approach from phenomenology's concept of describing the "essence" of people's experience with a phenomenon aspect of reality (Marton, 1981, 1986). This is defined by Marton as the "common, intersubjective meaning of that aspect" (1981, p. 180). Fourth, different than phenomenology's methodological approach leading to a recognized meaning of a reality, phenomenography is substance-oriented (Marton, 1981, 1986). The goal is to describe the variation in how people experience, interpret, perceive, or conceptualize an event. Finally, phenomenology is pre-reflective, meaning it seeks to describe the world as it was prior to becoming aware of what it could be or how it was lived as opposed to depending on an observer to interpret the variety of experiences to understand the broader picture (Marton, 1981, 1986). Assarroudi et al. (2016) use the analogy of a jigsaw puzzle to explain the role of the phenomenographic researcher as they come to understand the complete picture and how the size, shape, color, and image of each piece is contributes to reveal the complete picture of a phenomenon. Table 3.1 is a review of these differences between phenomenography and phenomenology.

Phenomenography allows the researcher to explore variation of experience usually through semi-structured, in-depth subject interviews with a few participants (Booth, 1997; Marton, 1981, 1986). Marton (1981, 1986) describes the non-dualistic ontological perspective of phenomenography as seeking to understand the world as experienced by each subject to form a picture of the phenomenon. In addition to Marton (1981, 1986) and Booth (1997), Hasselgren et al., (1997) describes this method as the way to define a finite number of ways a phenomenon can be experienced. This allows the researcher to manage their reflexivity by including their experience on the spectrum of understanding (Hasselgren et al., 1997).

Table 3.1. Review of differences between Phenomenography and Phenomenology

Phenomenography	Phenomenology
Origin is from empirical education	Origin is from theoretical philosophy
Second-order perspective	First-order perspective
To identify the number of qualitatively different ways a phenomenon is conceptualized.	To describe the "essence" of people's experience with a phenomenon (not finite)
Analysis leads to substance of how a phenomenon can be perceived, experience, conceptualized.	Methodological investigation leading to recognizing *meaning* of a phenomenon
Reflective and depends on interpretation of an observer	Pre-reflective and does not depend on interpretation of an observer

Interpretive Lens

A social constructionist paradigm serves as a grounding feature in this problem of practice study. My role as the Student Success Coordinator in the NACOE is to organize and implement retention initiatives such as the AUP retention program. Additionally, I coordinate the college's Orientation of first-year college students and serve in a variety of student support roles such as academic advisor and academic coach. This immersive vantage point to the student experience provides an intimate perspective to the student experience. Through this study, meaning was being collectively constructed with my perspective, input from research peers supporting program revision based on their knowledge of AUP populations in STEM, student experiences with their faculty and peers, and the study data. This reality made it important to select a paradigm respecting the integrated involvement of the researcher and colleagues while providing a systematic way to capture the knowledge and experience of the study participants (Creswell, 2013a).

Another premise of social constructionism is the role both internal and environmental influences play on the construction of knowledge and reality (Creswell, 2013b; Maxwell, 2013b; Savin-Baden & Major, 2013c). Essentially, as noted by Bronfenbrenner (1990; 1994, 1995b) and Bandura (1997b) we do not experience life in a vacuum separated from social influences. Instead, we are products of the meshing of internal and external phenomena which work together to shape human development. The purpose of this project described how shared experiences in academic and social settings influence the construction of academic self-efficacy among AUP First-Year students pursuing engineering or computing disciplines.

Stance, Positionality, and Reflexivity

Articulating factors influencing the personal stance, positionality, and reflexivity of this researcher are important to articulate as they inform the chosen research approach (Cloughet al., 2012; Savin-Baden et al., 2013). This section names and describes these elements and their significance.

Personal Stance

Social norms, familial expectations, time constraints, and gender bias were a few of the influences creating challenges in navigating higher education in my personal academic journey. Initially wishing to pursue a STEM degree, as an AUP student with minimal family support, I completed a non-STEM undergraduate degree after transferring to a large, public, land-grant university in the American Southwest. Several supporting factors (peer tutoring, adult mentors, supportive faculty, undergraduate research experiences, etc.) combined with an intrinsic drive led to me completing my degree. This experience formed my belief every student should have access to social systems supporting alignment of their academic goals by design rather than by default. Even if it is loosely framed, students should have a compelling vision guiding their decisions as it informs how they navigate success and challenge. If a student persists in a major or shifts from one degree to another, alignment of professional and academic goals with a vision should inform the process. When students make decisions based on pressure to meet an agenda not in line with their interests and goals it can influence their persistence. Increasing student perception of how advanced education after high school can help them pursue their interests and believe the investment of time and money are worth it.

Positionality

My positionality related to this research was formed after a commencement ceremony at the University of Arizona while standing next to a water feature. Reflecting on the lengthy and disjointed journey from high school to my college graduation, the wish to help other students like me complete their degrees by design rather than the way default framed my professional direction. Currently, I serve as the Student Success Coordinator for the NACOE and am involved in undergraduate program development as a student advisor. My belief in the power a college degree plays in developing the next generation is combined with an awareness that students must have their own academic compass to guide their journey. This momentum cannot come from anyone other than the student. Higher education faculty and staff are only trail markers guiding and coaching students along an academic development path toward *their* career goals.

As a problem of practice study, it is not surprising I hold a position in the NACOE and the Carnegie Project on the Education Doctorate (CPED) provides a framework for this type of scholarly research (Savin-Baden et al., 2013). Additionally, my family connection with Extension has allowed me a unique perspective of the land-grant university. Through this lens, I see where Extension leaves off and Higher Education as an institution picks up in preparing the Next Generation Expert (NGE). The scholarly approach toward program and assessment practices in Extension compares to those in a traditional higher education setting. The CPED project's format and Extension's community education format contains similar constructs. These are unique to me and a direct result of my development as an NGE in engineering and computing education. My proximity to students and interest in creating effective programming to support their success could influence how I interpreted student feedback (Garst et al., 2015; Perry, 2016; Savin-Baden et al., 2013a, p. 75). My stance and positionality required me to recognize and manage bias when students shared their ideas and perceptions related to their college experience in general and the intervention in particular (Clough et al., 2012).

Strategies to manage bias included a deep dive into engineering design thinking and computational thinking leading to an acceptance of my position as an interested novice in these practices. Second, journaling and acknowledging life events leading to this experience with trusted colleagues exposed biases and resulted in developing strategies to manage them. Finally, choosing a research approach that allows the researcher to acknowledge their experience as a point on a spectrum was a strategic decision. Phenomenography seeks to essentially catalog the human experience with a phenomenon which provided a way place my experience on a spectrum, validate its presence, and move on.

Reflexivity

A significant amount of reflection on life experiences is unavoidable during any project, particularly while listening to stories from students and alumnus, like Norm. Savin-Baden et al., noted: "…reflection is the turning back or illumination of something. When thinking about reflection as a mental process, it involves a process of consideration and meditation, of turning thoughts back upon themselves" (2013c, p. 77).

This process, while raising the ability to become critically aware of one's views as a researcher, is challenging and takes time to navigate (Day, 2012). For me, recognizing similarities in my life story both with Norm *and* AUP cohort participants has been, and were, a painful process and required a considerable amount of self-reflection, journaling and seeking resources to reflect critically rather than reinforce perceived injustices.

The resulting reflexive processes include first, recognizing the need to acknowledge my researcher role as being embedded in the experience with student participants. Establishing an open and curious stance about student engagement and their experience was important for me to hear their voice. Second, continuing to reflect personally on how I processed my experience confirmed the use of phenomenography as a research approach. Phenomenography allowed space to acknowledge my experience but keep focused on new perspectives shared by study participants (Marton, 1986). Continual journaling, dialogue with trusted colleagues, and acknowledging where student perceptions conflicted with what I anticipated or wished for them to see was important to set those feelings and impressions aside and accurately process student feedback. Finally, rather than including participants as research partners, a reliability practice not used in phenomenography, experienced colleagues familiar with the study, participants, and program served in this role. Peer researchers act as partners in confirming validity in the interpreted meaning of the student voice (G. Åkerlind et al., 2005; Collier-Reed et al., 2009).

Triangulation is a process in qualitative research of ensuring there are multiple data points to uncover new insights and gaining a deeper understanding of the research subject (Lincoln et al., 1986; Lord et al., 2017; Savin-Baden et al., 2013b). Multiple methods are applied to remind the researcher to be clear and transparent in their process and interpretation of the data. Within engineering and computing education research a *typology* identified by Walther et al., (2013) aligns with triangulation methods articulated in higher education research. This typology articulates 6 constructs for systematically approaching credibility and trustworthiness of the data. Later in this chapter the methods used from this typology are identified and described.

AUP Population and Research Site

This is a problem of practice study focused on an existing retention program in the NACOE. The AUP student retention program provides specialized academic advising and discussions to support academic program planning and exploration of the engineering and computing career fields. An MSU – Planning & Analysis report (2020) shows between 2014-2019, the AUP retention program supported 869 total students. Over a 5-

year period approximately 17% of students declaring a major in engineering or computer science were AUP. It is important to note over this period the number of AUP students declaring a major in the NACOE steadily increased from 120 in 2014, to 166 in 2019 (MSU Office of Planning & Analysis, 2020). Table 3.2 presents a brief comparison between AUP and academically ready (AR) student cohorts. Compared to their AR peers who arrive ready for pre-calculus (Level 4+) or higher courses, this population:

- Takes longer to complete an engineering or computer science degree;
- Are more likely to use academic coaches;
- Demonstrate an academic performance 0.5 GPA points lower than their AR peers;
- Be on academic probation within their first year; and
- Less likely to attend college events.

In addition to relying more heavily on student loans and including a higher percentage of first generation and Pell eligible students, AUP participants include a significantly higher percentage of URGs than the AR cohort. These student outcomes and the 56% retention average of AUP cohort (compared to 71% in AR cohort) demonstrate significant disadvantage compared to peer groups arriving ready for higher level math courses. Exploring methods of supporting AUP students is an important problem to study considering the NACOE's commitment to increasing diversity in engineering and computer science disciplines (Gunnink, 2017). The population of AUP students includes a larger percentage of URGs (34%) than their AR peers (29%). Additionally, data show male students who select an engineering or computer science major are more likely to be academically under-prepared than their female peers.

Table 3.2. AUP and AR Student Comparison. Data from MSU Office of Planning and Analysis

	All 1st Year Cohorts			GPA	Use of Support Services	Engagement	Academic Probation	Time to Degree
		Under-represented Groups (URG)						
	Male	Female*	All URGs**					
AUP (17%)	87%	13%	34%	2.51	14%	8 visits	24%	4.4 years
AR (83%)	82%	18%	29%	3.06	10%	13 visits	11%	3.9 years
Total Freshman	6842							

* Female population include: White, American Indian or Alaska Native, Black or African groups are included in Female population. American, Hispanic, Native Hawaiian.

** All URGs population includes: Males and females from American Indian or Alaska Native, Black or African American, Hispanic, Native Hawaiian groups; and White females.

There are several reasons this is an important NACOE student population to explore. First, the higher percentage of URGs making up the population of AUP students demonstrate these students' aspirations to pursue STEM degrees and careers. Second, over the 5-year span, AUP students declaring a major in the NACOE increased every year, suggesting a response to the invitation to consider a career in engineering or computer science (Gunnink, 2017; Norm Asbjornson College of Engineering, 2019). Retention programming demonstrates the institution's commitment to meet students where they are academically and support their aspirations. Finally, ABET engineering and computer science accreditation standards require colleges to demonstrate support for widening access to degrees in these disciplines (ABET, 2017b, 2019). Astin et al. (2012) echoes the importance of program evaluation. Invitations are empty promises if systems to support AUP cohorts are ineffective, absent, or hard to find. Frequent analysis and review of student programs aligns with advice and expectation for evaluation.

It is important to note the NACOE has many retention initiatives in place supporting all students. The specialized focus to understand the unique needs of AUP populations, which include a higher number of URGs, responds to advice by Marra et al. (2010; 2012), Burger et al. (2010), Hill et al. (2010), and Corbett et al. (2015) regarding the need for intentional programs. Comparing AUP cohorts before the NACOE's retention program was established (2011 – 2013) and post-implementation (2014-2019) shows a significant increase in persistence from years 2 to 3 (46% compared to 56%), years 3 to 4 (30% - 37%), and years 4 to 5 (25% - 38%). Table 3.3 shows pre- and post-program comparisons, between cohort differences, along with 4-year and 5-year graduation percentages.

Table 3.3. AUP and AR Student Continuation and Graduation Pre- and Post- Program Comparison.

	2 year Cont.		3 Year Cont.		4 Year Cont.		4 Year Grad.		5 Year Grad.		6 Year Grad.	
	2011 - 2013	*2014 - 2019*	*2011 - 2013*	*2014 - 2019*	*2011 - 2013*	*2014 - 2019*	*2011 - 2013*	*2014 - 2019*	*2011 - 2013*	*2014 - 2019*	*2011- 2013*	*2014- 2019*
AUP	46%	56%	30%	37%	25%	38%	2%	2%	14%	14%	19%	20%
AR	70%	71%	59%	62%	56%	57%	20%	28%	47%	47%	51%	50%

Graduation percentages reflect no increase or decrease in either AUP or AR cohorts. It is important to note that there was only a single year in which a six-year graduation rate could be computed. This is not adequate to assess impact especially because AUP students tend to take longer to graduate. While retention to degree completion is still significantly lower than AR cohorts, post program implementation students in AUP showed a higher percentage of continuation from years 2-3 (56%), 3-4 (37%), and 4-5 (38%). This increase in persistence suggests intentional retention programs may influence improved graduation rates for students in engineering and computer science disciplines.

Intervention

NACOE – AUP Retention Program

As part of an established retention program, AUP students in the NACOE are provided specialized academic advising which includes strategic discussions related to careers and engineering or computing majors. This required part of the program is combined with invitations to engage in a variety of activities or groups such as peer tutoring, peer mentoring, clubs and organizations, or undergraduate research. These engagements are encouraged, but not required. Table 3.4 shows support services (e.g.: tutoring, disability services, counseling) are used more by AUP students (14%) than AR students (10%). Engagement in campus events (e.g.: student clubs/organizations, study abroad fairs, sponsored events like convocation) are less likely to be attended by AUP students (8 visit average) compared to their AR peers (13 visit average).

Table 3.4. Engagement and Use of Support Services Comparison

	Use of Support Services	Engagement average per student
AUP (17%)	14%	8 visits
AR (83%)	10%	13 visits

Three components of the intervention were existing college programs supporting student persistence. Students were encouraged to engage with peer mentors and college clubs and organization, but only compelled to engage with a specialized academic advisor. For this study, Weekly Group Meetings were created in collaboration with college faculty and informed by the literature. These weekly meetings were compelled and facilitated contact with existing college programs established in addition to an academic advisor. These components are shown in Figure 3.2. This revised program was offered to a small group of AUP students. Participation was expected and designed to intentionally connect participants with peers, faculty, and experiences applying engineering or computing content outside the classroom. The existing intervention was still in place supporting all AUP students.

Figure 3.2. NACOE AUP Retention Program

The intervention components included: 1. Specialized Academic Advising (existing); 2. Six (6) weekly workshops (new); 3. Group and individual peer mentor connection with NACOE Peer Academic Leaders [(ePALS) existing]; and 4. Club & Organization connection (existing). Components 2-4 were identified for their potential to promote multiple sources of self-efficacy which are identified in Table 3.5. Items 2-4 were included as intervention strategies for this study and meant to facilitate participant engagement with self-efficacy sources available to all students in the college. This modified AUP retention program created compelled engagements with peer mentors, faculty and staff, and student organizations to ensure these interactions happened. In its original version, the AUP program leaves these engagements to the discretion of the student. Following is a description of the components in the AUP retention program organized for this study and how they worked together in combination.

Table 3.5. Self-Efficacy Sources connected to Intervention Components

	Intervention	Sources of Self-Efficacy*
1	Specialized Academic Advising	SP
2	6-Weekly group meetings in the 1st semester.	ME, VE, SP, PS or AS
3	Peer Mentoring involvement with ePALS	VE, SP
4	Club & Organization Connection	ME, VE, SP

*Note: ME = Mastery Experience; VE = Vicarious Experience; SP = Social Persuasion; PS or AS = Physiological or Affective States

Specialized Academic Advising. Academic Advising is provided for all students in the NACOE. The initial AUP retention program was established in Fall 2014 to provide specialized academic advising. These meetings provided support for creating a plan of study from the student's math and science levels. In addition, AUP students could have conversations with students about their career goals related to personal interests and how an engineering or computing degree would align.

Weekly Workshops. As a connecting feature, six, topic specific workshops were developed to foster engagement between student participants and their academic environment. Through these workshops it was anticipated that connection to all sources of self-efficacy would be made, including physiological response. Workshop topics included: Resiliency in STEM, Imposter Syndrome, Mindset in Problem Solving and Grand Challenges for the 21st Century Engineer/Computer Scientist. Faculty were invited as guest speaker/facilitators and peer mentors from the NACOE's Group and Individual Peer Mentors.

Recognizing the benefits of peer mentoring, the NACOE established a program in fall 2014 to support female students pursuing engineering, computing, or physics majors (Clark et al., 2015). This program evolved into a peer mentoring program (ePALS) supporting students pursuing majors in the NACOE using a group mentoring strategy. This approach invited first and second year students in engineering or computing majors to events supporting transition into college and through the first 60-credits in their major. The revised AUP program connected participants with peer mentors from the ePALS program through the workshops.

Clubs & Organizations. Opportunities to see the application of science and math in engineering or computing contexts outside of the classroom exist through student clubs and organizations. From their first year, students are encouraged to engage with groups working on projects addressing current problems or developing awareness of current issues in engineering or computing disciplines. However, rarely do first-year students choose to join a student club or organization which is a missed opportunity to find an academic network within their college. These experiences provide opportunity for formal and informal peer and faculty mentoring both of which have been shown to support retention (Craig, 1998; Crisp et al., 2017; Ong et al., 2018). Including student group connection fostered engagement by providing guidance to first-year AUP students on where to find information and align the goals and objectives of the club or organization to their own interests. Peer mentors were available to provide introductions or join students at a group meeting.

Combination of Programs. Following the advice of Chen et al. (2013), Usher et al. (2009), and Bandura (1997b), it was hypothesized that using the components to the intervention would create an environment where more than one source of self-efficacy was in use at a time, thus increasing effectiveness. Additionally, the following three, student-directed objectives informed the components added to the AUP retention intervention:

1. Influence development of academic self-efficacy with engineering or computing through topic-focused workshops.
2. Establish an academic community within the NACOE and foster an identity with academic content related to engineering and computing programs.
3. Increase student understanding of engineering and computer science to support identity development with academic content and establish a perspective and path toward engineering or computing careers.

A critical component of retention programming is assessment and feedback, which is one of the motivators for this study. These tools are beneficial for participants and organizers of an experience as explained by Tinto (2012b), Astin et al. (2012), and others in higher education research. As student bodies change, adopting a scholarly approach to program development and continuous improvement keeps programs fresh and relevant. In essence, staff become pracademics continually asking the questions: What are we doing? Why are we doing it?, and Is there something we can be doing better? (Walker et al., 2013; Wilson, 2015; Wilson et al., 2014).

Participant Selection

Participants for this study were invited from the Fall 2020 incoming, AUP student cohort. This cohort are students in their Freshman year, enrolled in a Level 3 or lower math course. Math level is the only determining factor in identifying cohort participants because that determines when students take science and engineering courses and affects estimated time to degree completion (e.g.: 4-years versus 5-years). Table 3.6 describes the expected math level and knowledge to take science, engineering, and computer science courses required for these majors.

Table 3.6. Non-Introductory Science, Engineering, Computer Science Courses by Required Math Level and Knowledge (Shaded Levels Determine AUP Cohort eligibility)

Math Level	Math Concepts	Science Courses	Engineering Courses	Computer Science Courses
1	Math Foundations	---	---	---
2	Intro to Algebra	---	---	---
3	College Algebra	---	---	---
4	Pre-calculus	College Chemistry College Physics	---	Python
5	Calculus	Physics (Calc-based)	Engineering Design	Data Algorithms

Available demographics describe this population of 160 students as predominantly male (128 students or 80%). Roughly half of AUP cohort students (78 students or 49%) were from Montana High Schools. In Fall 2020 the first time, full-time student cohort from Montana High Schools entering MSU consisted of 3,101 students (31% of Montana High School graduates). From this population of 1,180 students, 297 (25%) declared a major in engineering or computing. Fall 2020, first time, full-time non-resident students enrolling at MSU totaled 1920 students, 501 (26%) declared a major in engineering or computing. Further details comparing resident and non-resident student members in the Fall 2020 cohort are shown in Table 3.7. These include identified UAP Program cohort members for Fall 2020. Of the 297 (37%) resident students, 78 (26%) were evaluated as ready for a Level 300 or lower math course. Fall 2020 non-resident students declaring an engineering or computing major totaled 501 (63%), with 82 (16%)

being evaluated as ready for a Level 300 or lower math course. The fewer number of incoming students from Montana High Schools and the higher percentage of this group at a Level 300 or lower math level shows a disproportionate number of AUP students come from communities within the state. Aside from their math readiness level, compared to their non-resident peers, fewer Montana High School graduates declared majors in engineering or computing other majors. Table 3.8 provides additional details on the final UAP Cohort members. This group reduced from 160 to 138 after AP/IB/Dual Credits were received and moved students into Math Level 400 and above.

Table 3.7. Fall 2020 First-time, Full-Time Student Cohort enrolling at MSU

	Resident	% of Cohort	Non-Resident	% of Cohort	Total Cohort	% in NACOE or UAP
Total Incoming	1180	38%	1920	62%	3100	
Other majors	883		1419		2302	
Declared Engineering or Computing Major	297	37%	501	63%	798	26%
Math Level 100-300	78	49%	82	51%	160	20%
Math Level 400+	219	34%	419	66%	638	80%
Percentage AUP		26%		16%		

Table 3.8. AUP Population and Available Demographics

<table>
<tr><th>Gender</th><th colspan="2">Female</th><th colspan="3">Male</th><th rowspan="2">Population by Math Level</th></tr>
<tr><th>Residency</th><th>O</th><th>I</th><th>O</th><th>I</th><th>U</th></tr>
<tr><td>Math Level 3</td><td>8</td><td>8</td><td>45</td><td>34</td><td>2</td><td>97</td></tr>
<tr><td>Math Level 2</td><td>2</td><td>5</td><td>14</td><td>19</td><td>0</td><td>40</td></tr>
<tr><td>Math Level 1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td></td><td>10</td><td>13</td><td>60</td><td>53</td><td>2</td><td rowspan="2">138</td></tr>
<tr><td></td><td colspan="2">23</td><td colspan="3">115</td></tr>
</table>

All AUP cohort members were invited to participate in a 7-week, organized program in the Fall 2020 semester and was referred to by the program's name in communication to students. Due to social distancing requirements implemented in response to the COVID-19 pandemic during the semester, participation was limited to two groups of no more than 20 students each. In addition, workshops were changed a virtual platform for all but 1 which was held in-person, at an outside venue. A plan to modify the participation limit was made depending on number of interested cohort members but did not need to be implemented.

