Integrating Career Development into Biosystems Engineering

by

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Abstract

Career development is an important aspect of emerging adulthood and the experiences of post-secondary students. Particularly in the modern context, where technological advancement has significantly altered the world of work and will continue to do so, students need to be equipped with the skills to manage their careers and move forward amidst career uncertainty. This study is a grounded theory examination of students' experiences of career supports integrated into a biosystems engineering design course offered in the first year of a Biosystems Engineering Program at the University of Manitoba. Very little research has been conducted on the integration of career development into the classroom, though there are promising preliminary studies that speak to the potential positive implications for students. Using the systems theory framework of career development as the theoretical framework, this study seeks to better understand how students in a professional engineering program, who are typically thought to be career decided, experience in-class career supports. The literature review in this thesis examines the central focus of this study, the career development of post-secondary students, and covers two cognate areas, emerging adulthood with a focus on vocational and engineering identity development and reflection in experiential learning. Through utilization of constructivist grounded theory, a rigorous, social constructivist approach to the study design and qualitative analyses of participant interviews and student coursework is presented. The study proposes a low-level theoretical model of these experiences, entitled Becoming a Biosystems Engineering Student, which demonstrates the ways high school students interested in math and science are drawn to first-year engineering, where they tend to use deficit language to describe biosystems engineering. Students then progress to biosystems by either stumbling into biosystems engineering or a planned journey to biosystems engineering. Once in biosystems, students are influenced by the integrated career development curriculum, where they become more connected to their peers, professionals, and program, learn more about the labour market, clarify career options, and eventually begin to see options for themselves, define biosystems, and increase their comfort in an uncertain labour market. This progresses over time, facilitated by the career curriculum integrated into their coursework, with students shifting from identities as more general students to a biosystems engineering student identity.

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This thesis would not exist without the generosity and vulnerability of my participants – thank you to each of them for sharing their stories and teaching all of us about their career journeys and experiences as biosystems engineering students.

Thank you to my chosen family, family, and friends, you know who you are, and especially to my husband, Nish Balakrishnan, who is my most cherished cheerleader, trusted advisor, soulmate, and best friend. I need to specifically mention three of my dear friends, Stefanie Books, who used her social work skills extensively in helping me throughout my graduate program, as well as Hira Sabzwari and Samantha Jackson, who sat with me and worked when I ran out of energy, ensuring I actually finished this project. Finally, I would like to thank my dog, Oryx, who sat on my lap during much of my writing and analysis and provided the best support of all.

Chapter 1: Introduction

Undergraduate study is a time of personal and professional exploration, and with this exploration comes uncertainty and even distress. Students often feel pressure to know what they are doing with their lives, which is no simple task. Career planning takes time, effort, and sometimes, professional support from a career development practitioner. In fact, a study at a Canadian university found that a quarter of student counselling intakes were for career support, making it the fifth most common presenting issue (Cairns et al, 2010). Students, the majority of whom are emerging adults, are seeking career support as they take on the critical developmental tasks of their age: building their identities and planning their futures (Broderick & Blewitt, 2015).

For today's emerging adults, this time of exploration is further complicated by the rapidly changing economy, where continuous technological advancement decimates some positions and forces others to rapidly change (Lamb & Doyle, 2017). The gig economy is a new reality for many workers, which means that more workers rely on multiple temporary positions and full-time permanent employment is becoming harder to secure (Lamb & Doyle, 2017). Over the next decade, these trends are expected to continue, with automation making significant new demands on Canadian workers, requiring different skills than are currently expected (Royal Bank of Canada, 2018). Uncertainty and change have become the new normal in the Canadian workforce. Economists suggest that young workers need to be strategic in their skill development to be employable (Royal Bank of Canada, 2018).

A meaningful career path can have lasting effects. Having a positive view of one's career is not just important at work - the impact of a satisfying career reverberates throughout one's life.

In a study of individuals from around the world, career wellbeing was a critical predictor of overall wellbeing: those with career wellbeing were twice as likely to report overall wellbeing (Rath & Harter, 2010). In a world of job uncertainty, career development is challenging, but support from a professional can help improve career wellbeing, and thereby overall wellbeing.