Students who wished to participate registered for the program using Sign-up Genius. A consent form was provided to participating AUP students prior to and at the first meeting, which was in-person, for review. Opportunities to ask questions and/or opt out were provided prior to program implementation and throughout the project. Submission of a signed consent form confirmed participation in the study. The modified AUP program was the intervention and included compelled participation through workshop attendance. AUP cohort members who chose not to participate had access to their specialized academic advisor, NACOE ePALS, and NACOE clubs & organizations.

It is important to note the NACOE has multiple retention initiatives in place to support initiatives related to widening access to engineering and computing disciplines. It is the goal of the NACOE to strategically use resources focusing on retention to sustain their availability. Students opting out of the modified AUP program had access to specialized academic advising, peer mentors (ePALS), and participation in NACOE clubs and organizations.

Access to Participants and Confidentiality

As a problem of practice study, the college administration provided permission and access to participants. My role as the Student Success Coordinator presented several power dynamics that needed to be managed. First, this position includes an academic advising role with general engineering students ready for pre-calculus or calculus. Second, the AUP program management falls under my responsibility and admittedly I do have an interest in its success, but a greater purpose to create a program to meet student needs which will improve its outcomes. Finally, this position allows access to student data and contact information for the population. However, AUP cohort students have a different individual assigned as their academic advisor responsible for helping them with Freshman Orientation and academic advising.

To manage for any possible power differentials, invitations to participate were sent through email and an external process through Sign-up Genius was used for students to register to participate. The email (see Appendix B) was sent from my account which was determined to be better than coming from the NACOE Dean's Office. The belief was if students perceived the invitation came directly from the college Dean, they could perceive there was pressure for them to participate. Other steps were taken to manage expectations to participate. First, the invitation and consent form (see Appendix A and B) assured cohort members of continued support through the AUP retention program. Second, the workshops and the final feedback interview were detailed in a calendar-style document (see Appendix A) to explain the time commitment. Third, expectations to attend workshops were communicated clearly and how they would benefit their student experience. Finally, consent documents explained data would be gathered by recording workshops and an opportunity to provide feedback in a 1:1 interview. AUP students could choose to participate in the workshops but decline the interview. Participants were assured these recordings would be transcribed to produce the data for analysis and their identity would remain confidential. Finally, my role was presented as the Student Success Coordinator for the NACOE interested in learning how to best support all students in the college exploring a path to engineering or computing careers.

A $25 gift card was offered as thank you for participating in the workshops. This was given regardless of the number of workshops participants complete. An additional $25 gift card was offered to participants who also provided feedback in a 1:1 interview at the end of the program. Due to COVID-19 restrictions workshops were virtual, and participants were able to select either a video conference or face-to-face format for the 1:1 interview.

Participants

Eighteen AUP students from a variety of NACOE majors responded to the invitation to participate in the modified AUP program. Thirteen of the eighteen students who responded agreed to participate in the structured version of the AUP retention program, understanding the expectation to attend 6 workshops, and eight students agreed to provide feedback interviews. Table 3.9 provides available student demographics and notes who participated in the full modified program. Nine identified as female and nine as male. Six students were from communities in Montana and twelve were out-of-state residents. Eight students were registered for a Level 2 Math course and the remaining for a Level 3 Math course. Five students chose not to participate in a portion of the modified program but had access to the existing retention program for AUP students. Seven participants of the modified program completed the 6 workshops and feedback interviews. One student assigned the pseudonym “Christophe,” was not able to participate due to conflicting class meeting times. Christophe met frequently with his academic advisor for feedback on how to be successful. He was encouraged to access other existing resources to support success; which he did and believed that contributed to his academic success. Additionally, Christophe believed the experience helped him determine how to use college to meet his career goals and he wanted to be interviewed to share his experience. It was decided to include Christophe in the study.

Table 3.9. Program Participants, Interview Participants, and Available Demographics

Cohort Participant	Gender	O/I/U	Math Level	Major	Full Program Participant	Interview Participant
M5C	F	I	2	Construction Eng. Tech.	X	
M10S	F	I	2	Computer Science	X	
V7W	F	I	3	Computer Science	X	X
N15L	F	O	2	Environmental Engineering		
L6T	F	O	3	Biological Engineering	X	X
S8R	F	O	3	Computer Science		
M9L	F	O	3	Civil Engineering	X	X
O17O	F	O	3	Financial Engineering	X	
E18P	F	I	3	General Engineering	X	X
J11R	M	I	3	Computer Engineering	X	
J14O	M	I	3	General Engineering		X
J1M	M	O	2	Mechanical Engineering		
S2V	M	O	2	Civil Engineering	X	
B3C	M	O	2	Mechanical Engineering		
D4C	M	O	2	Mechanical Engineering	X	
D12D	M	O	2	Computer Engineering	X	X
J16R	M	O	3	General Engineering	X	X
M13J	M	O	3	General Engineering	X	X

Instrument, Data Collection, and Study Focus

Using guidance from Yeong et al. (2018) four steps were taken to develop an interview protocol. First, alignment between the protocol and research questions was considered (see Appendix C). Second, an inquiry-based approach was used in framing questions. Third, questions were developed collaboratively with another faculty member using their feedback and familiarity with engineering education and the study population. Finally, the interview protocol was tested with two students from a previous cohort year. Interview questions were developed with the four sources of self-efficacy, the modified program's four components and the goal of understanding the student experience (Åkerlind, 2005; Mamaril et al., 2016). Questions included in the protocol are as follows and include the program name. This name was created to communicate to cohort members the difference between this modified and the existing retention program which they already had access. Appendix C provides an alignment between these interview questions and the guiding research questions for this study.

Interview Protocol Questions

1. Share a little about your experience with related to the COE-X^2 (modified AUP Program)workshops and how you view your college classes.
2. How did the interactions with the ePALS help you learn about the NACOE?
3. Was the ePALS led pre-advising session helpful?
    a. How? What tools or tips did they provide?
4. Did you join a student group or club?
    a. What did this experience do for you?
5. Did the faculty led discussions influence your understanding of engineering or computer science?
6. Did the faculty led discussions give you feedback that was helpful with your academic classes?
7. How did you feel when you heard about your math placement?

8. How did you feel when you were told about the COE-X program (existing program) and your placement in the program due to math placement?

Three sources of data were collected during the delivery of the retention modified program. First topic-specific workshops were recorded. Second, semi-structured, one-on-one interviews were conducted with 7 program participants and 1 participant who chose to access similar resources as the other students in the study. These interviews followed the protocol detailed above, were recorded and transcribed. Finally, observations of the participants' behaviors were made by the researcher as an interactive member of the study. Transcribed interview data is most traditionally used in phenomenographic research (Åkerlind, 2005). This study focused on transcribed data gathered from 8 participant interviews.

Data Analysis

The analysis process was conducted in two parts. First, verbatim transcripts of one-on-one participant interviews were made from the recordings using NVivo transcription services (Åkerlind et al., 2005; Åkerlind, 2005). To protect participant identity, a letter-number code was assigned to each participant and a pseudonym generated for reference. Table 3.10 shows the interview participant's pseudonym being used in study findings chapter.

Following are brief introductions of study participants, beginning with female students. Mulan graduated from a Montana High School (MHS) and applied to MSU declaring Computer Science as her major. She knew this was a career of interest but was worried about meeting a 4-year graduation timeline. Ariel graduated from an Out-of-State

High School (OSHS) and applied to MSU declaring General Engineering as her major. She shared her academic and professional interests aligning with biological engineering. Elsa graduated from an OSHS and applied to MSU declaring Civil Engineering as her major. Even with a declared major, she shared an interest in exploring her options before settling on a major. Anna graduated from an MHS and applied to MSU declaring General Engineering as her major. She had explored engineering in high school but was not sure about the time commitment to pursue it in college. All female participants were assessed as having a math content readiness to be successful in College Algebra.

Male study participants were Christophe who graduated from an MHS and applied to MSU declaring General Engineering as his major. He was interested eventually going into business with his brother and a degree to help him meet this goal. Li graduated from an OSHS and was recruited to MSU as a member of an athletic team. He enjoyed writing but had also participated in robotics clubs in high school and declared Computer Engineering as his major. Flynn graduated from an OSHS and applied to MSU declaring General Engineering as his major. He was certain construction engineering would be his major but wanted to explore options before committing. Hans graduated from an OSHS and was recruited to MSU as a member of an athletic team. He declared General Engineering as his major to have time to explore major options but was certain something in the civil engineering area was the right major direction for him. Li was assessed at a Pre-College Algebra math readiness level and the remaining male participants were determined to be ready for College Algebra content.

Transcriptions were coded using methods informed by Saldaña (2021) and analysis processes by described by Åkerlind et al. (2005), Marton et al. (2005), and others. Identifying a set of qualitatively different categories is the goal of phenomenographic data analysis (Han et al., 2019). This is an iterative process focusing on a search for the collective meaning in participant responses and not meant to provide a description of an individual's experience (Barnard et al., 1999; Marton et al., 2005). Han et al. (2019), Sjöström et al. (2002), and Marton et al. (2005) and others provide descriptions of this process. A visual interpretation of the iterative cycle used for data analysis is shown in Figure 3.3. At its core are five components: familiarization, identification, sorting, contrasting & categorizing, and reliability checking. These are defined as follows.

1. Familiarization – Researcher reviews data to be familiar with the details of its content.
2. Identification – Identify data related to the phenomenon being studied.
3. Sorting – Identified data are sorted into patterns.
4. Contrasting and Categorizing – Patterns are pooled into concepts and contrasted leading to categories with descriptions.
5. Reliability Checking – Use of reliability checking methods by independent researchers with a portion of the data.

Table 3.10. Interview Participant Pseudonym for Study

Cohort Participant	Major	Interview Participant	Name for Study
V7W	Computer Science	X	Mulan
L6T	Biological Engineering	X	Ariel
M9L	Civil Engineering	X	Elsa
E18P	General Engineering	X	Anna
J14O	General Engineering	X	Christophe
D12D	Computer Engineering	X	Li
J16R	General Engineering	X	Flynn
M13J	General Engineering	X	Hans

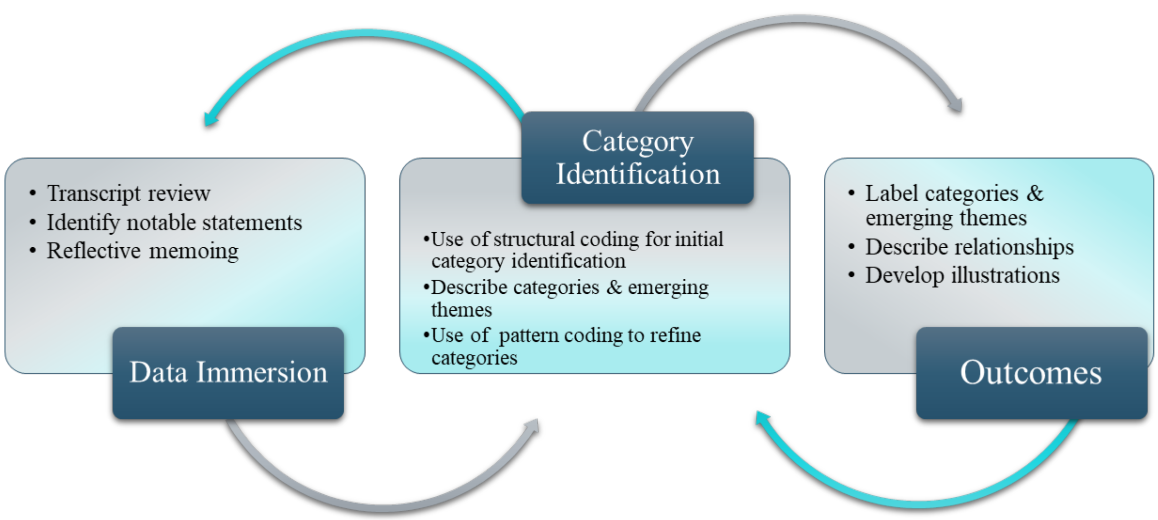


Figure 3.3. Visual Description of Iterative Cycle for Phenomenographic Analysis

After refamiliarizing myself with the data, a 1^{st} cycle coding method was selected with guidance from Saldaña's (2021) methods. Initially three elemental coding methods looked feasible: Structural Coding, Descriptive Coding, and In Vivo Coding. *Structural coding* allows data to be connected, or anchored, to a category (Saldaña, 2021). This study sought to understand student perception of their academic self-efficacy which has 4 categories and the threads emerging in these areas from their experiences related to pursuing an engineering or computing discipline. Also, structural coding works well with transcribed interview data. It was decided to focus mostly on interview transcripts versus field notes because of the research approach. Interviewer notes were used as a method of triangulation to increase trustworthiness of the data (Lord et al., 2017). These notes served as a reminder or method of clarifying meaning in the data but were not coded for this study.

Two other methods were considered. *Descriptive coding* provides a method of indexing topics or content (Saldaña, 2021). It is often used when analyzing field notes, journals, and other non-interview data. At first this seemed attractive; however, I moved away from this approach due to the primary use of transcribed interview data. *In Vivo* was also considered because of the focus on college students and its emphasis on finding meaning in the spoken word (Saldaña, 2021). The need to understand the student perspective in their language presented this approach as one to consider. Deeper consideration of this method included the study's purpose to understand the student experience in alignment with a theoretical framework. While this can be done with In Vivo, in the end it was decided to not use this approach.

The iterative analysis process included multiple cycles to deeply understand student experience and identify variation shifting from 1st cycle to 2nd cycle coding methods after the third iteration (Åkerlind et al., 2005; Åkerlind, 2005; Saldaña, 2021). The first iterative cycle aligned with the four sources of self-efficacy shown as themes in Table 3.11 with definitions to the right. These structural themes are: ME – mastery experience with content, VE – vicarious experience through peers, SP – social persuasion from faculty or staff, and PR – physiological to environmental influences. Additional themes emerged that did not fit into one of the sources of self-efficacy. These were coded with the theme “ET,” for emerging themes unique to this study. This first cycle was coded in NVivo, an electronic software package for qualitative research.

Table 3.11. First Iteration Cycle: Structural Themes

Structural Themes	Definitions
ME	Mastery Experience with content
VE	Vicarious Experience through peers
SP	Social Persuasion from faculty or staff
PR	Physiological Response to environmental influences
ET	Emerging Themes Unique to Study

Lack of familiarity with NVivo made its use awkward and difficult to manipulate without a significant amount of time spent learning how to use it. The decision was made to create an Excel spreadsheet for the second iteration cycle using Saldaña’s (2021) structural coding method to broaden out themes and categories. The top row of the spreadsheet held column titles: Structural Themes title, Descriptive Category Themes, and Descriptive Categories. Table 3.12 shows the results of this next layer of analysis resulting from this iteration cycle. Definitions are placed into columns underneath aligning with the theme or category. Careful consideration of the data along with placement into a more refined categories reflective of the content was part of this process.

Table 3.12. Second Iteration Cycle: Descriptive Categories

Structural Themes	Descriptive Category Themes	Descriptive Categories
ME	Potential Success	Perceptions related to academic self-efficacy Potential Success with Content
VE	Peer Interactions	Interactions or Feedback from or with peers
SP	Professional Interactions	Interactions or Feedback with or from Faculty/Staff
PR	Feelings related to experience	Feelings related to content Feelings related to interactions
ET	Unexpected findings	Pre-College Interactions COVID-19 Impact

During a third iteration cycle refined descriptive category themes and descriptive categories. These are described in Table 3.13 where the ET descriptive category themes were specifically named as pre-college interactions and COVID-19 impact with their defined categories. Additional descriptive categories were added to accurately represent the data. The results from this iteration cycle were printed and taped to a wall. This provided a physical way to view the data completely. Saldaña's methods include use of 2nd cycle coding. *Pattern coding* is a 2nd cycle coding method and pulls together the broad range of categories from 3 iterations using structural coding into more concise, salient units reflecting new major themes and categories within the data.

Table 3.13. Third Iteration Cycle: Defined Categories

Structured Themes	Descriptive Category Themes	Descriptive Categories
ME	Potential Success	Previous Experience with content Current experience with content
VE	Peer Interactions	Interactions or feedback from peers Interactions or feedback from peer mentors
SP	Professional Interactions	Interactions or feedback with or from advisors Interactions for feedback with or from faculty or staff Interactions or feedback with or from parents or siblings
PR	Feelings related to experience	Feelings related to content Feelings related to interactions
ET	Pre-College Interactions	Activities/Home life Peers Parents/Coaches/Adults
	COVID-19 Impact	Preparation for content Learning new content Program delivery perceptions

This study is the first to explore the student experience with a retention program in the NACOE focusing on AUP students. The goal is to provide an initial understanding of how AUP students perceive the development of their academic self-efficacy with engineering or computing content while participating in a retention program. Using pattern coding as a second cycle coding method enabled the researcher to summarize a large amount of material into themes which accurately described the range of complex experiences presented in the data. After careful study, researchers can often visually see patterns in the data and that was the case in this situation. Visually reflecting on the data over several days led to the realization that physiological states (negative and positive affect) threaded throughout the data and were influenced by relationships. Table 3.14 represents these themes and the categories emerging through the fourth iteration using pattern coding.

Table 3.14. Fourth Iteration Cycle Outcomes using 2nd Cycle Pattern Coding

<table>
<tr><th>Physiological Negative Affect</th><th>Developing Relationships with Academic Content</th><th>Physiological Positive Affect</th></tr>
<tr><td rowspan="3">Overwhelmed
Confused
Struggle
Challenge
Sense of being behind
Loss
Judged
Disappointed
Frustrated
Stress
Fear
Cry/Tears
Ignore</td><td>Mastery Experience
• Previous Experience
• Academic Readiness Level Response
• Current experiences learning academic content
• Confidence with academic content</td><td rowspan="3">Relief
Confidence
Reassurance
Reward
Achievement
Encouragement
Hope
Interest
Enjoyment
Excitement
Motivation
Persistence</td></tr>
<tr><td>Vicarious Experience
• Types of peer relationships
• Impact of COVID-19 Global Pandemic
• Influence of peer relationships with academic content</td></tr>
<tr><td>Social Persuasion
• Types of faculty or staff relationships
• Navigating New Environments
• Workshop influence
• Influence of feedback from faculty or staff with academic content</td></tr>
</table>

Chapter four includes a full description of themes and categories using interview excerpts to develop and explain the differences. The last portion of this chapter is directed toward articulating what steps were taken to ensure study validity and reliability.

Validity and Reliability or Dependability

Validity and reliability, or dependability, practices used in this study were primarily informed by seminal phenomenography researchers: Sandbergh (1997), Åkerlind (2005), Åkerlind et al. (2005), and Collier-Reed et al. (2009). Validity is the ability to demonstrate study outcomes reflect the phenomenon being studied (Åkerlind, 2005). Reliability as referenced in earlier work by Sandbergh (1997), Åkerlind et al. (2005), but in more recent work by Collier-Reed et al. (2009) has argued dependability is a more appropriate trustworthiness measure for phenomenographic research citing Lincoln et al. (1986). Essentially the end goal is consistency in data interpretation which supports research findings (Collier-Reed et al., 2009; Lincoln et al., 1986). At the heart of validity and either reliability or dependability is transparency and clarity. Walther et al. (2013) present a typology of quality validity and reliability strategies recognized by the engineering education research community. A selection from this typology is applicable to the data collection and analysis phases of this study. These include theoretical validation, procedural validation, communicative validation, pragmatic validation, and process reliability.

Theoretical validation focuses on the knowledge being produced in the study and its alignment throughout the research process (Walther et al., 2013). This is the most important validation method with additional strategies being a support to this initial approach (Walther et al., 2013). Using established processes in phenomenographic research I used purposeful sampling inviting participants of the AUP modified retention program to share their experience in a one-on-one interview. Data analysis used coding methods described by Saldaña's (2021) and analysis recommendations from the phenomenographic research community (Åkerlind et al., 2005; Collier-Reed et al., 2009; Cope, 2004).

Procedural validation. Identifying and using a procedure to be systematically followed is at the core of this validation approach (Walther et al., 2013). Through a process, validation strategies were identified and regularly used. These included analytical memoing, journaling, regular communication with trusted colleagues, and a phenomenographic research approach were all methods of managing bias and supporting study validity (Schwandt et al., 2007). For the data gathering phase, process validation was at the forefront through following a research protocol, acknowledging my own relationship with the topic, journaling, and actively listening to study participants were most used. During data analysis, analytical memoing, systematic analysis procedures including a constant comparative approach and coding methods were used to ensure constancy of process. Additionally, frequent discussions with peer researchers familiar with the population and literature managed the risk for misinterpreting participant meaning related to their experience.

Communicative validation as a validity method is commonly used and relies on research peers (Åkerlind et al., 2005; Walther et al., 2013). As with theoretical validation, this method occurs throughout the research process and relies upon consensus within the relevant community. For this study, faculty part of the college's diversity and inclusion initiative participated in the program design and study implementation. Data were gathered and analyzed by this researcher as part of the dissertation process. As a problem of practice study, this work will also inform the retention initiatives in the NACOE. Given this purpose, data analysis results were communicated to college and department administration and faculty in the NACOE college familiar with the AUP retention program and target student population. This happened in formal and informal peer review meetings, reviewing the data, describing what was found, and seeking consensus within the group.

Pragmatic validation. Student retention initiatives require sustainable funding, which is difficult to obtain. The nature of this Educational Doctorate is pragmatic. Its purpose is to provide useful knowledge that can be applied in practice. As part of a problem of practice study, results from this research will be used to inform the NACOE on best practices to support AUP students through the existing retention program. This work will contribute to additional research findings related to this population of students.

Process reliability. Aligning with advice from Åkerlind et al. (2005) to establish a clear, reliable process I completed all participant interviews before transcribing them. Then I transcribed all interviews using NVivo transcription support services. I listened to interview recordings and made corrections to errors in the transcripts. During data analysis I kept notes of interpretation in a format separate from notes of description.

Earlier in this chapter I articulated my stance, positionality, and reflexivity that could affect research decisions. These statements, in combination with selected validity and reliability practices, ensure the trustworthiness of results from this study (Collier-Reed et al., 2009; Lincoln et al., 1986; Walther et al., 2013).

This chapter presented the research methods guiding this problem of practice study aligning with the CPED framework. Using a phenomenographic approach of this qualitative study used a social constructionist paradigm grounded this project focusing on AUP students in the first year of their engineering or computer science degrees at a rural, land-grant university. Researcher stance, positionality, and reflexivity were defined, and strategies implemented to control bias and ensure validity and reliability of data were articulated. In addition to describing the population, participant sample, and intervention, this chapter also provided the process used to gather, clean, code, and analyze data. Visual representations were created for clarity. Following is a description of the findings identified through this process, including a realization their explanation would align more with the interconnection between the sources rather than as siloed components.

CHAPTER FOUR

FINDINGS

Introduction

This chapter presents the outcomes from this study, visually and descriptively presenting the qualitatively different ways Freshman students experienced a modified version of an AUP retention program. The overarching question and sub-questions guiding this study informed the study design and research protocol.