Complicating the road to career wellbeing, university students have increasing demands on their time. Many students work, volunteer, and maintain significant personal and familial responsibilities on top of their academic commitments (Reed & Kennet, 2017). For example, in the 2017-2018 school year, 63% of Manitoba university students between 20 and 24 years of age worked while attending school (Statistics Canada, 2019). Almost half of people surveyed in this age group stated they volunteer (Statistics Canada, 2018). Finding the time and energy to meet all of these commitments and engage in thoughtful career development is a lot to ask of students. In fact, a survey of over 13,000 Canadian university students found that 46% of students had not had a single conversation with a university staff or faculty member about their career (Brainstorm Strategy Group, 2018). This is in contrast to the high proportion of students seeking counselling support to discuss career issues (Cairns et al., 2010). This could suggest these conversations are perhaps reactive, with students requiring a counsellor to support a perceived crisis as opposed to practicing more proactive career planning. It could also suggest that students do not perceive that this is the job of academic faculty, or that faculty members are able to support their futures. Integrating career development opportunities into the classroom is one way to support busy students, giving them time to reflect on and plan their careers, and emphasizing academic faculty members' role in, and commitment to students' futures in collaboration with career development professionals. By making career development activities part of required coursework, busy students are given incentive to prioritize these tasks as academic imperatives.

This study is a grounded theory investigation into the experiences of biosystems engineering students who have taken a required course infused with career development supports. This first chapter presents the problem statement, purpose, research questions, and significance of the study and positions systems theory framework of career development as the theoretical framework for the study design and analysis. I also delineate the multifaceted roles I have taken on in relation to this project, explaining my roles as career consultant, research assistant, and graduate student. Finally, terms related to the major topics covered in this thesis are defined, and delimitations and limitations of the study will be discussed.

Problem Statement

This study focuses on biosystems engineering, which is a fitting discipline for in-class career interventions. The program integrates biology and engineering, developing students' expertise related to agriculture, bioprocesses, biomedical engineering, and environmental engineering (University of Manitoba, 2019a). Students begin their engineering education with first year courses common to all engineering students at University of Manitoba, then select their engineering specialization in their second year of study. For this reason, the biosystems engineering students in this study are in their first year of biosystems engineering education, but in their second year by credit hours of engineering education.

The biosystems program is less clearly linked to specific employment outcomes than other branches of engineering, such as mechanical engineering where job titles often explicitly match a graduate's major. In contrast, employers rarely explicitly seek a biosystems engineer by name in job postings (University of Manitoba Career Services, 2019). The program is also marketed differently than other engineering programs at the University; it is housed in the Faculty of Agricultural and Food Sciences, and the student advising webpage positions the major as a pathway to medical school (University of Manitoba 2019b). Though biosystems engineering is a professional engineering program, where students are typically thought to be career decided, it is multifaceted and does not have one distinct identity as might be found more commonly in other engineering specializations. The program provides diverse pathways to diverse occupational outcomes. While entering biosystems engineering is certainly a career decision, it is not a definitive direction that sets students on a clear course to a particular occupational outcome. Career indecision and uncertainty about outcomes may still exist as students navigate their biosystems engineering degree. Career support could assist biosystems students in this journey.

This line of reasoning could also extend to other engineering programs, for although students in engineering have selected a profession, this does not mean that they have a clear career plan. While the majority of students who graduate from engineering work in a related sector after graduation, 30% end up in other sectors (Statistics Canada, 2017). This means that engineers are pivoting to other fields, a transition that merits career support and discussion. Further, career development occurs throughout a lifetime and represents more than choosing a profession. For engineers, professional development has been conceptualized as engineering identity, as emerging and established engineers connect themselves to the profession by acquiring the technical and interpersonal expertise essential within the field (Murray, Chance, & Conlon, 2015). The strong sense of identity that is associated with the engineering profession could complicate students' ability to choose non-traditional career paths.

As discussed, biosystems engineering is a less traditional engineering field, and students and employers have struggled to define it (L. Peto, personal communication, 2019). This could limit biosystems students' ability to strategize their career. If a student is unclear about their skills or the jobs they are eligible for, it could be challenging to identify opportunities and market oneself to an employer. Understanding how biosystems engineering students experience career development supports within their curriculum will shed light on their emergence as professionals, their career development over time, and their understanding of what it means to be a biosystems engineer. As such, a grounded theory research study has been designed to examine the experiences of first year biosystems engineering students at the University of Manitoba taking a required design course that is infused with career development modules. Students' experiences of these modules will be explored through grounded theory analyses of their individual interviews and coursework.

The biosystems engineering program is uniquely situated for the infusion of career development supports. It includes required coursework through a 4-course design spine that all students must take, consisting of Design 1, Design 2, Design 3, and Design 4. By integrating career development into the courses in this design spine, all biosystems engineering students in the program will be exposed to these supports. The present study focuses on the experiences of students taking Design 1, but the larger longitudinal study this project sits within will also explore experiences of students in Design 2, 3, and 4, as well as students one year after graduation. The career supports being integrated offer an innovative way to support engineering students in their career journeys. The modules were designed by Career Consultants at University of Manitoba Career Services based on a foundation of evidence-based practice and created targeting the developmental needs of emerging adults. The modules include reflection, career exploration, career planning, networking, and goal-setting. These concepts are introduced through lectures, interactive activities, written assignments, and discussions. (More detail on the modules can be found in Chapter 3.) As will be demonstrated in the Literature Review in Chapter 2, very little research has been done on the integration of career supports into existing curricula. The integration of career supports in a biosystems engineering Design 1 course in this study will offer an innovative way of exploring the career journeys of engineering students.