1: Among students who participated in the AUP modified program, what are their perceptions related to their academic self-efficacy development in engineering or computing subjects?

a. What are student perceptions related to their belief they can be successful with engineering and computing content? For example, do they have a history of success with basic concepts suggesting mastery experiences.

b. What are student perceptions related to their interactions with peer mentors in engineering or computing disciplines? Do they have peers who look like them who they can watch or listen to vicariously for clues on how to behave?

c. What are student perceptions related to weekly AUP group discussions with engineering or computing faculty to provide academic encouragement? What sources of persuasion provide feedback (verbal or written) influence student's efforts to continue with challenging content?

d. What are student perceptions related to how they have responded physiologically to academic content in engineering or computing subjects? For example, does a student feel sad, anxious, discouraged, determined or resourceful and/or respond emotionally (i.e.: fear, anger, or tears) if they do not understand a concept or earn a low test score or answer.

Originally it was anticipated the sources of self-efficacy would be demonstrated in the data as separate components: mastery experience, vicarious experience, social persuasion, and physiological states. Through the data analysis process, however, it became evident that physiological states were not its own category. Instead, it was more reflective of what is found in sentiment analysis work by Liu et al. (2012), Zhang et al. (2018), and Pozzi et al. (2014). Sentiment analysis, also known as opinion mining, is "the computational study of people's opinions, appraisals, attitudes, and emotions toward entities, individuals, issues, events, topics and their attributes" (Liu et al., 2012, p. 415). In the business world the product of the synthesis of these states informs practices related to consumer products and services. The data showed a similar result with student perception of their academic self-efficacy presenting an image in which physiological states mesh throughout mastery, vicarious, and social persuasion experiences leading to a relationship with the academic content being studied. Rather than a distinct category, the analysis suggested physiological responses were the membrane through which relationships with STEM topics were developed through experiences with academic engagement, peers, faculty, and staff. In combination they manifested in students' developing relationship of academic self-efficacy with engineering or computing content.

This chapter will first provide a visual picture of the outcome, academic self-efficacy, as originally anticipated. Next a visual reconstruction of how physiological states became a connective membrane through which mastery, vicarious and social persuasion experiences where processed. Finally, the themes, sub-themes, and categories will be defined and described using excerpts from participant interviews telling the student experience story related to their developing academic self-efficacy.

Visual Description of Outcome Space

Bandura (1997c) presents the sources of self-efficacy as individual influences working together in developing a person's ability to develop confidence, represented visually in Figure 4.1. This is not surprising because constructs of a theory need to be clearly defined to be studied. Measuring sources of self-efficacy in student academic development in STEM disciplines are found in work by Loo et al. (2013), Usher et al. (2008a), and Mamaril et al. (2016). Their work quantitatively describes the amount of influence self-efficacy sources have in student confidence in their ability to be successful with challenging STEM content (Loo et al., 2013; Mamaril et al., 2016; Usher et al., 2008). Qualitatively, this study presents findings supporting a shift in this idea to one that is more fluid as visually demonstrated in Figure 4.2. Where physiological states shift from being a source contained in a silo, to one that sits in the space between environmental experiences, continually shading engagement.

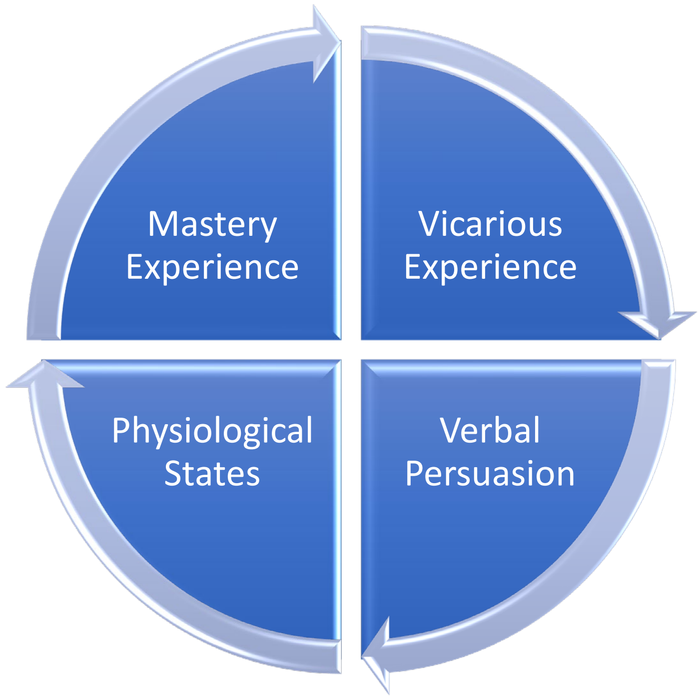


Figure 4.1. Visual image of Self-Efficacy Sources Pre-Study

Figure 4.2. Visual image of Self-Efficacy Sources Post-Study

Hutchison et al. (2006) noted the ability of physiological states to influence across all self-efficacy sources. Usher et al. (2006, 2008b, 2009) also show similar findings. In quantitative studies, such as in Loo et al. (2013) and Lin (2016), it is difficult to separate and quantitatively measure the power of physiological states. The nature of feelings to blend into other self-efficacy sources effectively shading the outcomes in an individual's experience with a phenomenon and their response to it (Lin, 2016; Loo et al., 2013; Mamaril et al., 2016; Usher et al., 2009). The qualitative findings from this study visually add to this work by describing how AUP Freshman in engineering or computing majors explain their experience with a retention program and its influence on their academic self-efficacy development. The four parts of the research question informed the themes describing the student experience with the AUP modified program.

Themes, Sub-themes, and Categories

The purpose of retention programming in the NACOE is to build academic confidence with STEM content and increase the population of students willing to engage repeatedly with challenging coursework. Eight study participants provided rich, descriptive data showing the fluid nature of physiological states on the other sources of self-efficacy. Illustrated in Table 4.1 are the themes and subthemes of academic self-efficacy emerging from the data as they align with Bandura's (1997b) sources. The influence of physiological affect is represented by color to demonstrate how emotions contribute to student response toward an experience. Just as colors blend creating new hues, affect—represented by emotions—influences student perception of engagement with mastery, vicarious, and social persuasion experiences in an academic environment.

Three main themes emerging in the data were *developing relationships with academic content*, *physiological negative affect*, and *physiological positive affect*. Sub-themes presented under relationships of trust as follows: *mastery experience*, *vicarious experience with developing experts*, and *social persuasion from current experts*. Additional categories presented under the sub-themes as noted in Table 4.1. Initially, Bronfenbrenner's bioecological theory (1995b, 1995a, 1999) informed situating Bandura's self-efficacy sources (1997c) under the heading *developing relationships with academic content.* Reflecting on student success research confirmed this heading as appropriate. Highlighting just a few seminal researchers informing this decision, Laurie Schreiner (2012) focuses on new college students trying to find their footing in a new environment; Alexander Astin (1999) and George Kuh (2007) highlight the importance of engagement; and Vincent Tinto (2017) reminds practitioners to consider the student perspective when developing programs. Their extensive body of literature in combination with many more contributors include topics related to the value of relationships confirming this decision as appropriate.

Physiological states presented themselves throughout participant responses, shading the influence of mastery experiences, vicarious experiences, and social persuasion. The thick-rich descriptions provided in the data presents how participants processed their experiences and engaged with their academic environment. Threaded throughout the remainder of this chapter is the student response to research question 1 and its sub-questions.

Table 4.1. Themes, Sub-themes, and Categories of Academic Self-Efficacy Influences

Physiological Negative Affect	**Developing Relationships with Academic Content**	**Physiological Positive Affect**
Overwhelmed Confused Struggle Challenge Sense of being behind Loss Judged Disappointed Frustrated Stress Fear Cry/Tears Ignore	Mastery Experience • Previous Experience • Academic Readiness Level Response • Current experiences learning academic content • Relationship with academic content Vicarious Experience with Developing Experts • Impact of COVID-19 Global Pandemic • Types of peer relationships • Peer influence on developing academic content relationship Social Persuasion from Current Experts • Navigating New Environments • Types of faculty or staff relationships • Workshop topic influence • Faculty/Staff influence on developing academic content relationships	Relief Confidence Reassurance Reward Achievement Encouragement Hope Interest Enjoyment Excitement Motivation Persistence

<u>Mastery Experience</u>

Mastery experiences are personal and they build on previous experience (Bandura, 1997b). Research question 1a sought to understand student perceptions related to their belief they could be successful with engineering and computing content.

1a: What are student perceptions related to their belief they can be successful with engineering and computing content?

Participants drew upon previous experience with high school courses, involvement with sports, and general college readiness in addition to math readiness and current coursework. All these combined to describe their developing relationship with engineering or computing content.

Previous Experience

A few participants spoke of their experiences in high school that shaped their college experience and served as a foundation from which their relationship with STEM academic content would be added. In most cases, college preparation for STEM disciplines focused on math and science content, as shared by Ariel, Mulan, and Flynn. Mulan and Flynn noted the levels of these courses available to them were influenced by school counselors or staff who supported their academic goals related to college. However, students were surprised to learn their AP, IB and Dual Enrollment college courses did not guarantee demonstrated readiness for pre-calculus or higher.

> Ariel: And then I took pre-calc and then I took Calc and then I took AP.
>
> Mulan: So I was a full IB student, so I had to take Math Studies and I couldn't take precalc because I had to balance a higher level with standard level.
>
> Flynn: My senior year, I was in a math class. I was in precalc, the class, but didn't want [to]mess up my GPA because she [my school counselor] wanted it dropped to a lower math.

Ariel noted access to Advanced Placement (AP) program math courses which her high school used to support students interested in earning college level credits. Mulan's high school used International Baccalaureate (IB), a similar program to AP. Prominent in this experience was the limitations in what she could take due to requirements her high school used for students interested in STEM coursework. In Flynn's case, he was in a pre-calc course, but his counselor moved him into a lower math course to preserve his high school GPA. For both Mulan and Flynn, they understood the reasoning even if they did not necessarily believe it was the right thing for their situation. In another experience, high school was one of the influences shaping their perception of writing as a hobby versus a career to aspire toward as explained by Li who was exploring careers in engineering and computing. He perceived these were better options for employment. “You know, I've always loved writing it's…. but I've always thought of this as somethin' like a hobby or something.”

In addition to AP and IB programs, some high schools have options for learning about engineering or computing. Anna was one participant whose high school offered these topics. From this experience, she recognized engineering from a less mathematically framed perspective, one of definitions and types of hands-on projects.

> So, I think when I was in engineering in high school, it was a lot different just because, we didn't really focus on that [math content]. It was more like big hands on projects, learning definitions, and stuff, it's a lot different than like real life kind of stuff...

Prominent in high school experiences were extracurricular experiences which contributed to student development. Three of the participants were prominent on their sports teams, serving in leadership and key player positions. While these experiences did not have an academic performance outcome, they helped students develop confidence in navigating challenging experiences. Anna noted her experiences playing sports as key to her level of confidence.

> Growing up I've always played sports. I know that being part of a team has always been a big part of my life. That's what kind of helped me build my confidence…

Another participant who had been heavily involved in sports but did not know a lot about engineering reported not being concerned about this fact. Hans was confident that if he stayed on track, he would figure it out by taking the classes for the major.

> I don't necessarily know too much about all the different types of engineering, but if, like if I stay on the same track I'm on, I'll eventually figure out, like, why I really want to do civil engineering and where it's...like why it's important to me that I'm taking that class [ECIV 101].

These experiences all contributed to the transition from high school to college. This is the moment when students learn how their preparation for college in high school translates to placement in key courses for their major – specifically math placement. Confidence in their academic ability, frustration with the limitations placed by high school programs or counselors, and recognition college is new and unknown territory were among the range of experiences shared by participants. Processing these experiences informed students' developing relationship with engineering and computing academic content.

<u>Response to Academic Readiness</u>

The NACOE is a unique college in that there is a single application to all programs which happens in conjunction with the admissions process to MSU. There is pressure to complete an academic degree in 4-years. To demonstrate an engineering or computing degree can be completed in this timeframe, programs are planned with Calculus 1 and Physics with Calculus as Year 1, Semester 1 courses along with high credit loads (16-18 credits). Students who come having completed AP or IB coursework high school, or are not ready for Calculus 1, experienced a range of emotion when they learned about their math placement levels. Ariel was very worried about how her parents would respond.

> So, when I heard that I was eligible for Algebra two, I was like, uh-oh, my parents are going to kill me.

Christophe felt judged which inspired him to question the accuracy of math placement. The outcome was a failed attempt, but eventually resulted in relief and understanding as will be seen later in this chapter.

> Christophe: It felt downgrading (math placement) a little bit.
>
> Jen: You did try to challenge the math placement
>
> Christophe: Oh, I failed that big time.

For an AUP student to pursue an engineering or computing discipline, the potential for a longer time to degree completion increases. As an out-of-state student, Elsa was surprised and worried her math ability placed her much lower than she anticipated, leaving her with a feeling she would be too far behind.

> When I first got my classes and they said I had to be in a lower math class, I was like: Oh, no! I'm going to have to take all these classes to get caught up and stuff.

In addition to Christophe's response, this is another example of the fluid nature of self-efficacy sources and the role physiological responses as the membrane filtering the experience. Elsa, Ariel and Christophe were all surprised by their math placement level, an emotion that was quickly followed by either worry about how to tell their parents or what this meant for their academic timeline. For Christophe, surprise was followed by a feeling of being judged and then disbelief in the accuracy of the placement test. In these cases, students are using multiple factors, such as shock, worry, shame, or discouragement, at once as they develop their relationship with engineering and computing content.

Not every participant was surprised by their math placement. When asked specifically, Hans, Li, Anna, and Flynn all commented minimally on the effect math placement had on their college transition based on their awareness of content they completed in high school. Anna communicated this most clearly:

> But coming into college, I knew that I would probably have to take college algebra again just so I can kind of like get back into it, kind of thing. 'Cause especially taking math online my whole second semester, I know I wasn't really into it as much as I should have been. So, I kind of knew coming into here that I would be like kind of a little bit below.

Students declaring a major in engineering or computer science do so recognizing a STEM directed curriculum and academic challenge. In addition to anticipating math level, the range in perspectives included concern about how to communicate this with parents, feelings of unwarranted judgement, and managing how the information informs their progress toward degree completion.

Current Experiences Learning Academic Content

Either despite or because of their foundational influences, college seemed to be a place to try new and hard things. Speaking of developmentally instigative characteristics, Bronfenbrenner (1993) describes the impact of a student's decision to engage, or not, with the environment. Like their AUP peers in the NACOE, by declaring a major in engineering or computer science, study participants responded to the college's invitation to consider a career in these disciplines. Li's purpose for participating in the AUP program was to find many ways to explore majors while working on developing math content. But he was also exploring majors outside of engineering and computing at the same time.

> Ummmm, to be completely honest, I think that this [to participate in the AUP program] was necessary just to figure out my path. I think that this [major change], I would probably came to this point, you know, I would'a gotten me to this point just to see what I, what I like to do.

Flynn shared the perception of the first semester taking a College Algebra class was a "refresher" mostly although some topics were challenging and required support from either a tutor or connecting with peers in the class. Despite the feeling of learning known content again, Flynn noted the value in correcting concepts not clearly understood.

> Sometimes it was like some of the initial lessons were super easy and I saw that other people were like struggling then. Yeah, but there's been stuff in there that I've had to get a tutor fixing stuff I've struggled with. So, so, I'm not being terrible. That's a good refresher, I guess.

Sharing a different perspective, Mulan, was relieved to be in a math class where she could review concepts she had missed in high school and gain a better foundation. Mulan considered what might have happened if she had been allowed to register for a higher level math. She was grateful for having avoided feeling overwhelmed by being in a math class she was unprepared which would have resulted in failure. The relevance of this synthesis between physiological affect and mastery experience is presented later in this chapter when Mulan describes her relationship with computer science content.

> I'm in College Algebra and I'm really glad that I took it because it's like if I hadn't taken it, I would have felt overwhelmed taking Precalc. So even though I'm kind of reviewing, it's still like a really good foundation I should have or else I'm just going to, like, burn and tumble in the future.

Anna seemed more interested in getting a good start with college behaviors. Recognizing some subjects needed more effort than others to earn grades she felt comfortable with as a reflection of her ability.

> I've never been like, a real, like really strong enough. I've never gotten necessarily bad grades But, when I had to apply myself to a lot more than any other class, like my other classes, I can breathe, get A's just fine.

Knowing the online nature of her high school experience would impact her college transition, Anna was less concerned about being in a certain math or engineering class, choosing instead to access out-of-class information on navigating college and exploring major*s*.

> So, I didn't really take classes that pertain to a certain field in engineering. I didn't take architecture for civil or stuff like that.

> But I did think that after going into and listening to some of the videos [during orientation] and joining those, that would actually help me in general with just like getting started with college.

Current experiences with academic content had a more general application as well, specifically the changes happening to students in their first year relating to college student development (Mayhew et al., 2016b; Pascarella et al., 2005a). Anna's concern about the transition to college and maintaining strong grades influenced her course selection avoiding what she perceived as harder classes. Mulan's experience influenced the relationship she was developing with STEM content and her ability to learn the material. Flynn described resources in his environment he was accessing to learn material he was struggling to understand. Li saw college as an opportunity to find out about himself and where his interests were readily directed. These experiences describe the leaps students make into adult life, college life, and their academic discipline. These changes happen fast, as if they have approached the widest spot on a river at full-speed with the intention of leaping across and landing gracefully on the other side, prepared to keep going. The range in student experiences indicated that assessing trajectory, force and power needed to make a successful jump is complicated and does not always end with persistence in a STEM discipline.

Participant Relationships with Academic Content

Working together, personal events and confidence in one's ability to successfully engage with challenging material support developing mastery and laying a foundational relationship with academic content (Bandura, 1997b; Bronfenbrenner, 1993, 1995b, 1995a, 1999). Findings from this study demonstrated that previous experience is an important influence for AUP students' transition to college and into a STEM discipline. It is more common for students to come without having participated in high school classes in engineering or computing. Physiological responses informed how participants interpreted their academic readiness for the content they were interested in learning (Bandura, 1997c). Negative and positive affective states shaded the outcomes of mastery experiences related to content. Coming into college, Anna had the most previous experience with engineering content and was quite concerned about the level of difficulty and the amount of time it would take from her schedule.

> I was definitely nervous for engineering just because I thought that it was going to be something that was going to be super difficult. Like, it was...that's all my time was going to be spent doing that.

She wanted to experience more during college beyond engaging with challenging content. Even though Anna was confident in her ability to learn difficult concepts, she was not sure of her interest and motivation. This led to uncertainty in a potential major for Anna, but she was confident in her ability to learn difficult content if interest and motivation were present.

> If it’s something that I'm passionate about, no matter how hard it is, I know that I'll keep going in that with sports or with school or with relationships, friendships, family, all that kind of stuff.

Most students begin college not quite sure what learning engineering or computer science looks like beyond math and science. The fast pace of exploring colleges, degrees, and career paths can be overwhelming and lead to quick decisions. On a college exploration trip, Li declared a general engineering path because he had enjoyed participating in robotics clubs after school and thinking his love of writing was not an academic path to pursue.

> Just seeing all the things I can do with writing. Like, looking, taking this semester to look instead of just picking something in a hurry again.

Repeated struggle with math content led Li to the realization that he did not like math. It could be fun, but it was a subject he really needed to work on. His interest in the subject did not match the effort it took him to be successful with the challenging material.

> I'm not really; I don't like math. Like, not that much. To be blunt...yeah, I don't like math at all, really.
>
> It’s not hard, but once you gotta…you gotta get into it. It’s hard, but fun at the same time.
>
> Math problems with words, that’s one thing that I’m experiencing now where it’s kickin’ my butt.

Li’s realization he was not that interested in math content provided important data related to students’ degree exploration. In Li’s case, it helped him learn about himself, his interests, and what he was willing to do. His confidence in the decision to move out of a STEM major was made as much based on his commitment as ability to engage repeatedly with challenging content. The purpose of the AUP retention program is to provide experiences for students to learn about engineering and computer science earlier in their academic foundation to support a decision made by design with the accurate information.

> It [interest] just kind of changed based on, like kind of on school and stuff, a little bit. What I was willing to tough out and do, what…you kind of find out about yourself a little bit. Like the math I would have to get up to, I was like, I know it in myself if I went…you know, I wouldn't want to put in that time.

Mulan had a different experience with managing challenging material. In high school, Mulan selected computer science as a major and began preparing by taking International Baccalaureate (IB) courses. Although she was surprised by her math placement, it was when Mulan struggled with her computer science content that she responded emotionally.

> So about halfway through the semester, with my computer science class, I was starting to get super, super stuck to the point that I was like crying over my homework.

Mulan experienced multiple physiological responses related to her computer science homework. In combination with a lower math placement adding more time to degree completion frustration with the content emerged.

> I was really, really overwhelmed with my computer science class this semester, so I'm thinking...cuz I still enjoyed it when I understood it, but it was the not understanding it that really got me super frustrated.

The product of the experience was a realignment of focus, almost as if Mulan were stepping back for a moment to breathe and collect her thoughts related to her academic direction. Mulan decided it was more important to focus on becoming a good student and *then* choosing an academic direction.

> But for now, I'm just going to like settle down in a good academic routine because I only just have that established and going into something that was super hard for me was just like, "What do I do now?"

Although computer science was still a consideration, it had shifted from its position as her major to possibly a minor.

> So, I'm hoping maybe to incorporate it as a minor or financial or economic engineering in the future.

The data presented effort, interest, time, and academic challenge as factors contributing to their developing relationship with academic content related to engineering and computer science. Physiological states including thoughts, emotion, and motivation informed how participants processed mastery experiences with academic content.

This section described student perception related to their belief they can be successful with engineering or computing content. Mastery experiences with academic material and physiological response merged to inform their developing relationship with academic content. First, data demonstrated how pre-college experiences influenced student confidence. Next, student response to how their preparation translated to an evaluation of college readiness by their chosen college was described. Finally, the result of courageously leaping into a STEM discipline described where students landed with their relationship to engineering or computing content. This included discipline-specific content as well as foundational content such as a math course. Engagement range of experiences in this category included three aspects related to student perception of their mastery experience and personal confidence with engineering or computing content.

Vicarious Experience with Developing Experts

Bandura (1997c) describes vicarious experience as interactions with experts who share similar attributes with the person such as age, year in school, and major. Within Bronfenbrenner's (1993, 1995b, 1995a, 1999) framework, vicarious experiences occur between microsystems in academic environments (mesosystems) the student moves through, such as classrooms, residence halls, and student activities. Microsystems in these settings would be developing experts, either same aged or slightly older peers who are also students. Visual and verbal cues are an important aspect of learning to navigate a new environment (Bandura, 1997c; Schreiner, 2012). Research question 1b sought to understand how these experiences related to students developing academic self-efficacy related to engineering or computer science content.

> 1b: What are student perceptions related to their interactions with peer mentors in engineering or computing disciplines?

Working within boundaries presented by the COVID-19 pandemic, participants looked for every opportunity to connect with their peers. They found value in connecting with same-age peers who shared similar interests and math start levels, as well as more experienced peers who could provide encouragement and direction. These connections helped students process confusion, uncertainty and perspectives related to academic content and manage their physiological responses to their experiences.

Peer Influences Through COVID-19 Pandemic

Interaction with peers is a primary interest of students transitioning to college (Oliveri et al., 2018). In Spring of 2020 a global pandemic closed borders, parks, schools, and all but essential businesses (Centers for Disease Control and Prevention, 2020). Hospitals were overrun with people needing critical care and shelter-in-place orders were issued. For colleges and schools, learning shifted to almost 100% virtual platforms which continued through the 2020-2021 academic year (Walke et al., 2020). Anna spoke overall about the unique college experience the 2020 Freshman class was having due to the pandemic.

> I think we're all living a different experience than other college Freshman years' experience.

The sense of loss her comment expresses provides a glimpse into student perceptions relating to limitations in their Freshman year of college. Normally vibrant and highly social, Orientation and Welcome events looked very different or did not happen at all in 2020. These events are where peer networking typically begins, with common experiences, social cues, and tips for success from more seasoned students being shared. Bandura (1997c) noted the value of these experiences particularly among peers who share similar characteristics and interests. Shifting to a primarily online format was noted as a challenge with this program because of the loss in opportunity to connect with people. Although participants were respectful, they reported their purpose in joining the study-version of NACOE's AUP retention program was to meet new people, not professors and teachers. Meeting a few of his peers through the program meant a lot to Hans who wanted to meet people who understood how he was coming to this experience.

> Hans: Just meeting a few, not necessarily just teachers, but just different people who kinda understand…

Elsa commented the online format reduced the amount of time available to engage with peer mentors. She recognized the format as creating missed opportunities for engagement with people who could provide helpful advice. Mulan echoed this critique expressing frustration with the amount of screen time without opportunity to engage.

> Elsa: Since it was mostly online, I feel like we didn't get to interact with them [peer mentors] as much as I would have liked to.
>
> Mulan: It might have been a little helpful to have more time to talk with other people who were in the group, because I felt like a lot of the time they were listening.

Anna articulated she had wanted to find out more about challenges with academic content from her peers. For her it was a way of seeking not only social cues but also if her peers believed the struggle to learn the academic content was worth it.

> Maybe just talk a little bit more on, like, the struggle kind of side of the classes. Because if you can hear that and still have a passion for it, then that kind of means like, do you want to keep pushing?

Ariel was looking for clubs to join and meet new people. The single, face-to-face meeting opened an opportunity to make connections where her classroom experiences had not. She liked the engagement aspect of the class when they made their open paper airplane and then had a competition. The shared experience with her peers included the engagement she had come to college to find and opportunities for connecting with people of similar, academic level and interest.

> It just was a really nice way to kind of get involved, just because with COVID it's been really hard to make connections in my classes. Where, like we actually do things with other people class-wise. So, it was cool to have that experience and see, like, that people still recognize each other after that experience. And, like, it would be good if COE-X continues to be like a club or a class.

Although it would not have made a difference regarding his academic direction, Li also noted the limitations COVID-19 restrictions placed on his ability to connect with peers trying to determine an academic direction. While Li realized math was not his favorite subject, writing about engineering would be interesting and align with his natural talents. He began considering majors in writing disciplines during the program, wanted more connections with peers his age which he saw complementary to his academic direction.

> Li: So, ummm, I think, I may have made more connections if it was like being in like, regular, without COVID, being in person. But I think I probably would probably would still at the same point in my journey right now.

Flynn and Hans were also looking for ways to connect with their peers and were disappointed that most of the modified retention program was delivered in an online format due to COVID-19 restrictions. Flynn commented on the difficulty of committing to one more hour of lecture-style, screen time. Hans noted he understood there was a reason for the program delivery style but was more interested in peer connections than just with teachers.

> Flynn: Face-to-face I think would have made a big difference. It's hard to feel like a full perspective of it, you know, sitting in front of a screen for an hour after I've already been sitting for four hours that day. It's like, you know, I could be doing so well, you know, like if it was a hands-on thing or actually getting to do something.

> Hans: Yea, I mean, but I understand this whole COVID thing right now and that makes it [WebEx] the best way to meet if not face-to-face.

Students recognized the loss these engagement opportunities had on their ability to make friends and share their learning experiences with each other. Bandura (1997c) points out cues can be visual and organic to the situation; in addition to verbal description providing coaching or review of experiences. The frustration with social distancing and loss of classroom-based experiences was voiced by all participants. They struggled with being frustrated and finding ways to be successful. The pandemic reduced the opportunities for students to robustly engage with their peers. Although participants did not come right out and say their frustrations were because they were missing out on important vicarious experience moments related to content, they knew they were missing out on something that could help them.

Relationships with Other Developing Experts

Taking advantage of a unique way to interact with their peers during a pandemic was a motivator for study participation. Interactions with developing experts in their academic community included those with same-age peers within their living or classroom environments, informal peer mentors engaged in similar extra-curricular activities, and program peer mentors. Anna compared her peers, particularly older peers as having a different influence than her coaches or teachers, one that helped her learn to have fun while working hard toward a common goal.

> I've always looked up to the older players (on HS soccer team) and on the people (on the soccer team) who can have fun with those on the field, but they can also make us succeed in the season.

Bandura (1997c) explains in addition to similar attributes, individuals look for behaviors and performance models that will assist their progression through challenging personal experiences. The program included one face-to-face meeting hosted in an outside environment to establish community outside the mostly virtual delivery. Ariel commented on the value of the experience and how significant it was to connect with developing experts and build her peer network.

> It was also nice to happen in person, too, just because I don't think a lot of the people there, like, including myself, had had too many in-person events this semester.
>
> So, like, it was cool to have that experience and see that people still recognize each other after that experience.

Elsa noted the value a course with other AUP students would have on connecting with others in a similar academic situation and shared interest in content. Finding friends was important to Elsa, particularly if it was with people in a similar experience and circumstance related to academic goals.

> I could, like, connect with them and be, like, OK. Then maybe I could possibly become friends with them. I could meet new people, and it is always nice meeting new people that are going through the same thing as you. So you are not alone.

It was comforting for her to know others were sharing a similar experience academically. Adding to Ariel and Elsa's perspectives, Hans found others pursuing the same academic program which strengthened his academic community with peers AND professors.

> I think you need a few different people around the school who're doing the same engineering…taking the same engineering path. And just meeting a few, not necessarily just teachers, but just different people who kinda understand.

Sharing a different perspective, Flynn was hesitant about the invitation to modified AUP program. He checked with a classmate and learned the invitation was unique to his academic circumstances.

> As soon as I saw I asked my friend Jack because he's in that same general engineering class as I was. I was like: "Hey, Jack, did you get this email

> about going to this meeting? I don’t know what it is.” and he's like, “No, I didn't get it.” and so it's almost like, “Oh, my God, it's a class.”

These experiences show the efforts participants were making to establish a new community within their new academic home. Diverse relationships were important to this group, particularly those allowing them to engage outside their living arrangements. This was observed during an interview with Ariel. She expressed frustration with her roommate and challenges related to living in the dorms during the interview when she paused the conversation to move out into the hallway with her computer. Ariel very briefly apologized for the interruption explaining her roommate had just begun a phone call or teleconference and was talking loudly. This made it difficult for her to hear and think about how to respond so she needed to move to quieter space

As demonstrated by Flynn, students check with their peers to validate opportunities and authenticate their experiences. The number of engagements with developing experts either with their same-aged peers, or those with a bit more experience was valuable and sought out. Proximity to these connections was most helpful with participants were able to as for advice or support related to their specific circumstance. Hans and Li, both student athletes on scholarship, shared how valuable the intimate experiences with their teammates were in relation to their academic journeys. Hans was looking for a road map to guide him through the civil engineering curriculum from his math start level. He found it organically in a valuable exchange of support with a fellow teammate who shared similar aspirations and was a little further ahead in the major.

> Actually, I was just cutting his hair last...couple of days ago. And I was just kind of going over like, like what he did, like what steps...path he took...taking like different classes and stuff like that. He was sayin’, tellin',

> me about how his civil engineering class...what he did in that class...and how he went to his different calculus...I don't know if he's pre-calc right now. And then different classes he took.

As a student athlete, the combined demands of scheduling, eligibility, and academic interests may create conflict and influence decisions. Hans explains not just any peer-to-peer engagement will work because of this reality making relationships with teammates just as important as peers not committed to a college sport.

> I think it can give me some good positive reinforcement. Cuz, if I know, like somebody, especially on the football team is doing the same thing I want to do. And knowing that if he can do it, I could do it – because scheduling and all the other stuff.

Seeking different support in a similar situation, Li asked other teammates to share their stories and strategies for matching their skills, interests, and academic pursuits.

> I just talk to them [team members] in the locker room and just talk to them about what their degree is, what they do, or how they find their classes, and some of them said they went University Studies [an academic advising office] and found out and some of them went straight from freshman year into something.
>
> Yeah, but right now I want to go University Studies a little bit to see.

These interactions paint a robust picture of the proximity peer relationships have on developing confidence with *any* curriculum. Both conversations were about learning how to navigate sports logistics just as much as academic content. Hans and Li talked about time and making decisions or getting advice on how to earn an engineering degree while being a college athlete. All participants experienced the pressure of time constraints, either as student athletes or meeting a 4-year time commitment to degree completion and this informed the connections they made. For Mulan, this meant she was looking to connect with peers who were serious students who could help her study. She appreciated finding academically focused people to support her academic goals.

> So that's really nice. Really nice to find people who are academically focused because I feel like it's kind of hit or miss with the people I meet with. Some of them are really going to college for some social aspects, you know. So, it's really nice to meet people who are academically focused.

College students navigate a variety of university environments (mesosystems) which contain peers, professors, classes, and expected behaviors (microsystems). The student is the connector between these environments. For example, Hans and Li were part of an athletic team, lived in campus housing, attended 4 to 5 classes, and were part of this study. They engaged in three of those areas together but others independent of each other. Mulan had another set of engagement system, but the program for this study was where she connected with Hans and Li. Moving fluidly through these spaces, Hans, Li and Mulan developed relationships with their peers in ways that supported their desired role as a college student but was unique how they processed the experiences. As proposed by Bronfenbrenner (1993, 1995b, 1995a, 1999), these dynamic perspectives operationalize how the individual interacts with microsystems moving fluidly through the mesosystems. Sometimes there is overlap between mesosystems, as with Hans and Li, but not always.

Broadening out on Hans' description of a peer mentor in his discipline *and* on the same college sport team, other participants were looking for similar organic relationships. Anna spent a lot of time with friends she had made in college who were pursuing other engineering disciplines. She wanted to hear about their experiences and include that information as part of the equation related to major selection.

> I know I spend a lot with my friends hearing what different engineering. So, I'm able to hear what they do in class and what they like and what they are doing.

In addition, to participating in the AUP modified pilot, Anna also attended Women in Engineering events with fellow classmates as a way of broadening her network. She looked for every opportunity to meet new people in an out of classes.

> Then we go to different things like the Women in Engineering. We did that last month and so that was nice to actually be able to go see.

> I went with a couple people that I knew from classes and stuff. I just have two girls in my engineering class. So, like, I would kind of know a couple of them, but honestly, I kind of liked it because then I got to see all these new faces I didn't really know that are also part of the program [WIE] and are each doing a different field.

The common, physiological responses threading through these authentic engagements were the comfort of feeling people they could trust, who understood their experience, validated the challenges being experienced and were sharing what worked for them.

Several participants shared how connections through the program and their classes established a peer network influencing their academic success with STEM related content. Mulan found friends studying similar content through attending the AUP program workshops and created a study group focusing on computer science coursework leading to success with this challenging material. The value she found in engaging with classmates exchanging perspectives related to computing concepts increased her confidence in learning the content and passing the class.

> I met some friends through it (the program), like Christophe and Hans. We have been working on our computer science homework, like every week, you know, and I would not have been able to pass the class without them.

Similarly, Flynn spoke about establishing these networks in a seminar-style class and his math class. When his classmates were not able to help, he found a tutor to help with the content. He found comfort in realizing classmates were struggling with the content and that reviewing the math concepts would lead to a firmer foundation.

> So for my CLS class, my friend Jack is in there. We definitely like to exchange papers before and stuff like that. And in my math class, I have a friend named Garrett and we help each other sometimes.

Mulan and Flynn’s examples of how they used their peer networks to support academic success reflected in other participants’ feedback and consistent with my experiences as an academic advisor discussing useful strategies to learn difficult material. Flynn also shared his response when peers (developing experts) seemed to be struggling with the same content, or when he noticed there were gaps in knowledge. In these situations, he reached out to individuals he perceived as current experts who could correct understanding. The tutor Flynn references was a trusted adult from his hometown who was a math teacher.

> Sometimes it was like some of the initial lessons were super easy and I saw that other people were like struggling then. Yeah, but there's been stuff in there that I've had to get a tutor fixing stuff I've struggled with. So, so I'm not being terrible. That's a good refresher, I guess.

Using an experience shared by Christophe introduces the benefit of compelled peer-to-peer engagements, versus those self-selected by the student. Class commitments prevented him from participating in the modified AUP program and compelled engagement with same-aged peers and peer mentors. However, his experience in physics provided this type of interaction and he recognized the value of peer engagement related to learning new content. In addition to the online tutorials [classes], his physics class established required peer study groups. By his own admission he would not have thought to establish his own peer study group, but it was the piece that saved his performance in the class.

> You have a tutorial every Wednesday, which is a WebEx meeting. I've been put in a group with the same three other people since the beginning and they actually helped me find some lecture videos and they helped me a lot with getting all the information down. Without them I'd probably be even further behind in physics.

When asked specifically, it was the female participants in this study who readily commented on the contribution of peer mentors as part of this modified program. Elsa noted peer mentors were more relatable to her than a faculty member even though she had limited interaction with them.

> They (peer mentors) know what I'm going through. So, I feel like it's more relatable to them. I can relate more to them versus a faculty member.
>
> Since it was mostly online, I feel like we didn't get to interact with them (peer mentors) as much as I would have liked to.

Similarly, Anna found them relatable and as a source of non-academic coaching. The workshop they hosted not only provided tips on how to plan an academic experience, but also gave advice on how to navigate challenge.

> I know for me that [peer mentor workshop] helped a lot get into "Okay, this is what you need to do as a Freshman and as you go forward in college.
>
> Plus me in general…like, Freshman like me. It's kind of nice to be able to see them [peer mentors] and be like: "Okay, well, they're doing all these different things through engineering and they've been able to go through the hard things and get through it and still are enjoying themselves.

This provided Anna with a sense of confidence that she could do hard things and still enjoy her college experience. Because of their vantage point as students with just a bit more experience, their advice resonated in a more realistic manner.

> The ePALS [peer mentors] were kind of there as like a student in and way, and so they are kind of on the same level as us. What the ePALS [peer mentors] have gone through and they're kind of on a, on a different level, I guess.

Their perspective also carried weight for Anna by verbally cueing potential pitfalls and how to avoid them.

> But I know they've been able to take things away and say, "Look at what was good for me, what worked bad, and hearing that was kind of nice because I don't really know many others here. So, hearing from an upperclassman on their perspective was something I still listen to.

For Ariel, this coaching from peer mentors prompted a physiological response and calmed the personal expectation that she needed to already know how to navigate college. Even though Ariel had never been to college before, she was anxious and found relief upon learning others had similar questions.

> It was so helpful to be able to sit down and realize other people do have the same questions that I do because I've never been to college before, so there was really no way to know what I'm doing.

In addition, they opened her eyes to the possibilities within a college experience. That clubs can add to your academic experience in a way that enhances what you are there to learn.

> I think her name is Hannah [peer mentor]. She was talking about how she's been in different clubs and how she's been able to even go to, I think it's Kenya, to do some work. That's what made me realize, like involving yourself in clubs like this gives you opportunities outside of school and outside of your classes. Like the interaction of hearing that she was in sports and she was in three or four different clubs and she had the ability to go and do things to help other people outside of the United States, that blew me away. I didn't realize how big the opportunities were.

Mulan was torn. She was frustrated there was not a peer mentor from her major as part of the program. It made it difficult for her to connect with the experiences they shared and believe they were completely transferable.

> I actually really did not like the whole thing [AUP retention program]. I think it would really work if there was someone who is, like, [in] computer science.

However, Mulan still found some value when it came to processing what to do when faced with a challenge.

> So just like being able to, I guess, see other people who are successful be flexible and like being like, 'OK, this isn't working. So, what can I do now?' I think that was really important to me.

Most notable in the compelled peer mentorship portion of this program was the value the women participants placed on the interactions. The men appeared to be more selective and minimalist in their peer engagements. When prompted, they did not find compelled peer mentorship opportunities notable as influencing their relationship with an academic content. However, peer mentoring was happening as described by Hans and Li earlier with their teammates. When specifically asked, Hans referenced the highly scheduled life of a student athlete making it difficult to participate it a lot of extra commitments.

Vicarious experiences with developing experts contributed their relationship with the content mostly through providing social cues. Peer connections were frustrated by engagement restrictions in place due to the COVID-19 pandemic, but students found a way to make these happen. For men they found more value in organic engagements compared to the women who saw value in every peer interaction; even when exact major-alignment was not present.

Social/Verbal Persuasion from Current Experts

Although limited in its power as a singular self-efficacy contributor, social/verbal persuasion serves as a method of strengthening an individual's belief in their ability to accomplish their goals (Bandura, 1997c). Authentic, persuasive feedback from knowledgeable and credible sources can be used as a means of fostering sustained effort toward accomplishing a challenging task (Bandura, 1997c; Usher et al., 2009). Ariel's statement about her college experience; "I've never been to college before…," demonstrates that she was looking for cues from her academic environment to support her success. Her decision to participate in the modified program suggests not just any support would do and aligns with Bandura's (1997c) concept of social (or verbal) persuasion. Broadening out on this idea was Anna's experiences with her coaches and their purpose in her growth as part of a high school soccer team. She trusted her coaches to be sure her team would be ready for competitions.

> I mean, my coaches have kind of played a different role (than teammates). They more are on the stricter side, I guess. They kind of set the rules for everyone.

Bandura (1997c) explains the need for credible, trustworthy sources who can provide knowledgeable guidance through what is relevant to an individual's circumstance, in the college environment social, or verbal, persuasion comes from *current experts* paid to either teach academic content or provide services to students. For the NACOE and this study, the AUP Program workshops provided the connection with current experts and provided the framework for participant responses to answer research question:

1c. What are student perceptions related to weekly AUP group discussions with engineering or computing faculty to provide academic encouragement?

Several subthemes emerged in this data: Navigating New Environments, Types of Relationships with Faculty or Staff, Workshop Topic Influence, and Faculty/Staff Influence on developing academic content relationship.

Navigating New Environments

Fresh environments, like college campuses, are abundant with new processes and systems for first year students to navigate (Meadows, 2008a; National Resource Center for The First-Year Experience and Students in Transition, 2012). New environments in a university include academic management offices, classrooms (e.g.: Registrar, Financial Aid, Student Accounts), academic colleges and/or departments, and campus housing. These environments within a university are mesosystems where the individual engages with microsystems, usually people (e.g.: faculty or academic advisors), within an office or classroom (e.g.: financial aid, Registrar, or academic colleges) which support their learning and success (Bronfenbrenner, 1993, 1995b, 1995a, 1999). In the NACOE the modified AUP retention program served as a new environment where faculty members, academic advisors, and professional staff supported students new to the college. Mulan noted the pressure she experienced as a Freshman in her first year of college. Feedback she received through the modified program validated her experience and gave her a source to turn to for support in figuring out how to make sense of the pace and environment.

> It feels like there's so much pressure when you're first getting into college and kind of having someone be like, 'This is first off…. it's going to not get worse, but it's going to get harder. But you're also going to get the works and wheels of it – so it's going to be okay. It's just figuring it out is the hard part.

When asked about the resources most helpful to her transition to college, Anna noted the people she had met. The most influential support came from the people near her as she moved from one environment to the next.

> Um…I think the biggest influences would probably be, I mean, I'm going say people. Because I know that's a pretty big influence just to say, that's who I'm surrounded by.

Sometimes connecting with current experts presented a challenge such as in Ariel's experience with her academic advisor. The disorienting feeling of going to college mentioned earlier combined with the online nature of Orientation presented challenges in connecting with her academic advisor.

> I also didn't feel I was connected because, like, I'd never met her or talked to her before. Just because, I think it was also kind of like a last minute schedule. Like my appointment kept moving because things were getting in the way or she wasn't available.
>
> I think I've only talked with her once and I think it was over the phone in my bedroom one night before I left for college.

Feeling a little uncertain about her classes Ariel made the decision to reach out to her academic college for more direction. Referencing college information, she found an email for the NACOE Student Success Coordinator and sent a message. The response helped Ariel learn current experts in a college setting support the student in different ways making establishing a new network important.

> I had emailed you about my classes rather than my initial advisor. And like you helped me transition towards like College of Engineering and Women

> in Engineering. So it was that role with faculty too that, like, you can still lean on other people and get to where you need to go, or they will help you get to where you need to go.

These experiences highlight Bronfenbrenner's (1993, 1995a, 1995b, 1999) description of people (microsystems) who interact directly with the individual within the spaces (mesosystem) they find themselves. It would be reasonable to assume a person would choose to interact with faculty, they believed provided the best feedback making it important to have clearly structured environments and points of contact within academic colleges.

<u>Types of Faculty or Staff Relationships</u>

Participants remarked on the types of current professionals influencing their academic experience. They valued academic advisors who understood how academic disciplines lead into career fields. Encouragement and coaching to engage within their academic community increased their developing relationship with academic content. Elsa found her academic advisor as a resource she could frequently use and access to a program as another layer to use in tandem with advising.

> Now I know that if I need to talk with my advisor about something, I can go to them whenever I need it, which is very helpful.
>
> I think it [AUP retention program] gives it [retention program] more broad area for you, I guess, versus just advising. I do advising and many other things I feel like that'd be more helpful.

For Mulan, the connection with her academic advisor helped her manage the news of her math level. Knowing her advisor was approachable and would listen was the support connection Mulan needed

> I really clicked with her (academic advisor) so it [math placement] didn't really bother me. I could have a conversation with whatever I was studying.

Realizing he wanted a different career path; Christophe needed a realignment of his academic path. Working with his academic advisor Christophe explained his goals related to building houses and asked questions about academic programs. The result was an academic path leading to a chosen career and appreciation for the contribution academic advisors make to the student experience.

> Even though it is not a general engineering or like an engineering-based path, it’s still very helpful what you guys (academic advisors) do.

University environments are complex and have different types of current experts contributing to the student’s developing relationship with academic content. Using Ariel’s experience with her academic advisor is a way to broaden this picture and explain different human systems functioning simultaneously within an environment. In some situations, the purpose of an academic advisor might be limited to selecting classes based on a set curriculum that feels ambiguous to the student. They may need more explanation about how courses lead to a career or which align better with a particular line of interest. In Ariel’s circumstance, she believed her questions would not be answered by her academic advisor.