Purpose

The purpose of this grounded theory research study is to investigate students' experiences with integrated career development supports in a required biosystems engineering design course in the first year of a Biosystems Engineer program at the University of Manitoba. The goal is to develop a low-level theoretical framework which can be used to inform career development professionals and engineering educators in designing integrated career development curricula.

Research Questions

The research is guided by these questions:

Central Question: Through exposure to in-class career development supports in a biosystems engineering course, what influences students' vocational identity development?

Secondary: How do students experience their identity development over time in the course?

Secondary: How do students perceive supports and barriers over time in the course?

Significance

This study fills a critical gap in the research on career development. Though many universities are already working to integrate career development supports into courses, there is scant scholarly research on the impact of this integration. Most of the information available is about how to logistically integrate career development into the classroom rather than peer-reviewed research studies on the impact of, or students' experiences with these types of programs. For example, at Cannexus 2019, the Canadian national career development conference, three presentations of the 164 listed in the programme shared how practitioners integrated career development activities into existing post-secondary courses. These activities, all developed by career development practitioners, included Kimberly Matheson & John Ault, who presented on how they worked with faculty to integrate career activities into courses at University of Saskatchewan; Miguel Hahn, Leigha Covell (Queen's University), and Marisa Brown (Brock University), who used similar strategies to bring career support to students in classrooms; and Byung Oh and Esther Chung, from University of Toronto Scarborough, who focused on how they encouraged faculty members to invite Career Consultants into their classes (Cannexus, 2019). A review of the literature, (expanded on in Chapter 2), only turns up three peer-reviewed research studies on the topic (e.g. Thomson, 2010; Tuffley & Antonio, 2013; Joy, Shea, and Youden-Walsh, 2015). At the University of Manitoba, the Career Services department has also worked to embed career interventions in various courses offered across campus and provided anecdotal evidence to their effectiveness (G. Langlais, personal communications, December 13, 2019), but no research on these interventions has been conducted. A possible reason for this is that direct-service practitioners, not researchers, are developing these interventions, and practitioners typically do not publish peer-reviewed research. There is clear interest in this topic, however, with career development practitioners already collaborating with teaching faculty members to provide service to students during class time. Research is needed to examine the impact and guide the further development of these practices.

Though the impact of integration of career development into existing classes has not been examined extensively, there is a large body of research on for-credit stand-alone career development courses. Career development courses, which will be explored more thoroughly in the Career Development of Post-Secondary Students section in Chapter 2, have been linked to numerous positive impacts, such as better career decision making (Roberts, 2004; Reese & Miller, 2006; Scott & Ciani, 2008; Gallo & Roberts, 2019), vocational identity development

(Scott & Ciani, 2008), and better academic performance (Folsom, Peterson, Reardon, & Mann, 2005).

It is important to note in the context of this work, however, that career development courses, though offering positive implications for students, are challenging to implement. At the University of Manitoba, the creation of a new course requires Senate approval (The University of Manitoba Act, 2019), and programs with strict accreditation requirements and highly prescribed coursework, such as those in the Price Faculty of Engineering, might be unable or unwilling to add additional classes to their programs. Further, stand-alone career development courses are primarily designed for career-undecided students. Students who have already chosen a clear career direction, such as engineering students, are likely to benefit from career supports as argued in this study, but likely require more focused support than offered in general career development courses, which is the presumption of this study. Further, these students are unlikley to access these courses, since they consider themselves “decided.”

The study provides insight into the impact and implications of in-class career development supports in a professional discipline, which is a unique situation that has not been previously studied. Through analyses of individual interviews and various coursework, this research is designed to illuminate the experiences of first year biosystems engineering students who engage in career development supports in a required first year design course within their degree program. Specifically, the study examines how these supports are experienced by students, with a particular emphasis on how students’ identities develop and grow personally, and professionally, as engineers.

Theoretical Framework: Systems Theory Framework

Systems theory framework (STF) of career development is the theoretical framework for the study. STF is a metatheoretical framework developed by Patton and McMahon (1999) to encapsulate the diverse theories in use in career research and career counselling. The framework situates the individual within their context and identifies the various contextual influences which impact the individual's career development over time, such as culture, family, or the labour market (Patton & McMahon, 2014). STF represents the theoretical underpinnings of the study's design, as well as the reflexive context for the analyses. This theoretical framework informed the choice of constructivist grounded theory for this study. Specifically, as a constructivist approach itself, STF emphasizes both the social and subjective nature of career development, which aligns with constructivist grounded theory where reality is perceived as a social construction (Charmaz, 2014). Further, STF is a model of the processes inherent in an individual's career, which is congruent with grounded theory's focus on processes and development of low-level theoretical frameworks (Charmaz, 2014). The following section will outline STF, and grounded theory as the study's methodology is described fully in Chapter 3.

Systems theory framework. Systems theory framework (STF) of career development is designed to integrate various existing career development theories into a holistic framework with a specific focus on the individual and the contexts which influences the individual's career development (Patton & McMahon, 2014). The key tenets of systems theory include patterns and rules; acausality; recursiveness; discontinuous change; open systems; and story (Patton & McMahon, 2014) as described here:

1. *Patterns and rules* exist within human systems, relating to language and cultural expectations, offering patterned influences which while not static, can demonstrate the expectations the individual within the system is operating within.

2. *Acausality*: There is no linear path which can be identified in career development. Humans are complex and many factors come together to produce outcomes.
3. *Recursiveness*: Further to the notion of systems theory being nonlinear, recursiveness extends this nonlinearity by suggesting that the system does not move in one direction. Changes can occur in all directions, and the past, present, and conceptions of the future all have the power to influence the system. Change anywhere in the system begets change elsewhere, in all directions.
4. *Discontinuous change*: systems are fluid and ever changing, but this change may occur in many ways, such as sudden bursts, not in a clear, gradual progression.
5. *Open systems*: Humans live in an open system, which means no one can be separated from their context. Career development occurs within the influence of larger factors, place, media, government, the economy, and more.
6. *Story*: The stories told about experiences give them meaning. This concept brings narrative counselling tools into the application of this theory by career development practitioners.

The major layers of this system include the individual system, the contextual system, time, and chance (Patton & McMahon, 1999). A visual representation of STF can be found in figure 1.