> I also wasn’t sure what I was supposed to expect with registration because jn high school, like my teachers would just be like, “Yep, you’re in these classes.” And I was like “Okay, cool.” Now it's like, "what classes would you like to be in?" And I'm like, "Oh no, that's too much freedom! I'm going to make the wrong choice." So that's just like a gap in communication. If I were to learn more or know her better, I probably wouldn’t feel the same way. So, and it’s also partially on my communication, too.

Confused and not sure how to ask the right question, Ariel decided to contact her college's Dean's Office to help her understand how to select classes in this new environment. The result was a strategy of how to select courses that helped her make an informed decision.

> And then with so…with the, I remember, you and I had a meeting in person where you showed me like a demonstration, a drawing to show me the different parts. I think you drew a car. Oh, yeah, that stuck with me because I was just that changed my kind of outlook on classes, too.

Another participant, Hans, noted a relationship with a current expert who shared a similar background with him. This allowed Hans to see his goal was possible and provide mentorship throughout his college experience.

> Just discovered a source and somebody who's already kind of been in my position and somebody kind of like understands what I'm going through and then kind of knows, like where I need to be pushed in a direction to be able to go.

Anticipated current experts on a college campus include faculty and course instructors. Students anticipate these relationships to support their knowledge acquisition relation to specific topics. Li's writing professor recognized his ability to write well and encouraged him to consider publishing his work.

> One of my professors, we're talking about I'm going to write. I write journal entries and she was like…I should publish them.

The benefit of relationships with a variety of current experts in a college environment is not revolutionary. A liberal arts education provides opportunity for a well-rounded education and exploring academic disciplines. Christophe wanted a practical degree supporting his interest in building houses, Ariel met with a student success coordinator to find a strategy for picking classes, Hans found a current expert who could explain how to be a student athlete and pursue an engineering degree, and Li's engagement with an English professor gave him confidence to pursue what he loved. These experiences speak to the importance of a variety of informed experts *and* the students' perception they are approachable. It helps when current experts are able to recognize student interests, calm fears, and provide direction and alignment in the career field.

<u>Workshop Topic Influence</u>

The structure of the modified retention program included 6-weekly meetings which fostered engagement with faculty, staff, and peers. Meetings focused on topics noted to be helpful in promoting persistence in STEM disciplines. Workshops were led by program coordinators and included faculty guests as part of the discussions, in addition to connecting participants with each other and college peer mentors. Topics were selected by current experts in the college and relied on research that showed topics beneficial to AUP student populations. These circumstances made it most appropriate to place the influence of workshop topics under social/verbal persuasion.

As part of her first semester experience, Anna found the weekly meetings helpful. She perceived the topics covered taught her a lot about college and just having the weekly meeting helped.

> I think just the Thursday meetings online that we did were beneficial. Just having that I know I learned a lot and just that our time period, that helped me a lot. So, I think those were probably the best for me.

The required, topic-focused weekly meetings were a feature designed for this study. When the organized program concluded, some students commented on how much they valued the connection the program provided. Ariel reflected on a conversation with her dad about the workshops ending. Although she knew the program was only a few weeks, Ariel was disappointed the weekly meetings with her AUP student group were ending.

> I found that the program itself was really rewarding because it stuck with me. I remember towards the last meeting, I was talking to my dad [at the end] and was like, ‘Man! I'm really sad there's no more meetings.

Flynn had a different perspective. While the topics were helpful to think about in terms of focusing his decision to earn a college degree, the online pace of the workshops was slow and not always something he enjoyed.

> Sometimes their [workshops] a little slow in a way. Some of the points are, like, helpful to think about. Like, you know, you’re getting an education for a purpose type thing. You know, so making those tough decisions.

Likewise, Hans described an experience that created confusion. He had logged on and found himself in the middle of a conversation with the instructors. He also was a little unsettled about potentially being the only student in the workshop.

> I was a little confused on some of the WebEx calls. Like what we're supposed to be doin', cuz I remember I went into one of the them and it was like jus me and one teacher talking to another teacher. I was pretty confused as like, that's where I was supposed to be.

Both Flynn and Hans had robust social networks through MSU’s college athletics program in place, which was unique to their circumstances. This was not true for all participants. Ariel described the workshops as an influential part of her Freshman year contributing to her confidence, focus, and engagement with course work and connecting with people outside the classroom.

> But overall, the COE-X meetings and like the experience of COE-X, related to my classes definitely changed my perspective on my classes. And it also made me more confident with my ability to join clubs and stuff like that.

> And it's just, experiences like that make me realize…made me realize it's easier to pay attention, like in class, and get along with people outside my classes.
>
> I thought it (the paper airplane race) was really cool because I didn't expect to make a paper airplane that day. So it was really fun to be like, I get to race!
>
> Just the whole experience made me more confident with my classes and with my ability, because I'll see the people that were in the meetings, in the dining hall and like I'll be able to say hi to them still.

Speaking specifically about the workshop topics, participants highlighted those which resonated and impacted their purpose as a student. One workshop focused on grand challenges for engineering and computing (Allan, 2010; National Academy of Engineering, 2017) and participants highlighted this as the most relevant material for them. Led by a computer science faculty member, the content and discussion oriented around challenges they would face in the career world and their progress through a degree program. Mulan really liked this workshop because of the automatic connection she had between the instructor and her academic interest. Not only was he a computer science faculty member, but his spouse was her academic advisor.

> The workshop I really liked was the one with the Computer Science Professor…. because there was an automatic link with computer science for me. But I feel like of the advice it was really applicable, and I could relate it to other things besides computer science.

Hans appreciated the honesty of the presenter and the advice to work toward something you're interested in and eventually you will get there.

> He (faculty presenter] was kind of saying, like, how he didn't really know what he was going to college for…I think from that one was taken away, like, you don't really know what path you're on until you make it, I guess. So it's just thinking along what you know, what you like doing, and eventually it'll work itself out. It's kind of what I got from that one.

For Elsa and Anna, workshop topics that resonated with them were different and aligned with personal experiences. Imposter syndrome is the feelings of inadequacy that affects an individual's confidence (Collins et al., 2020; Heaverlo, 2011; Reyes, 2020) and Elsa found this topic relatable and easier to apply.

> I think, I don't know, the imposter syndrome one was better for me because I related to it more. So, it stuck with me versus the resiliency one.

Resiliency is the ability to adapt well to an changing environment, particularly those that produce stress, adversity or trauma (Ross et al., 2021; J. Wang, 2009). Anna's stressful circumstances during the timing of this workshop topic influenced the relevance of this topic to her situation. It helped her create a strategy to navigate meeting multiple commitments in a timely way.

> I know the ones [workshops] that the ePALS did was definitely helpful and the resilience one. That one definitely helped me a lot because that was like during a pretty stressful week. And so it was kind of nice to be able to take that and say, "okay, this is what I could work on and this is how I can work on that.

These participants' experiences support the intent of offering organized workshops, rather than leave it to chance that students will develop skills to navigate uncertainty, inadequacy, or questions of degree appropriateness. There appears to be value in discussing topics related to confidence to develop skillsets to manage discouragement and uncertainty. Additionally, platforms to explain how a degree tracks into the workforce are helpful in supporting students as they develop a relationship with challenging content in engineering and computing disciplines.

Faculty/Staff Influence on
Developing Academic Content Relationships

Students transitioning to college environments often leave home and strong relationships with family members. Even as a distal influence, Ariel’s relationship with her dad served as a catalyst in her decision to participate in the modified retention program. In a phone call with him, Ariel expressed her physiological response to receiving the invitation to participate, but despite her excitement seemed to be looking for encouragement or permission to join the group.

> And I called my dad and we talked about it and he's like, you should do it. If it sounds interesting. I know that you're missing out if you don't. So, I was really excited.

Finding similar trusting support systems strengthen social persuasion as a source of self-efficacy development (Purzer, 2011; Sachitra et al., 2017). Ariel valued the involvement of faculty and the support system they provided.

> It was nice to have involvement from faculty because there was like a support system there, too.

In Anna’s case, she liked hearing about the life experiences of faculty presenting in the workshops and the challenges they navigated successfully.

> It was kind of nice (to have faculty participate) because then I was able to hear it from somebody who's been through all this before and wasn't just a student. It was actually a faculty member who's gone through more than all of us have and then ended up somewhere...at somewhere...even though they know the struggles of it. They were still able to come out and do something that they love.

Elsa found the platform helpful for closing the distance between students and faculty and staff, making it easier to talk to somebody. The effort to create situations where introductions can be made is a focus of creating community within our college. Elsa’s experience supports this intention to facilitate relationships between students and the people in place to help them succeed.

> I feel like it's easier to talk to somebody when you know them better, versus not knowing them.

It is these engagement opportunities that influence a student's developing relationship with academic content. As an example, Hans shared a conversation with a faculty member who told him about the Empower Center and the resources available for students – including him. Although Hans had briefly toured the center and heard about it during the workshops, his ability to use the center's resources had not synthesized until he had an in-depth, one-on-one conversation with a faculty member from an URG in STEM encouraged him.

> I just met with a Professor last week. He said his wife works in the Empower Center and that if I ever needed help with engineering stuff to make sure I go there.

Christophe echoed this by sharing how he had learned through meetings with his advisor there were resources available to help when he was struggling. In addition, his instructors had organized study groups all of which increased his confidence.

> I feel more confident about the classes because I know there's resources. I can do that they can help me if I am struggling. So, I mean, that was about the confidence and it was nice.

The concept that it can take multiple touches to support the development of the NGE is prevalent in the data. In other circumstances it is one that opens the gate to embracing a path previously considered unavailable. This was the case for Li who believed his love of writing was a hobby until a professor encouraged him to reconsider resulting in the decision to take a step back and re-evaluate an academic path that could align with his interests and his talents.

> …me and her [writing professor], we had a discussion, and she was like, 'You're really good. You should think about doing this.' And I was all...and I kind of thought about, yeah, maybe, maybe....

In combination with Li's current mastery experiences related to his developing relationship with math, social persuasion from a current expert who could speak to opportunities in the work force for talented writers led to more confidence in exploring non-STEM degree options.

Christophe spoke about the difference between course delivery styles and his ability to connect with the material. For him, distance delivery separated Christophe from the instructor and the content being covered which diminished his motivation for learning the content even when he knew there were additional support resources.

> I get math very easy when I'm taught by the right person."

> "Not having a consistent in person class it's very hard for me to find motivation to try to remember everything.

The face-to-face style delivery of his engineering course presented real-time, hands-on interaction with the content. In addition, it provided a method of support from the instructor Christophe appreciated.

> My Professor, he helped a lot just because one assignment with the plane I just made. He helped me design that.

Noting other experiences with faculty in a classroom environment, Elsa shared an experience with an assignment that was graded lower than she expected due to little mistakes she had not seen.

> So for drafting & design I had to do a 3D model of something. I was really proud of that, but I got a "B" on it.
>
> I think that was just like little mistakes that I made (on my assignment) that I could have fixed, I guess.

Whereas Ariel described her independent efforts to not fall behind on her work and know her projected final grade calculation. She valued the inclusion of faculty as part of this program but did not seem to translate this to course instructors.

> I think I have either B+ or A- calculated final grade for microbiology and stuff like that. So even though there are days that there, there is a lot of work I find that I don't necessarily fall behind with it.

For new Freshman entering college their connection to home, parents, and K-12 style academic delivery styles is strong. Students regularly talk with their parents, sharing experiences and processing what this means for their academic pursuits. The new college environment places the student in charge of their experience which can be disorienting with so many new environments to navigate. Coaching the transition to college includes prompting use of support structures, fostering curiosity and allowing autonomy. Faculty and staff relationships that spark student interest, inspire learning, and highlight their ability with the material make a difference. For example, having a current expert (English professor) validate and encourage Li's writing talent sparked his interest and curiosity related to literary careers, inspiring his consideration of non-STEM majors.

Social, or verbal persuasion is most effective coming from a recognized current expert who is also a trusted source of authority (Bandura, 1997c). In a higher education environment, current experts are most commonly faculty, academic advisors, and other staff members hired to either teach or provide student support. Students found workshops to be a place where their worries were acknowledged, and topics helped them manage their struggles and physiological responses to the academic experiences. Faculty and staff were important to the developing relationship students had with academic content. Students moving into a new learning environment may not understand how to process assignments on grades. Rubrics may help, but perhaps more important are conversations that encourage engagement with the material and highlight how a student's current talent meshes with content being taught. This could influence a student's decision to pursue a certain discipline.

Summary

This chapter described the qualitatively different ways study participants experienced a modified version of the NACOE's retention program for AUP students. An overarching question and sub-questions informed the study design and research protocol. The data introduced a unique perspective of how Bandura's self-efficacy sources interact with each other. Rather than being siloed influences on an individual's developing relationship with an experience – such as academic content -- physiological states sits in the space between mastery, vicarious, and verbal/social persuasion experiences. In this position physiological responses became a membrane through which students experienced a STEM academic environment established to support AUP students. This perspective informed the themes, sub-themes, and categories along with their presentation with physiological responses threaded throughout participants developing relationship with engineering and computing academic content.

Some participants arrived with mastery experiences in engineering or computing academic content, but others did not. This foundation combined with student responses to their math level ranging from expectation to surprise and worry regarding their math placement resulting from a placement algorithm established by the Mathematics Department. New experiences with math, science, engineering, or computing content at the college level were influenced by environmental factors and filtered through their physiological responses to the experiences. In combination, they informed the student's developing relationship with engineering or computing related content.

Vicarious experiences occurred with developing experts who were either same-aged peers or slightly older peers in mentorship roles (informal and formal). The COVID-19 pandemic limited the amount of student engagements. This made it challenging to find the variety of robust visual cues and shared experiences anticipated from a college experience. Students depended on these engagement opportunities, taking advantage of any opportunity to widen their peer network. Physiological responses affected relationships with developing experts which supported decisions students made to participate in activities, explore majors in and out of STEM disciplines, and learn academic content.

Faculty and staff served as current experts providing social, or verbal, persuasion in a variety of engagement spaces, such as advising offices and classrooms. Participants relied on academic advisors to guide their transition into the college environment and find their place in a new academic home. Faculty and instructors were the connection between the student and academic content. These engagements were filtered through physiological responses influencing the developing relationship between the student and their developing relationship with STEM and non-STEM disciplines.

In combination, data presented the fluid, nature of external environments and the internal process a student uses to process events and determine how to interact. The intertwined nature of physiological responses was noticeable in how students communicated their perceptions. Even shared experiences had a different interpretation resulting from physiological states such as stress, frustration, or worry. It was this finding which informed the consideration of physiological states as the filter or connective tissue through which students experience mastery, vicarious and social persuasion events. Students pull in experiences with environmental influences filter them through physiological affect and push out a response to the event. This dynamic engagement between the student and their environment is where relationships are developed. In this situation the purpose was to understand how these events influenced academic self-efficacy with engineering or computing content.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

Introduction and Overview

Maintaining its mission as the land-grant institution for the state of Montana, Montana State University is an open access university with a single application of admission. Aligning with this mission, the Norm Asbjornson College of Engineering (NACOE) responds to call to educate the next generation expert (NGE) in engineering and computing professions. Admission to the NACOE occurs with this single entrance application which allows access to *any* degree within the college *regardless* of academic preparation as a high school student. The invitation to come ready to engage with their academic community and content for the discipline they are interested in is extended to every student. Following up that invitation are retention programs designed to meet students where they are and move them forward through the engineering or computing discipline that interests them.

Using phenomenography this problem of practice study explored the student experience with a modified version of an AUP retention program developed to support Freshman in engineering or computing majors. This approach provided a snapshot of eight student-participants' experiences with a structured retention program and its effect on their developing relationship with engineering or computing content. Data were gathered through one-on-one, semi-structured interviews to answer an over-arching research question, with four complementary questions focusing on how sources of self-efficacy influence individual's engagement with challenging academic content. The scope, limitations, assumptions, and significance of this study established guiding parameters and purpose as well as the decision to focus on this research as a scholarly practitioner.

These questions align with two theoretical frameworks combined to represent how complex process in a student's developing relationship with complex academic content. Bronfenbrenner's (1993, 1995a, 1995b, 1999) bioecological model of human development explains the complex layers in an individual's environment. Bandura's (1997b) self-efficacy theory provides a method to explain the internal process an individual uses to make sense of their ability to engage successfully with an experience. Using these theories as nested, complementary frameworks shown in Figure 5.1, this study reviewed the developing relationship college Freshman have with engineering or computing content, which is often limited. Next, the literature review narrowed to academically underprepared students (AUP) beginning with college experiences declared in an engineering or computing major and in a math course lower than pre-calculus. Perception of college readiness influenced the relationship between the student and challenging content their majors required. Finally, the value of an academic environment established to support the next generation expert (NGE) as students built a relationship with engineering or computing content was presented through current findings. The work of these current experts in engineering, computing, and higher education research frames the value of environments that include recognition of physiological response to mastery, vicarious, verbal/social persuasion experiences related to STEM fields of study.

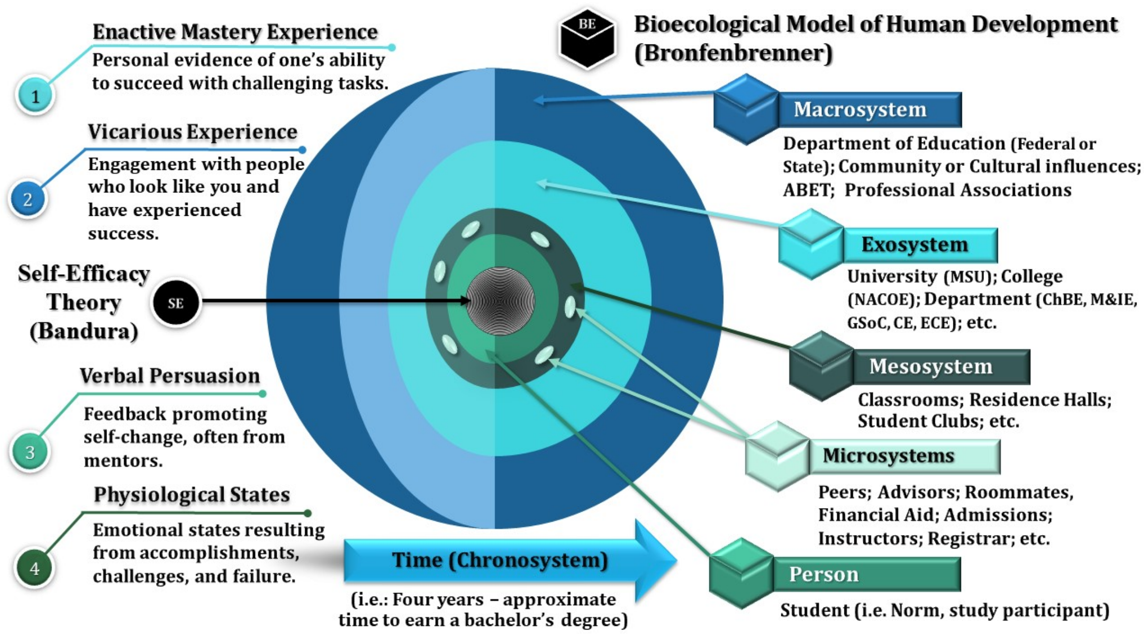


Figure 5.1. Conceptual Framework for Study

The methods chapter explained the research approach, stance, positionality, and reflexivity methods used to direct this study. Additional validity and reliability methods were included after the population, intervention, participant selection, data selection and iterative analysis process described. Chapter four describes the interpretive space and findings from the analysis process. The most revealing being a method of communicating the integrated nature of physiological states as a student engages with their academic environment through mastery, vicarious, and verbal/social persuasion experiences.

Physiological responses such as emotions, behavior, and physical changes in the body serve as a membrane in the space between an individual's engagement with environmental forces and their interpretation of the experience. In this case, results were filtered through emotion and affective states and influenced how students processed their experiences – shading their perception of their ability to be successful with challenging academic material. This process resulted in a variation on the traditional depiction of Bandura's (1997c) sources of self-efficacy, shifting physiological states to sit in the space between environmental influences of mastery, vicarious, and social persuasion experiences. Acting as a membrane through which engagement with their environment shades the student experience with a phenomenon – in this case a modified retention program which compelled interaction with their academic college (Bronfenbrenner, 1993, 1995a, 1995b, 1999).

Rethinking Interaction between Bandura's Self-Efficacy Sources

Considering the interactive nature of the environment and how a student processes their engagement experiences was a primary interest in this study. Understanding the perspective of the student required an ability to explain the components of their environment making bioecology theory the most comprehensive way to accomplish this task (Bronfenbrenner, 1993, 1995a, 1995b, 1999). Also affecting a person's development is engagement with their environment. Bronfenbrenner's (1993) theory describes these constructs as a series of developmentally instigative characteristics which inform how a person engages with others and what that might look like such as robust exploration of academic content with a peer study group. Where bioecology theory stops, self-efficacy theory picks up with how its sources influence student response (Bandura, 1997b, 1997c). In a way the two methods together provide a way to complete the story in the picture through understanding the role physiological response plays in changing the shade of color on the student experience. Presented, side-by-side in Table 5.1 are the sources of self-efficacy with developmentally instigative characteristics. The difference is in the story they tell about the individual's engagement with their environment.

Table 5.1. Side-by-Side Comparison of Developmentally Instigative Characteristics and Sources of Self-Efficacy

Developmentally Instigative Characteristics	Sources of Self-Efficacy
Personal Stimulus Characteristics Qualities that respond to the environment either inviting or rejecting engagement in a manner that impacts psychological growth.	*Enactive Mastery Experience* Personal evidence of one's ability to succeed with challenging tasks.
Select Responsivity A person's decision to explore their environment seeking engagement of a solitary or socially connected nature.	*Vicarious Experience* Engagement with people who look like you and have experienced success.
Structuring Proclivities Dispositions influencing the nature of engagement a person has with activities. Especially when they are increasingly more complex in nature.	*Verbal/Social Persuasion* Feedback from environment promoting self-change, often from mentors or perceived experts.
Directive Belief Systems About the Relation of the Self to Their Environment Emotional/Affective states resulting from accomplishments, challenges, and failure.	*Physiological States* Emotional/Affective states resulting from accomplishments, challenges, and failure.

The fluid, push-pull nature of how a student pulls in experiences as they engage with their environment, cycle the events through a physiological response filter and then push the result of this process back out came alive through this study. Students go into a college experience with some idea of their ability to engage with challenging material in a complex environment. Their academic environment includes several mesosystems with their very own set of microsystems that only connect through the student. For example, Hans and Li were part of MSU's athletics program (mesosystem), the NACOE (mesosystem), and campus housing (mesosystem). In each of these spaces, they engaged with peers, coaches, professors, advisors, and tutors which are all examples of microsystems within their respective mesosystem. These microsystems provide social cues, verbal feedback, visual examples, and mastery experiences unique to each of those spaces. When challenging experiences occur, such as with academic content, physiological states become the filter influencing engagement. Students synthesize experiences and make decisions affecting their path forward in each setting. Experiences in the modified AUP program included experiences with mastery, vicarious and social/verbal persuasion, as well as acknowledging the influence of physiological states. It was up to the student to interpret how these factors affected their academic self-efficacy with engineering or computing content.

The literature describes and measures sources of self-efficacy as separate silos, which makes logical sense in seeking to make sense of the impact each area has on the developing individual (Hutchison et al., 2006; Lin, 2016; Mamaril et al., 2016; Usher et al., 2008b). In a 1990's conference presentation where Urie Bronfenbrenner (1990) discussed his theory in action, he expressed the importance of more research in context. This study followed his advice resulting in data presenting evidence leading to a re-thinking of how sources of self-efficacy work together within the student. Already suggested in the research were findings (Hutchison et al., 2005; Loo et al., 2013; Mamaril et al., 2016) showing physiological states have an affect which have been described in their own category within the study findings and results. In this study, physiological states have been presented as a membrane serving as a filter between the student and their more tangible experiences with their environment: mastery, vicarious, and verbal persuasion experiences. It is through this filter, presented in Figure 5.2 as dashed lines, that experiences are influenced and take on a new shade of color. For students these experiences can affect their relationship with academic content, leading to their persistence, or not with a STEM discipline.

Figure 5.2. Physiological States as the Connective Tissue between Mastery, Vicarious, and Verbal Persuasion

This chapter discusses the findings and how they inform AUP students transitioning from high school to college with an interest in pursuing engineering or computing majors. Their previous experiences, range of preparation and current experiences in college include engagement with peers which were not previously determined as a separate component in the development of the NGE. The equation introduced in Chapter 1 included interest as a factor in the development of the NGE in engineering or computing. Interest, like physiological states, relies on the student to process internal perspectives and engage with their environment. Data from this study show peers are the closest and most engaged microsystems in this process which informed their inclusion as an influential factor in the NGE equation.

Next, the discussion will include analysis of the college environment and its influence of an AUP student interested in pursuing a degree in engineering or computing. Academic communities, environment structures and dynamic relationships within these spaces all converge within the student influencing their ultimate decision related to an academic discipline. As previously described, students shift between many environments (mesosystems) within a university, each with their own set of peers, professors, mentors, advisors, or coaches (microsystems). Findings from this study describe why it is important to consider academic environment influences for students with STEM aspirations.

NGE Students Arriving AUP to Pursue Engineering or Computing

MSU, as the State's land grant university and the NACOE have an open access agenda. This means acceptance to the college happens with admission to the university and the invitation to pursue any degree in the engineering college is extended to everyone (Gunnink, 2017). Since its beginning, MSU recognized many of the communities in the state were limited in their access to advanced coursework commonly expected for first year college students in engineering or computing. The message intended is a welcome to new Freshman to their academic college no matter their academic preparation. As the first of several strategies the invitation, followed by additional retention programming, aligns with Tsui's (2007) literature review and Yoder's (2012) ASEE program review and speaks to the need to be intentional with strategies to support wider access to engineering and computing majors. The invitation to consider a career in engineering or computing and acceptance to the NACOE regardless of academic preparation are initial efforts to create a welcoming and supportive environment. Using bioecological theory and self-efficacy theory acknowledges the complex layers involved with developing a relationship with academic content (Bandura, 1997b; Bronfenbrenner, 1993, 1995a, 1995b, 1999). Bronfenbrenner's (1999) work highlights relationships with environmental influences, seeking to operationalize the complex nature of their effect on development. More importantly, his work focused on making sense of the environment in order to put solutions into practice to influence better development outcomes (Bronfenbrenner, 1999). Bandura's (1997b) work completes the picture through introducing physiological affect which is the filter through which self-efficacy promoting experiences (mastery, vicarious, persuasive) are distilled into a response or decision on how to engage. Following is an explanation of how previous experience, range of preparation, and first-year experiences combine to influence the developing relationship between AUP students and engineering or computing content.

Previous Experience

This study provides a new perspective on the developing relationship between the NGE and engineering or computing content. It operationalizes the NGE equation presented in Chapter One. Where the sum (Σ) of Talent (T), Interest (I) and interaction with Current Experts (CE) multiplied by the sum (Σ) of New Knowledge (NK), New Skills (NS) and New Experiences (NE) leads to an outcome (=) of the NGE.

$$\boldsymbol{NGE = (T + I + CE) * (NK + NS + NE).}$$

Working in conjunction with environmental influences and sources of self-efficacy, a method of understanding how students internalize stimuli and engage with an experience emerged (Ericsson, 2009). Whether students know it or not, they bring valuable experience when they come to college to engage with current experts. Current experts have developed a relationship with their content area and have decided to teach the NGE how to establish their own connection with a field of study in a higher education environment (Agogino, 2008; Dym et al., 2005).

Possessing natural ability, or *talent*, for subjects is helpful for developing academic self-efficacy (Duckworth, 2016; Ericsson, 2009). Broadening this idea is work by Stipanovic et al. (2017), Beyer (2014), and Worley (2010) presenting *interest* as an equally compelling drive in a student's decision to pursue engineering or computing disciplines in college. Anna's efforts to learn as much as she could about engineering before college to help her make a final decision on a major support this idea. College is an opportunity for developing NGEs to engage with a consolidated group of CEs to hone their talents through incorporating new knowledge, skill, and experience to existing potential. Engagement with a CE without interest, as noted in the data from this study, the drive for learning challenging material is not present. Anna's experience with high school engineering classes sparked her interest in careers related to these disciplines. Conversely, Li shared how writing had been the most interesting part of his high school experience. His first semester in college accentuated his love of writing and lack of interest in mathematics ultimately influenced his decision to pursue a non-STEM degree.

Figure 5.3 visually represents the influences of current experts, talent, and interest on the developing NGE.

Figure 5.3. Visual Representation of Influences in NGE Development

<u>Range of Preparation</u>

Previous experiences in high school present varying levels of college readiness for new Freshman. Engineering and computing programs in high school are limited, resulting in a limited understanding of these disciplines among academically ready (AR) and AUP populations, but this is where the similarity ends. When new Freshman arrive on college campuses their immediate environment (mesosystem) and networks (microsystems) change, in addition to personal responsibilities (Bronfenbrenner, 1993, 1995a, 1995b, 1999). Conley's (2005) work around the hidden agenda in the college environment shows the transition to college is its own challenge. Similar work by Villanueva et al.'s (2018) speaks to the hidden curriculum in engineering education which widens the gap between underrepresented populations and to degree completion. Often URGs are the first in their families to go to college or pursue engineering or computing degrees and not aware of how to navigate the college environment. In addition, the networks supporting learning complex material or engagement within an academic environment take time to establish (Gelles et al., 2019; Villanueva et al., 2018). Adding the full demands of adult responsibilities to the mix, it is as if Freshman have raced full speed to the edge of a river with the intention of leaping to the other side without fully assessing the width, depth, or conditions associated with the action. For many, it is after they have leapt, or entered college, that these assessments are made, which often results in worry and concern that the outcome might look different than the one anticipated.

The data showed AUP students who participated in the study begin their college experience learning to navigate a new academic environment, considering the pursuit of a challenging major, and feeling as if their math level had put them too far behind to achieve their goals. Anna, Elsa, and Christophe considered these elements as factors in their degree choice. For some students they were not aware their math level would be different while others saw college as the next step but needed more information regarding how a degree prepared them for a career.

The gap between high school and college is recognized with colleges responding with programming to support students transitioning from high school. These are helpful solutions which make a difference. However, widening access to college engineering and computing programs must include normalizing the reality that students arrive with varying levels of academic preparation. Castro (2014), Peck (2021), and McKay et al. (2016) express the importance of not using a deficit mindset in establishing programs and seeing promise in AUP student populations. *Deficit thinking* is the idea that students are destined to fail in academic pursuits because of missing elements impacting academic preparation. This manner of thinking has its roots in bias and perpetuates stereotypes further distancing students from academic success in areas most needing diverse perspectives (Castro, 2014; McKay et al., 2016; Peck, 2021).

Current Experience with College and Academic Content

Even with the layers of complexity, pursuing a college degree is compelling. The data showed students were equally excited about making new connections and finding peers who shared their same academic aspirations. Confidence in a learning environment's ability to meet them where they are without judgement and move them forward makes a difference (Castro, 2014; McKay & Devlin, 2016; Peck, 2021). Hutchison et al. (2006) Booth et al. (2012) and Mamaril et al., (2016) demonstrate mastery experiences in combination with vicarious and social/verbal persuasion sources increase the development of academic confidence in engineering content (Bandura, 1997c). Unexpected findings from this study provide context for how physiological responses to current experiences in a student's academic environment are important in shaping responses to academic disciplines (Bandura, 1997b; Bronfenbrenner, 1993, 1995a, 1995b, 1999).

Two participants, Hans and Li, had a unique component to their academic experience which set them apart from other study participants. Their college experience included a robust athletic community providing an early summer transition to college, academic support, time management guidance and more; supporting their shift into college and their role as student athletes. Hans' interest in civil engineering worked in tandem with his confidence in the ability to figure out the academic content required despite his starting math level. Using peers and faculty, Hans engaged his environment, asking questions, and using resources to support assimilating new knowledge, new experience, and new skills. Neither Hans or Li seemed concerned by their math placement; nor did they express worry about the possibility of an extended timeline to degree completion. Instead, they were confident in the resources and processes available to support their search for and selection of a major. It is important to note Li described his decision to pursue a non-STEM major as a journey of discovery related to his interests and skill rather than the reverse.

In contrast to Hans' and Li's experience are AUP peers, Anna, Christophe, Elsa, Flynn, Ariel, and Mulan who participated in the study, but did not have ties to the athletic community. Their shift from high school to college was challenging to navigate and they spoke about the struggle to just figure out how to be adults and students. A couple participants were prepared for their math placement and what that meant, but others expressed feeling surprised, judged, and very far behind their peers. Learning to function in their new college environment was a shared concern about finding new friends with shared interests and searching out academic support that met their needs. Additionally, feeling pressure to perform, get along with new people, and find new friends with shared interests influenced students' decisions to search out academic support that worked for their needs, and a variety of other challenges. These were all noted as leaps into new territory making it overwhelming to think about either committing to an engineering or computing major or persist in one. For Anna and Mulan, they stepped back from also committing to a specific major. It was not a comfortable topic, and both paused making this decision in favor of focusing on becoming a good college student. Christophe decided he wanted to pursue a trade and go into business with his brother noting his academic advisor as being a contributor to aligning his academic direction with professional goals.

These findings suggest developing academic self-efficacy is about far more than mastery experiences, which has been suggested by Mamaril et al. (2014, 2016). Interest, or motivation as referred to in Mamaril et al.'s (2014, 2016) work, might be considered a physiological response. The engagement between current experts (faculty) and students hones and refines their talents while adding to their knowledge and skill. Through this dynamic interaction students gain mastery experience and are prepared for engineering or computing disciplines and careers. Robust research around peer mentoring also demonstrates the need for peers in an academic environment (Leung et al., 2012; Marra et al., 2010; Ong et al., 2018; Peregrina-Kretz et al., 2018). They provide social cues, shared experiences, and strategies for moving through challenging experiences which can provide a road map to persistence. More importantly, peers provide a network of examples which look like the student in age and experience. Including environmental factors and students' physiological responses using bioecological theory provides a comprehensive cycle describing what is happening through the process.

Factoring in the influence of peers and what they offer for the developing NGE is important. It inspired a reconsideration of how peers (insofar as they are often part of vicarious experience and social persuasion) might be a factor in the NGE equation and updated visual representation of influences in an NGE's development in Figure 5.4. Using Anna's experience with high school sports where she described the weight of feedback from her peers versus her coaches, the equation from Chapter One evolved from its original form to include peer influences as a factor. Where the sum (Σ) of Talent (T), Interest (I), Current Experts (CE) *and Peer Influence (PI)* multiplied by the quotient of the sum (Σ) of New Knowledge (NK), New Skills (NS), New Experiences (NE) *and Example Network (EN)* leading to an outcome (=) of the NGE. While the data presented Peer Influence (PI) and Example Network (EN) as factors to be considered in the developing NGE exactly where their influence occurs should be a focus in future research. Currently, the data suggests PI is a factor to include with T, I, and CE while EN (of peers) presents as an addition to NK, NS, and NE.

$$NGE = (T + I + CE + PI) * (NK + NS + NE + EN)$$

Figure 5.4. Updated Visual Representation of Influences in NGE Development

Strength of Environmental Influences

Academic self-efficacy research in engineering and computing education by Hutchison et al. (2006) found mastery experiences, along with drive or motivation (physiological response) as highest ranked influences in persistence. Loo et al.'s (2013) regression analysis found strength in highlight students' prior knowledge, reinforcing concepts and building on these experiences to strengthen academic confidence. Lin's (2016) computing education study echoed these findings, but also finding vicarious and physiological states as predictive of computing self-efficacy and persistence. In combination these studies present complex nature of a student's developing relationship with these content areas within an academic environment.

These findings and this data in combination with Mamaril et al.'s (2016) discussion of academic self-efficacy development show physiological response are significant variables for predicting persistence in engineering and computing disciplines. Using a first-year design project, Booth et al. (2012) created a comprehensive, supported environment to build academic self-confidence. The result showed all sources of self-efficacy were observable in their findings leading to a greater confidence with engineering content and stronger sense of involvement in the academic community.

Moving away from deficit thinking creates an inclusive academic environment, increasing the ability for institutions to widen access to engineering and computing disciplines(Castro, 2021; Guzdial, 2008; Riley, 2021; Smit, 2012). A South African university normalized any level of academic preparation in entering first-year mechanical engineering students as contributing to their development as NGE's (Qonda, 2017). To support first-year AUP students, Qonda implemented a peer-assisted learning program as a sustainable support solution, gathering feedback on impact and improvement. The program improved study and problem-solving skills along with methods of coping with assignments and tests. Participants reported the value they found in an academic community where they could develop confidence with content, learn to ask and answer questions, and believe their college was interested in their success. Integrated, monitored, and guided student peers programs recognize and integrate these valuable connections into the academic community (Anderson et al., 2015; Johnson et al., 2011; Kisch, 2012). Monitoring and providing training demonstrates interest in encouraging quality experiences and minimizes risks associated with peer programs (Attarzadeh et al., 2011; Colvin et al., 2010; Leidenfrost et al., 2011, 2014)

Academic Community

Data from this study supports the idea that a student's relationship with engineering or computing content is a product of sources of academic self-efficacy in combination with their engagement with environmental influences. Building off the robust community Hans and Li joined as part of athletics provides evidence that an intentionally structured environment makes a difference. The transition from high school to college includes more than changing academic learning environments. For new Freshman, life as they have known it changes fast and on multiple levels (Conley, 2005; Schreiner, 2010). Using Bronfenbrenner's (1993, 1995b, 1995a, 1999) contextual layers to describe the significance of this change in a student's mesosystem from their family home to their college home and the microsystems that change. Microsystems are those immediate influences in a person's environment (Bronfenbrenner, 1993, 1995b, 1995a, 1999). For Freshman these can be roommates, classmates, professors, academic advisors, peer leaders, and representatives in college administrative offices. Their proximity and frequency of engagement over time is a key factor in their development (Bronfenbrenner, 1993, 1995b, 1995a, 1999). When Freshman move from home to college living environments microsystems from home environments shift from the mesosystem to the exosystem. Finding similar trusting support systems strengthen social persuasion as a source of self-efficacy development (Purzer, 2011; Sachitra et al., 2017). Students learn quickly their lives are changing faster and more dynamically than originally anticipated. Decisions become important and the cost factor of mistakes are higher. Clear signs pointing out stepping-stones across the river, either through coaching or demonstration, increase the probability first-year students will successfully reach the riverbank on the opposite side.

Environment Structure

Using Bronfenbrenner's environmental systems thinking (1993, 1995b, 1995a, 1999) and Bandura's (1997c) self-efficacy sources, the structure of the AUP retention program was modified slightly for the study cohort. Through the application of modular systems thinking, the structure of the environment and the presence of self-efficacy sources were considered (Madhavan, 2015, 2016). The study cohort environment provided a network of current experts, peer mentors, similar-aged peers, and expectation of weekly engagement for 6 weeks. It provided a community focused on similar goals, much like a college sports team. In sharing their perspectives, Hans and Li described the robust support structure of the athletics program. When comparing the components of these two programs the similarities were quickly recognized and paired as shown in Figure 5.5. The four components of this study's AUP retention program structure align with support structures available through MSU's athletics program. Starting with the upper-left side of the image, MSU Athletics provides academic support staff and coaches who support the players well-being, preparation for their sport, and academic progress to meet eligibility requirements which compares to Specialized Academic Advising and Class attendance in NACOE's retention program for AUP students.

Next, teammates serve in the role of peers and peer mentors. Hans and Li described the value of time they spent in the locker room talking or listening to other players and learning or being encouraged by their experience. College sports includes coached practices to prepare players for their role on the team and competitions where teams test the results of the work they have done. In an academic setting, this compares to student clubs and organizations coached by a faculty advisor, but dependent on the developing team members to plan, design, and implement projects either for competition or contribution to a community. Finally, not leaving the transition from high school to college or academic success to chance, MSU Athletics organized classes and supported study programs which create a community of student athletes, normalize the need for learning how to "do" college and increase potential for success. Ariel and Hans both commented on being new to the college environment and appreciative of support helping to become familiar with new systems. Adding weekly group meetings (like sports practice) as a component of the AUP retention program created the beginnings of a community. For Elsa and Ariel, the weekly meetings provided support like Athletics' life skills class by providing tips on how to make the transition to a college environment.

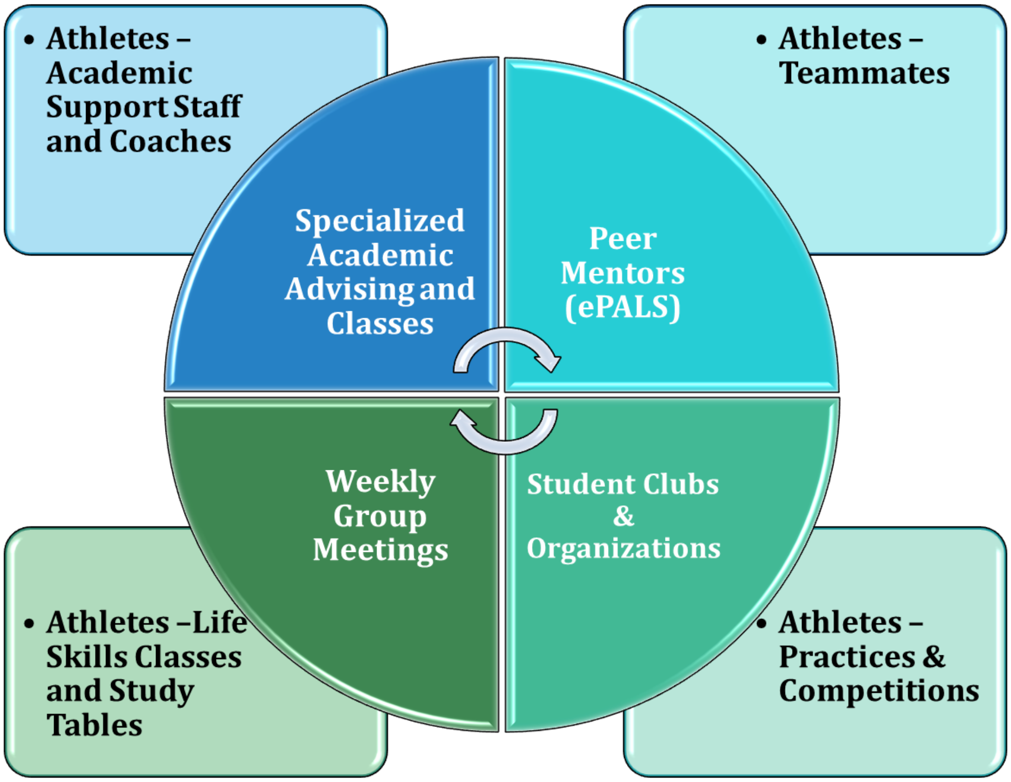


Figure 5.5. AUP Program Structure Comparison to MSU Athletics Program Structure

In 2016, Lewellyn et al. (2018) formed an NSF-funded consortium of Redshirt programs with the purpose of expanding the program to additional engineering colleges. Borrowing from the college athletics practice of redshirting athletes to support their transition, these programs address diversity, equity, and inclusion related to STEM disciplines including students arriving AUP. Redshirt-style programs followed the GoldShirt model established at University of Colorado Boulder (CU Boulder) which included a summer program, mastery experiences with technical content, community building with peers in their cohort, peer mentorship and current expert engagement (Ennis et al., 2010). Like the South African university program (Qonda, 2017) this program normalized situations which contribute to college readiness and included monetary support to remove barriers related to the financial cost of pursuing an engineering or computing degree.

Dynamic Relationships

Bioecology theory highlights relationships and their influence on an individual's development (Bronfenbrenner, 1993, 1995b, 1995a, 1999). For college students, they are developing relationships with new places, new people, new concepts; and blending them together with their own experience (Bhaduri et al., 2017; Marra et al., 2009; Strayhorn et al., 2013). Vicarious experience and verbal or social persuasion come from engagement with the environment and establishing relationships (Bandura, 1997c). Fostering a strong sense of community are at the heart of the GoldShirt in Engineering program at CU Boulder and Redshirt in Engineering Consortium programs at a number of universities (Ennis et al., 2010; Llewellyn et al., 2018). These programs included similar components to the intervention for this study and are designed to support diversity, equity, and inclusion with the idea of changing the college environment while responding to the need for NGE specialists in the career field (Ennis et al., 2010; Llewellyn et al., 2018).

Equally important are the peer-to-peer networks which were established between program participants and more experienced students (peer mentors) who had begun their academic journey from a similar foundation. In addition to similar attributes, Bandura (1997b), individuals look for behaviors and performance models to assist their progression through personal experiences. Student engagement with their college environment is the product of many relationships and influencing factors. To encourage engagement and minimize financial worry the programs include a monetary support feature. Its purpose is to remove the worry associated with pursuing an academically challenging degree which requires foundational coursework to be completed first.

The data showed peer mentoring in both formal and informal styles proved to be a helpful retention method. Timely informal peer mentoring described by Hans and Flynn influenced their perception an engineering degree was attainable regardless of their math level. Bandura (1997c) explains vicarious experiences provide environmental cues from sources believable to students, in this case. The data supported this idea demonstrating peer feedback in both these methods led to academic confidence. Having a peer network was noted as critical support for other participants and as a contributing factor to the NACOE's name sake, Norm Asbjornson's, ability to arrive AUP with the goal of becoming an engineer and achieve it (Nickerson, 2018). An ASEE study of best practices in engineering and computing education include programs fostering community through peer connections (Yoder, 2012). These existing practices provide starting places for promoting retention and persistence in Underrepresented Groups (URG), and AUP students interested in engineering and computing careers. Student participant experiences in this study included those with peers who were engineering or computer science majors and those who were not. These peer experiences supporting their ability to learn how to function in a new environment and meet their academic goals.