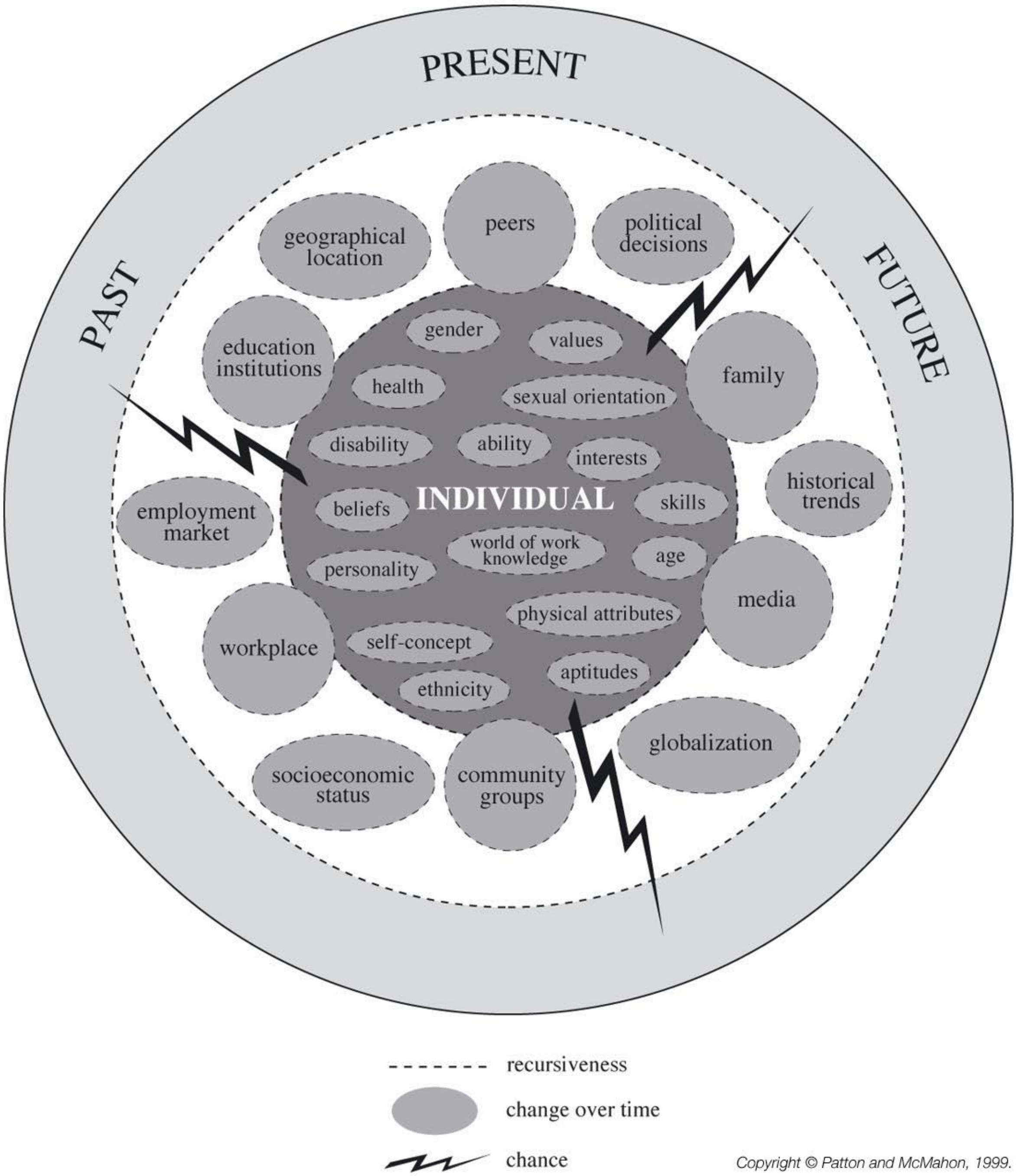

Figure 1. Systems Theory Framework of Career Development. Reproduced from Patton and McMahon (1999), with permission from authors.

Central to STF is the individual, sitting amidst a variety of influences specific to the self: gender, values, health, sexual orientation, disability, ability, interests, beliefs, skills, world-of-work knowledge, personality, age, physical attributes, self-concept, ethnicity, and aptitudes (Patton & McMahon, 1999). These ideas have been integrated from an array of career development literature and theories. For example, the centrality of the self in career development is present in multiple theories, including Super's (1990) Archway Model, Holland's self-directed search (1966) and Savickas' (2013) career construction theory. Patton and McMahon (2014) consider an individual to be an interrelated and complex system, connected to and a part of a greater contextual system.

This contextual system includes the social system and the environmental-societal system. The social system consists of peers, family, media, community groups, workplace, and education institutions. Essentially, this is "the other people systems with which the individual interacts" (Patton & McMahon, 2014, p. 248). In turn, as is inherent in a system, this social context influences the individual and shapes many of the individual's characteristics. This is also not static, and is expected to change throughout life as different groups enter the individual's sphere (Patton & McMahon, 2014).

The environmental-societal system sits amidst the social system in the diagram, but is a broader system with overarching impact. This system includes geographic location, political decisions, historical trends, globalization, socioeconomic status, employment market, and geographical location (Patton & McMahon, 2014). These influences can significantly impact the individual, providing opportunities and introducing barriers to career development. As society changes, the employment market evolves, which in turn impacts the worker, who is also impacted by issues such as globalization and technological advancement (Patton & McMahon, 2014). This can impact the skills expected of individuals, for example.

A further layer to SFT is change over time. Career development is positioned as a process involving continuous change, decision-making, and adaptation (Patton & McMahon, 2014). Again, this is not linear. The past, present, and future are interrelated, with the present influencing the view of the past, the past influencing ideas about the present and future, and the future remaining ever changing amidst the uncertainty of the wider world (Patton & McMahon, 2014).

The final influence is chance, which is represented with lightning bolts in the diagram. There is unpredictability, i.e., chance, in the system which influences career development (Patton & McMahon, 2014). Chance is also present in other models, such as happenstance learning theory, which highlights the value of chance events, i.e., happenstance, encouraging individuals to be open to new opportunities that may come about in their everyday life and to harness those events as opportunities for reflection, self-discovery, and career growth (Krumboltz, 2004).

STF, a critique. STF has its limitations. This way of looking at career planning is a Western construction. The individual’s needs and their personal reflections on these needs take centre stage, which may not be fitting for individuals from collectivist cultures, who may weigh familial and community expectations heavily in their career decision-making (Cheng & Berman, 2012). At the same time, the social focus of STF is compatible with collectivist perspectives, with context and culture surrounding the individual and recognized as critical influencers of career development. Beyond this, a major strength of STF is its flexibility: it can be adapted to work for the individual’s unique lived experience and career. This puts the onus on the practitioner or researcher using this theoretical orientation to be cautious when applying STF to ensure the individual's specific needs or experiences are being addressed and that their cultural and lived experiences are respected.

As opposed to seeking one choice for the future, a career can be conceptualized as continuous recalibration of the future, responding to development of, and changes to the individual and their context. It is an ever-changing process in which specific career planning tools can be engaged. In this research study, STF informed the methodology, the positioning of the researcher (e.g. as self), the development of the research questions and interview protocol, the data collection and analysis, and will be used to ground the reflexivity of the researcher engaging in this study.