Although limited in its power as a singular self-efficacy contributor, verbal or social persuasion from a current expert serves as a method of strengthening an individual's belief in their ability to accomplish their goals (Bandura, 1997c). Authentic, persuasive feedback from knowledgeable and credible sources can be used as a means of fostering sustained effort toward accomplishing a challenging task (Bandura, 1997c; Usher et al., 2009). Ariel's statement about her college experience; "I've never been to college before…," demonstrates that she was looking for cues from her academic environment to support her success. Her decision to participate in the pilot program suggests not just any support would do and aligns with Bandura's (1997c) concept of verbal or social persuasion. He explains the need for credible, trustworthy sources who can provide knowledgeable guidance through what is relevant to an individual's circumstance (Bandura, 1997c).

Added to this robust community feedback from athletic coaches, instructors from their classes, and academic advisors both Hans and Li were confident in their ability to make a solid choice in an academic pursuit. Just as important was their confidence in having a network to help them see or figure out how to be successful. Focusing on the unexpected news several AUP participants received regarding their math level, the range of emotions became a factor in degree choice. For others, they valued feedback from their academic advisors who assured them there was support for their goals including a degree path. It is true all ended up realizing they were in the appropriate math class for their preparation, but initially the range of emotions experienced became a factor in degree choice. Returning to the leaping a river at full-speed analogy, having an academic advisor was a valuable relationship for students. Using their advisor's help, they had been directed to steppingstones assisting them in making the crossing with more manageable leaps.

Implications for Practice

Students interested in engineering and computer science majors arriving AUP to college campuses would benefit from gracious space. *Gracious space* is an emotionally safe, adaptive environment where healthy growth occurs between everyone involved in the experience (Hughes et al., 2004). Patricia Hughes (2004), with the Center for Ethical Leadership, developing this idea and method of supporting change in groups where diverse perspectives are present. Briefly defined the four constructs of this method include the *spirit* you bring with you to a place. Recognizing your demeanor and readiness to engage with the environment influences outcomes. *Setting* considers how the environment is structured, including how tables and chairs are organized or the presence of simple hospitality markers such as food and beverages. Issuing an *invitation to the stranger* is about inviting those with a different perspective toward a topic or issue either due to their background, race, gender, experience, or other qualities which provide a new way of viewing an idea. Finally, *learn in public* is a mindset to be open to the new perspectives being brought to the stage. Being willing to set aside bias or judgement to listen with the intent of collaborating and establishing a new way of thinking or addressing a problem or situation.

While not a formalized gracious space environment, the NACOE invites AUP students to consider disciplines in these subjects by not having pre-engineering or pre-computing programs and a single application for acceptance to the college which happens through the university's Admissions Office. Invitations to join an environment must be followed by a plan to encourage and foster engagement which values the input from the individual. This section presents an overall implication for practice in the NACOE, and perhaps the larger university, with several approaches to consider as solutions.

Using Hughes' (2004) idea of fostering community change through understanding the members involved at the heart is providing gracious space which allows for collective growth. From the literature and this data, students engage with higher education environments to prepare them to enter into work force positions (National Science Board, 2019; Riley, 2021; Wang, 2013). It is important to recognize each group depends on the other but have their own agenda and desired outcomes from their relationships. Data from this study presents the idea that students (the NGEs) will commit the time and energy it takes to learn new content, but ultimately, students need to know the academics line up with a career they will like doing. College is the place students believe will support their development of a relationship with people, content, and careers.

This study focused on the AUP student agenda and their perception of how the NACOE's retention program supported their academic self-efficacy with engineering or computing content. Findings showed some AUP students processed learning about their math level by worrying they were too far behind or had to catch up. Their perception of not having gracious space to learn the academic content needed for the majors they were interested in was part of their filtering process in continuing with a major in engineering or computing. Moving the needle on the retention scale is most effective when the student is motivated. This study did not look at motivation; however, it did look at student physiological response to their academic environment and its influence on their self-efficacy related to engineering or computing content. Part of their filtering process was related to feedback from their environment that a degree must be completed in 4-years and this influenced persistence for some participants.

When an AUP student decides an engineering or computing major is where their interests lie because they like the careers these disciplines lead, chances are it will take them longer to graduate. Pushing a 4-year agenda does not foster a relationship consistent with the invitation to meet students where they are and move them forward, particularly for Montana students who wish to become engineers or computer scientists. In fact, in combination with academic pathways beginning at calculus to finish in 4-years, financial aid supports ending after the 8th semester and requiring a 15-credit-per-semester minimum for academic scholarships to payout sends the message of an empty promise. If a student arrives AUP, they will need more time to complete an engineering or computer science degree and funding to support their goals. Gracious space practices, *spirit, setting, invite the stranger and learn in public* invite students with the intention of meeting them where they are, learning how to coach alignment between them and the college environment, and then creating a reasonable pathway forward which provides equitable opportunities as their AR peers.

Offering fast-tracked summer courses delivered in 4-week or 6-week time frames to learn complex content at high tuition and housing costs is neither a solution – nor in line with gracious space practice. This solution robs students of opportunities to earn money to off-set college costs and/or participate in paid internships in a work force environment aligning with their degree. This offer mostly benefits the university and further separates AUP students from their AR peers. The literature around deficit thinking pushes for normalizing pursing STEM degrees from any academic preparation level (Castro, 2014; McKay et al., 2016; Smit, 2012). Hughes' (2004) concept around gracious space invites strangers to a public space to learn and foster learning in return. Inviting students to a college campus to pursue any discipline, in this case engineering or computing, will only be effective if there is space normalizing the condition in which they arrive. By not having pre-engineering or pre-computing programs and a single application for acceptance, MSU and the NACOE have extended an open invitation. What needs to follow is the development of gracious space for those who respond.

Faculty at University of Colorado's (CU Boulder) engineering college recognized the need to respond. Ennis et al. (2010) developed the GoldShirt in Engineering program patterned after the Redshirt concept for college student athletes which provides summer practices to improve performance, an extra year to support their role as student athletes, and a strong academic support community to promote success. The success of the GoldShirt program led to a larger, National Science Foundation funded project by Llewellyn et al., (2018) to develop the Redshirt in Engineering Consortium demonstrating this is a growing prospect for supporting AUP student interested in engineering or computing degrees and careers. Data from this study supports this approach as one to consider in supporting AUP students interested in engineering or computing majors. This style of program would provide an academic community networked with peers, faculty, and support resources to help students process their interest in engineering or computing disciplines.

As a problem of practice study seeking to implement a solution at its completion, a Redshirt-style program includes a significant, sustained-resource commitment presenting it as a challenging immediate-action item for the NACOE. Study participants provided feedback on other solutions that would interest them and provide support for future students arriving AUP and interested in engineering or computing majors. First, Ariel suggested a student club aligning with her perspective that AUP students should *choose* to engage with the program. It aligned with her belief that if a student was forced to participate it would affect their engagement with the program and the sense of community. Second, Mulan, Elsa and Flynn suggested different versions of a credit-bearing courses to provide support to students transitioning to college. Mulan had participated in a course prior to the first day of classes. It allowed her to move in early, engage in activities structured around a topic directed by faculty, meet new people, and become comfortable with a new environment. Thinking along the similar lines, Elsa and Flynn suggested a semester long class providing similar support. Either platform would solve a problem AUP students experience meeting a 15-credit minimum requirement to maintain access to financial scholarships. Often students are compelled to find a 1-credit course to meet the minimum required credits and take activity classes they are not excited about. Creating a course with content designed to support transitioning to college AND exploring engineering or computing disciplines would provide social/verbal persuasion from current experts. In addition, connections with college peer mentors could be made in addition to fellow student Freshman sharing similar aspirations and academic foundations.

Supporting academic self-efficacy development in AUP students considering engineering or computing majors is a complex problem. Findings from this study support creating environments for AUP students to explore engineering and computing disciplines. These environments should include a space which normalizes academic readiness levels, listens to the student experience, and understands they are processing experiences with multiple, simultaneous environments through a physiological response filter which leads to their final decision to persist in an engineering or computing discipline. It is naïve to believe every AUP student curious about engineering or computer science careers will persist in through these academically challenging majors. However, if an AUP student chooses to pursue a non-STEM major, it should be because their career aspirations align more closely with that field of study. The decision should not be because of a perception of insufficient time, funding, or academic support to pursue a STEM discipline

Limitations and Future Research

Present in this study were limitations that must be acknowledged. These include the location of this study, which was conducted at a large, rural research university. As a problem of practice study, the decision to examine a small population to understand the student perspective related to a retention program was informed by efforts to support AUP students interested in engineering or computer science majors. As an intentionally targeted effort, it may be difficult to generalize these findings to larger and/or more urban student populations. However, establishing academic community groups in a similar fashion to athletics programs should be considered as new approach to promoting student retention. Student populations have their own unique characteristics which are important in creating programs to support retention and persistence. Creating an academic community which fosters progression to a common goal without a timeline should be considered as a retention approach, particularly in AUP populations. This study is part of a growing effort to understand how best to contribute to educating the NGE in engineering or computer science and doing so by focusing on non-traditional populations entering these disciplines. Future work is needed to monitor effectiveness of programs in meeting goals to widen access to engineering and computer science careers and what this looks like in other locations.

Another limitation was the focus specifically on AUP students in a single college and the small sample size. Generalizing these findings to the larger AUP student population, particularly in other disciplines, would present a challenge. There was gender and a small range of racial diversity, and all participants arrived interested in engineering or computing disciplines. Using phenomenography as a research approach provided a way of describing findings from this study as the start of exploring the range of AUP student experiences with NACOE retention programs and their contribution to academic self-efficacy development (Alsop et al., 2006; Barnard et al., 1999). However, the 8 participants were not broad enough to generalize the findings with confidence to the larger AUP cohort declared in NACOE majors. Transferring findings to populations in other STEM or non-STEM majors would require consideration of nuances in student groups in these disciplines. Future work should include AUP students from a wider range of majors and diverse groups including non-traditional aged, American Indian, and Hispanic.

Finally, this work uses work from seminal researchers in higher education, engineering education and computing education and applies it in a contextual fashion using a complex theoretical framework. As noted by Seidman (2012) and Tinto (2012b), more practitioners are needed to apply current theories in a complex fashion. Understanding and exploring the complex academic environment and its influence on academic self-efficacy development in AUP student populations is needed if we are going to move the needle on the retention scale. To do so, more research is necessary using complex theoretical frameworks to understand what factors are involved and how they work in conjunction to inform decisions students make to choose academic directions. For engineering and computing colleges, understanding the retention problem, and implementing solutions tailored to meet the needs of a wider range of characteristics in student population is their own grand challenge for the 21st Century.

Conclusion

This study sought to understand AUP student academic self-efficacy related to engineering and computing content and their experiences with a college retention program. The complex theoretical framework informing this study and data analysis provided a method of explaining how extrinsic and intrinsic processes synthesize within the student leading to a response to environmental spaces and development of relationships. Through this lens the data showed a new way of considering how sources of self-efficacy work together influencing student response to their environment and decisions related to challenging academic content. Rather than considering each source of self-efficacy as their own influential element, physiological states became the filter through which students respond to environmental influences through mastery, vicarious, and social/verbal persuasion experiences.

This is important when considering environmental factors AUP students experience when arriving to college and begin interacting peers, faculty, and staff in academic, social, and living spaces daily. Students arrive on college campuses with some level of knowledge, skill, and experience which has informed awareness of their talents. Based on their interests they select a set of classes and begin learning from current experts while they assess if their academic direction is appropriate. A range of physiological responses contributed to how AUP study participants made decisions related to mastery, vicarious, and social/verbal persuasion experiences. These decisions were a synthesis of engagement with many environments (e.g.: living, social, family, classroom), blending with internal physiological responses and informing things like academic choices.

Students seek to establish relationships within the college environment to support their transition into higher education and their academic disciplines. How these environments are structured is important. Strong, well-organized, cohesive environments that foster healthy relationships with peers, faculty and academic content have a better chance of retaining students, particularly those arriving AUP and considering engineering or computing majors. Programs like CU Boulder’s, GoldShirts in Engineering have borrowed from college athletics structures to create inclusive environments for AUP students and foster persistence. These environments foster relationships with peers, faculty, and academic content in engineering and computing majors.

Inviting AUP students to pursue engineering and computing degrees must include the gracious space for them to begin from any academic readiness level without judgement. Because of the depth and breadth in these academic disciplines, the invitation must be paired with a reasonable path that normalizes their preparation. While this study had limitations due to the sample size and location, the literature supports this idea through the concept of avoiding deficit thinking. Deficit thinking places the student in a position of being disadvantaged due to how they were raised, where they went to high school or if they have parents who graduated from college. This literature explains AUP students benefit from environments which normalize their preparation and provides reasonable pathways forward that bridge rather than extend the gap between them and the AR peers.

This study contributes to the literature by demonstrating a need for using comprehensive theoretical frameworks to understand the student experience. The importance of supporting more interest in engineering and computing majors to fill the need within the work force has been clearly communicated. High school students are being called on to become the NGE in engineering or computing disciplines. The growing population of students arriving AUP for STEM majors indicates they are responding to the call. If AUP students are willing to respond to the call to come, engage repeatedly with challenging material, they should be met with an environment designed to help them accomplish their agenda.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPLICATION FOR REVIEW

Full Committee Review
Expedited Review X

MONTANA STATE UNIVERSITY
Institutional Review Board Application for Review
(revised 06/01/15)

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THIS AREA IS FOR INSTITUTIONAL REVIEW BOARD USE ONLY. DO NOT WRITE IN THIS AREA

Application Number: Approval Date:
Disapproved: IRB Chair's Signature:

****
****

Date:

I. Investigators and Associates (list all investigators involved; application will be filed under name of first person listed)

NAME: Jennifer Clark TITLE: Student Success Coordinator
DEPT: Norm Asbjornson College of Engineering PHONE #: 406-994-7836
Complete Department and/or Home Address (where you want the approval letter sent):
E-MAIL ADDRESS: jennifer.clark6@montana.edu
DATE TRAINING COMPLETED: __10-27-2019_______

SIGNATURE (PI or ADVISOR): ______________________________

NAME: Maria A. Velazquez TITLE: Diversity and Inclusion Leader - Empower
DEPT: Norm Asbjornson College of Engineering PHONE #:406-994-7193
COMPLETE ADDRESS:
E-MAIL ADDRESS: maria.velazquez@montana.edu

DATE TRAINING COMPLETED: _11/12/2019_________

Do you as PI, any family member or any of the involved researchers or their family members have consulting agreements, management responsibilities or substantial equity (greater than $10,000 in value or greater than 5% total equity) in the sponsor, subcontractor or in the technology, or serve on the Board of the Sponsor? _____ YES _X__ NO

If you answered Yes, you will need to contact Kellie Peterson, Legal Counsel-JD at 406-994-3480.

II. Title of Proposal: NACOE COE-Xploration2: Considering Environment Connections as Support for Developing Academic Self-Efficacy

III. Beginning Date for Use of Human Subjects: August 16th 2020 – or after official IRB approval is received.

IV. Type of Grant and/or Project (if applicable): NACOE COE-Xploration2: Considering Environment Connections as Support for Developing Academic Self-Efficacy (internal)
Research Grant: N/A
Contract: N/A
Training Grant: N/A
Classroom Experiments/Projects: N/A
Thesis Project: N/A
Other (Specify): N/A

V. Name of Funding Agency to which Proposal is Being Submitted (if applicable): N/A

VI. Signatures
Submitted by Investigator
Typed Name: Jennifer Clark
Signature:
Date: 08/4/2020

Faculty sponsor (for student)
Typed Name: N/A
Signature:
Date:

VII. Summary of Activity. Provide answers to each section and add space as needed. Do not refer to an accompanying grant or contract proposal.

A. RATIONALE AND PURPOSE OF RESEARCH. (What question is being asked?)

The College of Engineering - Xploration (COE-X) program provides specialized academic advising and discussions to support academic program planning and exploration of the engineering and computing career fields. Since implementation, the COE-X program has supported 869 students, over 17% of incoming Freshman between 2014 -2019, data from MSU's Office of Planning and Analysis. Table 1 presents a comparison between COE-X and Non-COE-X student groups. Compared to their peers who arrive ready for pre-calculus or higher levels of math, this population:

- Takes longer to complete an engineering or computer science degree;
- Are more likely to use academic coaches;

- Demonstrate an academic performance 0.5 GPA points lower than their Non-COE-X peers;
- Be on academic probation within their first year; and
- Less likely to attend college events.

In addition to relying more heavily on student loans and including a higher percentage of first generation and Pell eligible students, COE-X participants include a significantly higher percentage of underrepresented populations than their Non-COE-X peers. Underrepresented populations in the NACOE include: first generation, Female, American Indian or Alaska Native, Black or African American, Hispanic, Native

Table 1: *COE-X and Non-COE-X Student Comparison. Data from MSU Office of Planning and Analysis*

	Gender		Under-represented Populations	GPA	Use of Support Services	Engage-ment	Academic Probation	Time to Degree
	Male	Female						
COE-X	15%	3%	35%	2.51	14%	8 visits	24%	4.4 years
Non-COE-X	67%	15%	9%	3.06	10%	13 visits	11%	3.9 years
Total Freshman	4918							

Hawaiian, and students who identify with the LGBTQ+ community.

These outcomes and the 56% retention average of COE-X cohorts (compared to 71% in non-COE-X cohorts) demonstrated significance in the disadvantages under-academically prepared students face when compared to peers arriving ready for higher level math and science courses. Exploring methods of supporting under-academically prepared students is an important problem to study and part the MSU's strategic plan and the NACOE's mission and vision.

Project Description:

Currently COE-X provides strategic academic advising to under-academically prepared students seeking a degree in engineering or computing.

This pilot project, College of Engineering – Xploration2 (COE-X2) expands the COE-X program to include 6 weekly workshops, targeted group peer mentoring, professional student association connection, and 1 Focus Group session to pull data related to student perceptions of this revised program and its support of their academic self-efficacy.

NACOE ePALS will provide the peer connection at each discussion session, lead one of the sessions, and facilitate connecting COE-X2 participants with a NACOE club/organization aligning with their interests.

NACOE Faculty will be invited to present a 15-minute presentation on key topics for at least 2 of the discussion sessions.

Project Objectives:

There are 3 student-directed objectives:

1. Increase student understanding of engineering and computer science to support identity development with academic concepts and establish a perspective and path toward engineering or computing careers.
2. Establish an academic community within the NACOE and foster an identity with academic content related to engineering and computing programs.
3. Influence development of academic self-efficacy with engineering or computing

The overall program objective is to increase the number of COE-X students who engage with support resources and persist to degree completion. Participant feedback will be gathered to obtain a perspective of how COE-X2 influences sources of academic self-efficacy from a college environment. The following research questions will inform an interview protocol.

Questions	Sub-Questions	
1	In students who participated in the COE-X2 program, what are their perceptions related to academic self-efficacy development in engineering and computing subjects?	
	1a	What are student perceptions related to their belief they can be successful with engineering and computing content? (ME)
	1b	What are student perceptions related to their interactions with peer mentors in engineering or computing disciplines? (VE & VP)
	1c	What are student perceptions related to weekly COE-Xpanded discussions with engineering or computing faculty to provide academic encouragement? (VP)
	1d	What are student perceptions related to physiological responses to academic content in engineering or computing subjects? (PH)
2	In students who participated in the COE-X^2 program, what are their perceptions of college resources that contributed to academic self-efficacy development in engineering and computing subjects?	
	2a	What are student perceptions related to peer mentor contribution to their academic self-efficacy related to engineering or computing subjects? (VE)

	2b	What are student perceptions related to faculty and staff contributions to their academic self-efficacy related to engineering or computing subjects? (VP)
	2c	What are student perceptions related to a class organized to support academic self-efficacy development? (PH)

B. RESEARCH PROCEDURES INVOLVED.

All 1st year, College of Engineering - Xploration (COE-X) participants will be invited to participate in a 7 week organized program. College of Engineering - Xploration2 (COE-X2) program students will be invited to participate in a 6 lesson seminar in which topics such as resilience, engineering problem solving and impostor syndrome will be addressed, among other topics. Students electing to participate will register for the program using Sign-up Genius. A consent form will be given to participating COE-X students prior the 1st meeting for their review with an opportunity to ask questions and opt in or out before attending the first meeting to avoid a need to publicly decline participation. At the opening event, participants will be asked to submit a signed consent form (attached). Participants will be allowed to stop the program at any time during the 7 weeks. Participants will be provided an opportunity to review research prior to any publications to confirm interpretation of findings related to their input. The results of the study will be available to the students upon request.

C. DECEPTION - If any deception (withholding of complete information) is required for the validity of this activity, explain why this is necessary and attach debriefing statement.
N/A

D. SUBJECTS

1. Approximate number and ages
   How Many Subjects: **40**
   Age Range of Subjects: **18 years old and above**
   How Many Normal/Control: **N/A**
   Age Range of Normal/Control: **N/A**

2. Criteria for selection: **Beginning engineering or computer science major at College Algebra or lower math level. Academic advising is provided through a COE-X program advisor.**

3. Criteria for exclusion: **Beginning engineering or computer science major at Pre-calculus or higher math level. Academic advising is not provided through a COE-X program advisor.**

4. Source of Subjects (including patients): **COE-X program participants (pool)**

5. Who will approach subjects and how? Explain steps taken to avoid coercion.
   Please see attached email sample

   a. **Jennifer Clark, Student Success Coordinator for the NACOE will send email invitations to Incoming Freshman COE-X students informing them about COE-X^2 and explaining what it is and how it will help them.**
   b. **To increase potential for a diverse sample, an email invitation will first be sent to students who meet the under-represented populations in STEM demographics. Two days later the remainder of the COE-X student population will receive an email invitation.**
   c. **Depending on response rate, student candidates may be contacted via cell phone to extend a more personalized invitation. To minimize coercion, students will be invited to access their email invitation to register as a participant in COE-X^2.**
   d. **Students will also be informed their decision to participate is voluntary and not required in order to receive currently established COE-X program services.**
   e. **Students will be assured their input would be confidential and their identity would be separated from their survey responses. Jennifer Clark oversees the COE-X program and coordinates interventions with their academic advisor as needed.**

6. Will subjects receive payments, service without charge, or extra course credit?
   Yes or **No**
   (If yes, what amount and how? Are there other ways to receive similar benefits?)
7. Location(s) where procedures will be carried out.