Managing My Multifaceted Roles in the Context of this Study

I have multiple, intersecting roles within this research study: Career Consultant, Research Assistant, and Master's student. For the purposes of transparency and to clarify the complexities of these multifaceted roles, this section will detail each of these positions, articulating what constitutes my Master student research and how my other roles intersect with my research. Specifically, for each role I will disclose my history within the role, my responsibilities, and their connection to this research project.

Career Consultant. Since 2015, I have been employed fulltime in Career Services at the University of Manitoba as a Career Consultant. This role includes a myriad of responsibilities, including one-on-one career support of students, the development of curricular and career resources, the coordination of career programs, and the development and facilitation of career modules that occur in university classrooms and at Career Services. The history of Career Services providing career supports in Price Faculty of Engineering classrooms (including Biosystems Engineering) and other classrooms at the University of Manitoba predates my time at the department. In 2018, a team of career development professionals, which included Career Services staff and staff from the Cooperative Education and Industrial Internship Program within the Price Faculty of Engineering, began creating a career development curriculum for the University. This curriculum, as well as other existing Career Services resources, are the base of the interventions used in this study. As a Career Consultant, I tailored these existing career interventions to integrate them into the biosystems engineering Design 1 course. I consulted with Career Services staff throughout the development, including my supervisor, the Director of Career Services, Gail Langlais.

In my role as a Career Consultant, I facilitated all the career supports in the biosystems engineering Design 1 course except for the Goal Setting & Resumé Gaps session, which was facilitated by Lynda Peto, Business & Professional Development Consultant at Cooperative Education and Industrial Internship Program within the Faculty of Engineering. Other modules were facilitated in partnership with Gail Langlais, Director of Career Services and Lynda Peto. Dr. Jillian Seniuk Cicek, one of my co-advisors for my Master's program, was present during the facilitation of all of these career supports in her capacity as co-instructor of the course, and Dr. Danny Mann, the other co-instructor of Design 1, was present for the majority. The schedule for the interventions and the professionals involved in the facilitation is as follows:

- **September 9, 2019**: Embracing a Career Mindset (Dr. Jillian Seniuk Cicek and Dr. Mann in attendance);
- **October 21, 2019**: Your Career in Biosystems Engineering – Part 1 (with Gail Langlais; and Dr. Jillian Seniuk Cicek in attendance);
- **October 23, 2019**: Your Career in Biosystems Engineering – Part 2 (with Gail Langlais; and Dr. Jillian Seniuk Cicek in attendance);

- **October 28, 2019**: Introduction to Informational Interviewing (with Gail Langlais and Lynda Peto; and Dr. Jillian Seniuk Cicek in attendance); and
- **November 29, 2019:** Goal Setting & Resumé Gaps (by Lynda Peto, with Rebecca Balakrishnan; Dr. Jillian Seniuk Cicek and Dr. Danny Mann in attendance).

To summarize, a series of modules were created by Career Services and Co-Operative Education staff (including myself). They were adapted by me in discussion with Dr. Seniuk Cicek and Dr. Danny Mann (the course co-instructors) for the purpose of integrating them in the biosystems engineering Design 1 course. These career supports were facilitated by me throughout the Fall 2019 term as a staff member at Career Services, with support by two other career professionals, Gail Langlais and Lynda Peto.

Research Assistant. I am a Research Assistant (R.A.) to Dr. Jillian Seniuk Cicek. The research study described herein sits within a broader, longitudinal study in which Dr. Seniuk Cicek is the Principal Investigator and I am the R.A. This larger research project will follow the 2019 cohort of first year Biosystems students from the Design 1 course through to three additional Biosystems courses (Design 2, 3 and 4), which will all have career development interventions, as well as through a post-graduation follow-up one year after this cohort graduates from the Biosystems program. Since Dr. Seniuk Cicek is the co-instructor of Design 1, as well as for Design 3 and 4, she is in a conflict of interest with the potential participants. For this reason, she required an R.A. to conduct the recruiting, data collection, and data management for the study. I was engaged as Dr. Seniuk Cicek's R.A. in January 2019. Within this role, I initiated writing the ethics application for this longitudinal study (within which my Master's research study is situated), which was approved on October 21, 2019 (see Appendix I). On December 2 and 6, 2019, as the R.A., I introduced the study to Biosystems Design 1 students to recruit participants, and collected informed consent letters from them. Within this role I collected and managed all identifying data, kept a codebook, and anonymized the data. Once the data was anonymized and the appeal period for the course was over, Dr. Seniuk Cicek is able to access the data as needed in both her role as Principal Investigator for this project and in her role as co-advisor of my Master's thesis with Dr. Priya Mani.

Master of Education thesis student. I am writing a thesis as part of my Master of Education in Counselling Psychology, which sits within the Faculty of Education, Department of Educational Administration, Foundations & Psychology. Dr. Priya Mani (Faculty of Education) and Dr. Jillian Seniuk Cicek (Centre for Engineering Professional Practice and Engineering Education, Price Faculty of Engineering), are my co-advisors for this degree. I transitioned into the thesis stream of this program on January 21, 2019. My thesis study is designed to explore students' experiences with the career interventions in Biosystems Design 1, which constitutes the first year of the longitudinal study. As a Master of Education student, my responsibilities include: designing the study as described throughout this thesis, writing this thesis, defending my thesis to my committee, and conducting the research described in this proposal for this study. Data collection for this study did not begin until I successfully defended my proposal and received approval from my thesis committee, and the grade appeal period for the Fall 2019 Design 1 course has passed. At which time, the research study commenced with data collection.

Definition of Terms

Commonly used terminology within this study are defined in this section, organized into terms related to STF, career development, engineering, emerging adulthood, reflection in experiential learning, and grounded theory methodology. Terminology can be defined as follows:

Relevant terms for STF.

Acausality: The notion that there is no linear path which can be identified in career development. Humans are complex and many factors come together to produce outcomes (Patton & McMahon, 2014).

The contextual system: This system includes the social system and the environmental-societal system (Patton & McMahon, 2014).

Discontinuous change: systems are fluid and ever changing, but this change may occur in many ways, such as sudden bursts, not in a clear, gradual progression.

The environmental-societal system: This system includes geographic location, political decisions, historical trends, globalization, socioeconomic status, employment market, and geographical location (Patton & McMahon, 2014).

The individual: Within STF, the individual constitutes gender, values, health, sexual orientation, disability, ability, interests, beliefs, skills, world-of-work knowledge, personality, age, physical attributes, self-concept, ethnicity, and aptitudes (Patton & McMahon, 1999)

Open systems: The notion that no one can be separated from their context (Patton & McMahon, 2014). Career development occurs within the influence of larger factors, place, media, government, the economy, and more.

Recursiveness: The notion that a system is nonlinear, changes can occur in all directions, and the past, present, and conceptions of the future all have the power to influence the system (Patton & McMahon, 2014). Change anywhere in the system begets change elsewhere, in all directions (Patton & McMahon, 2014).

The social system: This system consists of peers, family, media, community groups, workplace, and education institutions. Essentially, this is "the other people systems with which the individual interacts" (Patton & McMahon, 2014, p. 248).

Systems theory framework of career development (STF): A metatheoretical framework developed by Patton and McMahon (1999) as a way to encapsulate the diverse theories in use in career research and career counselling. It focuses on the individual and the systems and context the individual is situated within (Patton & McMahon, 2014).

Relevant terms for career development.

Career: "Career is a lifestyle concept that involves the sequence of occupations (paid and unpaid) in which one engages throughout a lifetime, including work, learning and leisure activities. A career can go through many changes and we only get one" (CERIC, n.d.).

Career development practitioner: "Career development practitioners […] facilitate the ability of clients to take charge of their own career development by assisting them in the process of identifying and accessing resources, planning, and managing for their career-life development. It is used as an umbrella term that refers to any direct service provider in the career development field" (CERIC, n.d.). As a career consultant at University of Manitoba, I identify as a career development practitioner, which is the umbrella term for the profession.

Job: "A job is a paid or unpaid position requiring a group of specific attributes enabling a person to perform a configuration of tasks in an organization or a particular environment, part time or full time, for a short or long duration of time" (CERIC, n.d.).

Occupation: "An occupation is a group of similar jobs or types of work sharing similar skills, education, knowledge, and training, and found in different industries or organizations" (CERIC, n.d.).

Relevant terms for engineering.

Biosystems engineering: an engineering specialization that combines biology and engineering practice and can be applied to agriculture, biomedical engineering, environmental engineering, and bioprocesses (University of Manitoba, 2019a).

CEAB graduate attributes: twelve specific learning outcomes defined by the Canadian Engineering Accreditation Board (CEAB), based on the Washington Accord, that delineate the knowledge, skills, attitudes, values and behaviours of an engineer. Canadian engineering programs must demonstrate that their graduating engineering students are competent in all 12 of these CEAB graduate attributes as one of the requirements of program accreditation (Seniuk Cicek, 2017; Engineers Canada, 2018).

Student: for the purposes of this study, this term will refer to an individual currently enrolled in an undergraduate post-secondary program.

Relevant terms for emerging adulthood with a focus on engineering and vocational identity development.

Emerging adulthood: the developmental period between 18 and 29 years of age (Murray & Arnett, 2019).

Engineering identity: the constantly evolving notion of who and what an engineer is and does, encompassing personal features and professional competencies (Murphy et al., 2015).

Vocational identity: "the development of a coherent view of oneself as a worker" (Brown & Hirschi, 2013, p. 309).