Program Structure:

40 COE-X^2 Participants			
WebEx Group 1 20 participants Weeks 2-6		WebEx Group 2 20 participants Weeks 2-6	
Week 1 & 7 Face-to-Face		Week 1 & 7 Face-to-Face	
1 ePAL Liaison who would coordinate connection with this group	1 ePAL Liaison who would coordinate connection with this group	1 ePAL Liaison who would coordinate connection with this group	1 ePAL Liaison who would coordinate connection with this group
1 faculty 1 administrator (Maria/Jen) who will coordinate discussion topics	1 faculty 1 administrator (Maria/Jen) who will coordinate discussion topics	1 faculty 1 administrator (Maria/Jen) who will coordinate discussion topics	1 faculty 1 administrator (Maria/Jen) who will coordinate discussion topics
1 academic advisor – Emily Mason	1 academic advisor – Emily Mason	1 academic advisor – Emily Mason	1 academic advisor – Emily Mason

Program Plan:

Self-Efficacy Survey Distributed to ALL COE-X students				
Invitation to participate extended.				
Locations may change due to COVID-19 protocols for Week 1 and Week 7				
	Group 1	Group 2	Topic	
Week 1 F2F	Aug 27	Aug 27	Welcome - Explanation of purpose, structure and expectations Modified, ePALS delivered NACOE Club & Organization Fair match-up	Jen Clark; Maria Velazquez; Amy Stix; Brett Gunnink; Christine Foreman; ePALS members
Week 2	Sept 3	Sept 3	14 Grand Challenges for the 21st Century Engineer/Computer Scientist	*Brock LaMeres* *Clem Izurieta*
Week 3	Sept 10	Sept 10	Resiliency in STEM – Academic Self-Efficacy	Maria Velazquez *Guest*
Week 4	Sept 17	Sept 17	Imposter Syndrome - Academic Self-Efficacy - Learning Community Engagement (Abbie Richards/Sarah Codd)	*Sarah Codd* *Stephanie Wettstein* *MaryAnn Cummings*
Week 5	Sept 24	Sept 24	Solving Problems is about Mindset	Jen Clark *Paul Gannon*
Week 6	Oct 1	Oct 1	Peer Mentor Session: How to use academic resources; apply for scholarships; preparing for academic advising	Jen Clark ePALS
Week 7 F2F	Oct 8	Oct 8	Focus Groups	Jen Clark Maria Velazquez

Structure for Welcome Session (Outdoor, Socially Distanced protocols will be used)

I. Welcome
   a. Thank you for choosing to participate in this pilot College of Engineering Exploration program.
   b. Introduce myself
   c. Introduce Maria
   d. Introduce ePALS liaison and any attending the event.

II. Explain the structure

a. 7 weeks
b. 60 minute meetings (Week 1 and Week 7 will be face-to-face in a socially distanced setting; Weeks 2-6 will be held through WebEx Events)
c. Participants are asked to commit to full 7-week program
d. Participants will receive a $25 MSU Bookstore gift card as a small thank you from the college
e. Participant will also receive a $25 MSU Bookstore gift card should they choose to participate in the Focus Group to provide feedback about the COE-X^2 program.
    i. 1st week is the overview, welcome and connection to ePALS who will talk about how getting connected with clubs/organizations can help explore interest areas in engineering and computer science.
    ii. 2nd week – 6th week will be held via WebEx events.
        1. Each event will have a topic introduced by a faculty member (about 10-15 minutes) followed by a discussion session allowing for questions.
        2. ePALS will join to facilitate connections. COE-X participants are encouraged to meet with peer mentors in other settings.

Structure for WebEx Workshops (50 minutes)

I. Welcome (3 minutes)
II. Introduce Topic and Guest Presenter (2 minutes)
III. 10 minute – topic driven – guest presentation
IV. 30 minute facilitated discussion (participants & ePALS)
V. 5 minute wrap up, thank you & dismiss

Structure & Semi-Structured Interview Protocol for Face-to-Face Focus Small Groups
(60 minutes)

See attached semi-structured interview protocol and consent waiver

I. Welcome (2 minutes)
II. Explanation of Focus Group Purpose and Informed Consent Waiver (3 minutes)
III. 45 minute – protocol driven interview
IV. 10 minute wrap up and signature for gift card(s).

E. RISKS AND BENEFITS (ADVERSE EFFECTS)

1. Describe nature and amount of risk and/or adverse effects (including side effects), substantial stress, discomfort, or invasion of privacy involved. **COE-X^2 participants will be asked to commit 1 hour of their time per week for 7 weeks (total of 7 hours) to this program. They will be asked for permission to record the WebEx sessions and final Focus Group**

sessions in order to gather data for analysis. Only the text from the recordings will be used for analysis and any identifying details will be separated in order to preserve confidentiality. With these precautions, there limited foreseen stress, discomfort or invasion of privacy associated with student participation in this program and study.

Participants will be offered modest, monetary benefits as a token of gratitude for their engagement in this program and study:

2. Describe nature and amount of risk and/or adverse effects (including side effects), substantial stress, discomfort, or invasion of privacy involved. **COE-X^2 participants will be asked to commit 1 hour of their time per week for 7 weeks (total of 7 hours) to this program. They will be asked for permission to record the WebEx sessions and final Focus Group sessions in order to gather data for analysis. Only the text from the recordings will be used for analysis and any identifying details will be separated in order to preserve confidentiality. With these precautions, there limited foreseen stress, discomfort or invasion of privacy associated with student participation in this program and study.**

   Participants will be offered modest, monetary benefits as a token of gratitude for their engagement in this program and study:

   Participant Incentive:
   - $25 gift card (at week 7) ($1000)
   - Snacks for Week 1 Meeting ($75 - $100)

   Focus Group Participant Incentive:
   - $25 gift card ($1000)
   - Dinner/Snacks for Week 7 Focus Group Sessions ($75-$250)

2. Will this study preclude standard procedures (e.g., medical or psychological care, school attendance, etc.)? If yes, explain.
   No

3. Describe the expected benefits for individual subjects and/or society.
   Students will benefit from college supported:
   - **Strategies to explore engineering and computing fields;**
   - **Engaging weekly with a peer mentor from their college;**
   - **Identifying support systems within their college;**
   - **Networking with faculty presenters; and**
   - **Development of an identity as an engineering or computing student.**

Through guided, topic driven conversations with college faculty and staff, students will obtain an awareness and knowledge about engineering and computing fields. Such knowledge will help them begin to recognize what they find exciting about their academic goals and that there are others, like them, who have aspired to pursue STEM careers. The next generation of COE-X students will benefit from the results of this pilot study, as new interventions and tools will be designed based on the results of this study.

F. ADVERSE EFFECTS

1. How will possible adverse effects be handled?

   By investigator(s): **Students will be encouraged to discuss their concerns with Jennifer Clark.**
   Referred by investigator(s) to appropriate care: **Appropriate resources will be provided to address or resolve concerns.**
   Other (explain):

2. Are facilities/equipment adequate to handle possible adverse effects? **Yes** or No
   (If no, explain.)

3. Describe arrangements for financial responsibility for any possible adverse effects.

   MSU compensation (explain):
   Sponsoring agency insurance:
   Subject is responsible: **X**
   Other (explain):

G. CONFIDENTIALITY OF RESEARCH DATA

1. Will data be coded? **Yes** or No

2. Will master code be kept separate from data? **Yes** or No

3. Will any other agency have access to identifiable data? Yes or **No**
   (If yes, explain.)

4. How will documents, data be stored and protected?
   Locked file: **X**
   Computer with restricted password: **X**
   Other (explain):

VIII. Checklist to be completed by Investigator(s)

A. Will any group, agency, or organization be involved? **Yes** or No
(If yes, please confirm that appropriate permissions have been obtained.)

This study is being conducted with the support of the Empower Center in the Norm Asbjornson College of Engineering. The Empower Center supports all under-represented populations in STEM including American Indian or Alaska Native, Black or African American, Hispanic, Native Hawaiian, and Female.

Maria Velazquez, Empower Program Coordinator and Faculty-in-Residence; Amy Stix, Empower Center Director; and Brett Gunnink, Dean of the Norm Asbjornson College of Engineering are part of the organization and delivery of this project.

B. Will materials with potential radiation risk be used (e.g. x-rays, radioisotopes)?
Yes or **No**

1. Status of annual review by MSU Radiation Sources Committee (RSC).
Pending or Approved
(If approved, attach one copy of approval notice.)

2. Title of application submitted to MSU RSC (if different).

C. Will human blood be utilized in your proposal? Yes or **No**
(If yes, please answer the following)

1. Will blood be drawn? Yes or **No**
(If yes, who will draw the blood and how is the individual qualified to draw blood?
What procedure will be utilized?)

2. Will the blood be tested for HIV? Yes or **No**

3. What disposition will be made of unused blood?

4. Has the MSU Occupational Health Officer been contacted? Yes or **No**

D. Will non-investigational drugs or other substances be used for purposes of the research? Yes or **No**

Name:
Dose:
Source:
How Administered:
Side effects:

E. Will any investigational new drug or other investigational substance be used?
Yes or **No**
[*If yes, provide information requested below and one copy of: 1) available toxicity data; 2) reports of animal studies; 3) description of studies done in humans; 4) concise review of the literature prepared by the investigator(s); and 5) the drug protocol.]*

Name:
Dose:
Source:
How Administered:
IND Number:
Phase of Testing:

F. Will an investigational device be used? Yes or **No**
(If yes, provide name, source description of purpose, how used, and status with the U.S. Food and Drug Administration FDA). Include a statement as to whether or not device poses a significant risk. Attach any relevant material.)

G. Will academic records be used? **Yes** or No
For identification of eligibility based on mathematics level.

H. Will this research involve the use of:
Medical, psychiatric and/or psychological records Yes or **No**
Health insurance records Yes or **No**
Any other records containing information regarding personal health and illness Yes or **No**

If you answered "Yes" to any of the items under "H.", you must complete the **HIPAA worksheet**.

I. Will audio-visual or tape recordings or photographs be made? **Yes** or No
The WebEx recording feature will be used to obtain an audio recording of workshop discussions. The Focus Group sessions will be audio recorded using 2 devices.

J. Will written consent form(s) be used? (**Yes** or No. If no, explain.) (Please use accepted format from our website. Be sure to indicate that participation is

voluntary. Provide a stand-alone copy; do not include the form here.) **Yes. See attached Consent Form**
See attached Interview Protocol for Focus Group sessions

COE-X^2 Pilot Study Calendar

Wk	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
31 Aug-2 Aug-8	2	3	4	5	6	7	8
32 Aug-9 Aug-15	9	10	11	12	13	14	15
33 Aug-16 Aug-22	16	17 Classes Begin	18	19	20	21	22
34 Aug-23 Aug-29	23 Study Week 1	24	25	26	27 Face-2-Face Face-2-Face	28	29
35 Aug-30 Sep-5	30 Study Week 2	31	1	2	3 WebEx WebEx	4	5
36 Sep-6 Sep-12	6 Study Week 3	7 (Holiday)	8	9	10 WebEx WebEx	11	12
37 Sep-13 Sep-19	13 Study Week 4	14	15	16	17 WebEx WebEx	18	19
38 Sep-20	20 Study Week 5	21	22	23	24 WebEx	25	26

Sep-26					WebEx		
39 Sep-27 Oct-3	**27** Study Week 6	**28**	**29**	**30**	**1** WebEx WebEx	**2**	**3**
40 Oct-4 Oct-10	**4** Study Week 7	**5**	**6**	**7**	**8** Face-2-Face Face-2-Face	**9**	**10**
41 Oct-11 Oct-17	**11**	**12**	**13**	**14**	**15**	**16**	**17**

SUBJECT CONSENT FORM FOR PARTICIPATION IN HUMAN RESEARCH AT

MONTANA STATE UNIVERSITY

Project title: *COE-Xploration^2: Considering Environment Connections as Support for Developing Academic Self-Efficacy*

You are being asked to participate in a research study related to improving student support services for engineering and computer science students in the Norm Asbjornson College of Engineering (NACOE). We are investigating the impact of a revised version of the NACOE's, College of Engineering - Xploration^2 (COE-X^2) program as a support for students beginning an engineering or computer science programs from a foundational math level (College Algebra or below). This research aims to create an inclusive environment for the COE-X student cohort. Through adding weekly, topic focused meetings with faculty, peer mentors and staff, the goal is to support student exploration of engineering and computer science, increase academic self-efficacy and establish a foundational mindset for engineering. The research questions for this study focus on describing the outcomes from your experience as a COE-X cohort member and/or with the revised COE-X^2 Program. More specifically in its purpose to connect students with the NACOE and explore engineering or computing fields.

Results from this study will be used to improve the level of support offered to the COE-X student cohort and to foster the development of their engineering identity. You have been identified as a possible subject because you are: 1) a full time or part time student at Montana State University; 2) pursuing a degree from the NACOE; 3) registered in a College Algebra (M 121Q) or lower math course; and 4) part of the current COE-X cohort. Participation is voluntary and you may choose to not to participate in this pilot COE-X^2 program. At anytime you may choose not to answer a question, and/or you can stop at any time. Your participation or non-participation will not affect your status as a student in the NACOE, or as a member of the current COE-X cohort.

If you agree to participate you will be asked to attend 6 workshops (held weekly at 3 :00pm for Group 1 and 4:00 pm for Group 2) and participate in 1 focus group session (held hourly on October 8, at 3:00; 4:00; 5:00; and 6:00 pm). The total time commitment for this study and program is 7 hours over a 7 week period.

Date and Time Commitment	**Aug. 27**	**Sept 3**	**Sept 10**	**Sept 17**	**Sept 24**	**Oct 1**	**Oct 8**
	Welcome Overview		7 events and workshops 1 hour per week.				Small Focus Group (w/ Snacks)
3:00pm Group	3:00 pm	3:00 pm	3:00 pm	3:00 pm	3:00 pm	3:00 pm	3:00 pm (NAH 115)

4:00pm Group	4:00 pm	4:00 pm	4:00 pm	4:00 pm	4:00 pm	4:00 pm	4:00 pm (NAH 115)
	Outside	WebEx	WebEx	WebEx	WebEx	WebEx	5:00 pm (NAH 115)
	NAH						6:00 pm (NAH 115)

Risks:

- Other than a commitment of your time, there is very minimal potential risk anticipated with this project and your participation.
- There is no risk to current services provided with the COE-X program regardless of your decision to participate or any survey responses.

Benefits:

In addition to specialized academic advising this pilot will:

- connect you with new friends and classmates who are part of your college;
- explore your interests in engineering and computing disciplines.
- Connect with student groups working on projects in the NACOE
- Peer support help finding academic resources, applying for scholarships through the NACOE, and preparing to meet with your academic advisor.

Compensation:

- $25 MSU Bookstore Gift Card for completing the 6 workshops
- $25 MSU Bookstore Gift Card for participating in a Small Focus Group Dinner

Alternatives available:

There are no consequences for declining to participate or answer any question(s). You have the right of not participating.

Source of funding of project:

Funding for this program is provided by the NACOE

Cost to subject, if any:

Participants are asked to commit 7 hours of their time.

Confidentiality:

Your information will be kept confidential and the results will be presented in the form of aggregated data. Your personal information will be kept on a separate file that will be password protected. The software used for the questionnaire is secure.

- WebEx and Focus Group interviews will be audio/video recorded to preserve integrity and accuracy of conversations. All conversations will be transcribed and separated from the audio/video for analysis to preserve identity of participants.
- Identifying information will be separated so they will not be associated with your responses on any reports of the data.

Please let us know if you have any questions or concerns. If you have any questions, concerns or comments please contact Ms. Jennifer Clark at jennifer.clark6@montana.edu or (406)-994-7836 and or Dr. Maria A. Velazquez at maria.velazquez@montana.edu or (406)-994-7193. If you have additional questions about the rights of human subjects you can contact the Chair of the Institutional Review Board, Mark Quinn, (406) 994-4707 [mquinn@montana.edu].
Explain status regarding confidentiality of records.

AUTHORIZATION
I have read the above and understand the discomforts, inconvenience and risk of this study. I agree to participate in this research. I understand that I may later refuse to participate and that I may withdraw from the study at any time. I will receive a copy of this consent form by email for my own records.
By signing your name, you indicate that:

- You have read and understand the information previously provided.

- You agree in voluntarily participating and you understand you have the right to not answer any questions or stop at any time.

Signature: ________________________________ Date: ______________________

Printed Full Name: ______________________________________

3:00pm Group Schedule

	3:00pm Group	4:00pm Group	
Meeting Dates	Meeting Location and Time		Topic of the Week
(Thursday)	3:00 – 3:55pm	4:00 – 4:55 pm	
Aug 27	Tent behind Asbjornson Hall	Tent behind Asbjornson Hall	Welcome - Explanation of purpose, structure and commitment ePALS match-up - NACOE Club & Organization Introduction
Sept 3	WebEx	WebEx	14 Grand Challenges for the 21st Century Engineer/Computer Scientist – Exploring Academics
Sept 10	WebEx	WebEx	Resiliency in STEM – Academic Self-Efficacy
Sept 17	WebEx	WebEx	Learning Community Engagement & Imposter Syndrome - Academic Self-Efficacy
Sept 24	WebEx	WebEx	Solving Problems is about Mindset - Exploring Academics
Oct 1	WebEx	WebEx	Peer Mentor Session: How to use academic resources; apply for scholarships; preparing for academic advising
Oct 8	NAH 115	NAH 115	Focus Groups: Share your experience

4:00pm Group Schedule

	3:00pm Group	4:00pm Group	
Meeting Dates	Meeting Location and Time		Topic of the Week
(Thursday)	3:00 – 3:55pm	4:00 – 4:55 pm	
Aug 27	Tent behind Asbjornson Hall	Tent behind Asbjornson Hall	Welcome - Explanation of purpose, structure and commitment ePALS match-up - NACOE Club & Organization Introduction
Sept 3	WebEx	WebEx	14 Grand Challenges for the 21st Century Engineer/Computer Scientist – Exploring Academics
Sept 10	WebEx	WebEx	Resiliency in STEM – Academic Self-Efficacy
Sept 17	WebEx	WebEx	Learning Community Engagement & Imposter Syndrome - Academic Self-Efficacy
Sept 24	WebEx	WebEx	Solving Problems is about Mindset - Exploring Academics
Oct 1	WebEx	WebEx	Peer Mentor Session: How to use academic resources; apply for scholarships; preparing for academic advising
Oct 8	NAH 115	NAH 115	Focus Groups: Share your experience

APPENDIX B

E-MAIL INVITATION FOR AUP PILOT PROGRAM

Dear *COE-Xploration Cohort Member*,
Congratulations! As a member of our college community interested in Mechanical Engineering, and part of the COE-Xploration (COE-X) Program cohort, you have been selected as a candidate for 1 of 2 pilot cohorts. In addition to specialized academic advising you already receive, COE-Xploration^2 (COE-X^2) will include 1) a Welcome event; 2) 5-COE-X^2 Workshops; and 3) a Feedback Session.
The benefits to you are:

- Connecting with new friends and classmates who are part the College of Engineering;
- Exploring your interest in engineering and computing disciplines with the help of faculty and peer mentors;
- Connecting with student groups working on projects in the College of Engineering;
- Peer mentoring support to help find academic resources, applying for College of Engineering scholarships, and preparing to meet with your academic advisor

There are 40 seats for this 7-week, pilot COE-Xploration^2 (COE-X^2) pilot. Participants are asked to commit to all 7 sessions that meet on Thursdays beginning August 27 through October 8. Please reference the table below detailing the dates and times of the two groups. To Register, please use the Sign-up Genius link to reserve your seat in the group that fits in your schedule.

Date and Time Commitment	**Aug. 27**	**Sept 3**	**Sept 10**	**Sept 17**	**Sept 24**	**Oct 1**	**Oct 8**
	Welcome Overview	7 events and workshops 1 hour per week.					Small Focus Group (w/ Snacks)
Group 1	3:00 pm	3:00 pm	3:00 pm	3:00 pm	3:00 pm	3:00 pm	3:00 pm (NAH 115)
Group 2	4:00 pm	4:00 pm	4:00 pm	4:00 pm	4:00 pm	4:00 pm	4:00 pm (NAH 115)
	Outside	WebEx	WebEx	WebEx	WebEx	WebEx	5:00 pm (NAH 115)
	NAH						6:00 pm (NAH 115)

The COE-X^2 pilot is part of a study considering environmental connections as support for developing academic self-efficacy. Your participation and feedback are valuable, but decision to participate is voluntary and will not impact the support you are receiving from the current COE-X Program. WebEx and focus group sessions will be recorded to preserve integrity and accuracy of conversations but will be transcribed to protect student identity. Your identity will be kept confidential. Other than the commitment of your time, there is very minimal potential risk anticipated with this project and your participation.

We value your perspective. It is very important to creating meaningful programs to support all students in our college. We hope you will participate in the college's, COE-X^2 pilot. If you have questions about this pilot, the study, or participating please contact Jennifer Clark by email: jennifer.clark6@montana.edu or phone 406.994.7836.

Warm Regards,

COE-Xploration Program Director
NACOE Student Success Coordinator

APPENDIX C

WORKSHOP TOPICS AND INTERVIEW PROTOCOL

COE-Xploration^2 Workshop Topics and Interview Protocol

COE-X Cohort: Non-pilot participants *(for those who could not or elected not to participate in pilot)* As a student interested in majors offered through the Norm Asbjornson College of Engineering, your success is important to us. We know receiving appropriate academic advising is important and have developed the College of Engineering-Xploration (COE-X) program to support students beginning engineering or computer science degrees from a pre-algebra or algebra math start. Academic Advisors provide specialized curriculum planning, connection to academic support resources, the NACOE Online Advising Center website, NACOE support systems such as ePALS (NACOE Peer Academic Leaders), the Empower Program, Women in Engineering community, and other specialized organizations to support under-represented populations in engineering or computing majors.
COE-X^2 Cohort: Pilot Participants Only Feedback from peers who have persisted through and student completion data have shown that this program has had some positive affect, but there is more we as a college can do to support students exploring engineering and computing professional careers. The NACOE has structured a College of Engineering-Xploration^2 (COE-X^2) pilot that includes 6 workshops (1 in-person and 5 topic-driven, web-ex delivered) in addition to specialized academic advising. All workshops were supported by NACOE faculty, staff and ePALS. As a COE-X Cohort participant, you were selected to receive an invitation to participate in this pilot version. These workshops included the following topics: 1. Welcome, Orientation & Introduction 2. 14 Grand Challenges for the 21st Century Engineer/Computer Scientist with Clem Izurieta (Computer Science faculty) 3. Resiliency in STEM with Maria Velazquez 4. Imposter Syndrome with Jen Clark, Maria Velazquez and MaryAnn Cummings 5. Peer Mentor Session 6. Mindset and Degree Exploration 7. Participant Feedback Interviews
Explanation of the Study This study is exploring your particular experience with the COE-Xploration (COE-X) program as it is related to academic self-efficacy. Academic Self-efficacy can be described as the confidence to engage repeatedly with challenging content resulting in success. Self-efficacy sources include internal confidence, vicarious sources that demonstrate how to navigate challenge, verbal encouragement from experts

(teachers/coaches), and physiological (emotions, or other physical reactions) responses related to engagement with academic material. The structure of this interview is informal which allows you an opportunity to share your experience. The questions are intended to understand your perceptions related to your development of academic self-efficacy with engineering or computer science content and the potential impact of the COE-X program.			
1a	Share a little about your experience related to the COE-X^2 workshops and how you view your college classes.		
1b;2a	How did the interactions with the ePALS help you learn about the NACOE?	Was the ePALS led pre-advising session helpful? How? What tools or tips did they provide?	Did anyone join a student group or club? What did this experience do for you?
1c;2b	Did the faculty led discussions influence your understanding of engineering or computer science?	Did the faculty led discussions give you feedback that was helpful with your academic classes?	
1d; 2c	How did you feel when you heard about your math placement?	How did you feel when you were told about the COE-X and your placement in the program due to math placement?	
2c	Do you believe COE-X would be helpful as a 1-credit class?		