Relevant terms for reflection in experiential learning.

Experiential learning: Learning through experience, with respect to the experiential learning cycle (Kolb & Fry, 1974).

Experiential learning cycle: The cycle for learning follows *concrete experience* (full involvement in the experience); *reflective observation* (reflecting on the experience from multiple angles); *abstract conceptualization* (integration of newfound understanding into theories); and *active experimentation* (application of these theories; Kolb, 2015).

Relevant terms that apply to grounded theory methodology.

Coding process: "a qualitative research process in which the researcher makes sense out of text data, divides it into text or image segments, labels the segments, examines codes for overlap and redundancy, and collapses these codes into themes" (Creswell, 2012, p. 618).

Confirmability: a measure of trustworthiness in a qualitative study which is reached when the criteria for credibility, transferability, and dependability are met (Lincoln & Guba, 1985).

Constant comparison method: In this method of analysis, researchers compare "data with data, data with code, code with code, code with category, category with category, and category with concept." (Charmaz, 2014, p. 342). As the concepts become more abstract, the researcher can then connect them to the relevant literature (Charmaz, 2014).

Credibility: confidence in the trustworthiness of the findings of a qualitative study (Lincoln & Guba, 1985).

Dependability: when there is consistency in qualitative research and enough information and oversight is present for the community to believe that the findings could be repeated (Lincoln & Guba, 1985).

Diagramming: A visual tool used to illustrate the categories of, and relationships between grounded theory data being analysed (Charmaz, 2014). This process occurs simultaneously with sorting and integration of categories (Charmaz, 2014).

Field note: Field notes are the researcher's notes during qualitative data collection, recording the researcher's observations of participants (Creswell, 2012). They provide an opportunity for triangulation (Charmaz, 2014). A field note template can be found in Appendix B.

Grounded theory: A qualitative research methodology in which conceptual frameworks or low-level theories are constructed based on gradual, categorical analysis of qualitative data (Charmaz, 2014).

Member check: A process through which participants in a study are asked to examine quotations, analysis, and findings in the study to check if they are accurate (Creswell, 2012).

Memo: Memos are entries written by the researcher at various points in the data collection and analysis process, where the researcher logs reflections, impressions, and ideas which can inform future analysis (Charmaz, 2014). Memoing will occur throughout the study, with the researcher logging various impressions. During the analysis process, memos will serve to support the research in reflecting on the results and to track the process of analysis (Charmaz, 2014). A template of the memo style to be used in this study can be found in Appendix A, alongside examples of initial reflections and notes.

Reflexivity: In this study, reflexivity will refer to the researcher's honest reflections on their personal perspectives, interpretations, and theoretical lens (Creswell, 2014). Reflexivity will be used when writing memos while collecting and analyzing the data to identify and mitigate bias.

Saturation: The point at which no further insights are emerging from the data (Creswell, 2014), and thereby data collection and analyses can cease.

Theoretical sampling: In theoretical sampling, further data are collected and analysed based on categories already developed (Charmaz, 2014). This allows categories within the data to be connected, gaps in the categories to be recognized and addressed, and theoretical categories to be tentatively developed until theoretical saturation is reached (Charmaz, 2014).

Thick descriptions: Thick descriptions are vivid, detailed descriptions of data which help the reader to understand how the results of a qualitative study might connect (or not connect) to other situations (i.e., transferability) (Lincoln & Guba, 1985).

Transferability: the applicability of the findings to others' experiences, which is facilitated through thick description (Lincoln & Guba, 1985).

Triangulation: "the process of corroborating evidence from different individuals (e.g., a principal and a student), types of data (e.g., observational fieldnotes and interviews), or methods of data collection (e.g., documents and interviews) in descriptions and themes in qualitative research" (Creswell, 2012, p. 629).

Delimitations and Limitations of the Study

The study focuses on the 2019 cohort of first year undergraduate biosystems engineering students at the University of Manitoba, which means the information shared is specific to the experiences of this group and will not unequivocally reflect post-secondary students more broadly. Engineering is a professional degree with a strong professional identity, and biosystems engineering is a distinctive discipline within this broader profession, as already discussed. The delimitations of this study allow for a vivid examination of the experiences of biosystems engineering students who take a required course with in-class career development supports. The study is also focused on emerging adulthood. This is a critical stage of human development, in which career exploration and planning are a major focus for many people (Arnett, 2019). Since this study has a focus on identity development, which is particularly prevalent in emerging adults, it makes sense concentrate on this population, who make up the majority of individuals in University of Manitoba classrooms (University of Manitoba Office of Institutional Analysis, 2018a). Individuals in later stages of life, who have already undergone significant identity development or who have already had significant career exploration through a much longer career history will likely experience the career supports differently than their younger, "emerging adult" counterparts, who are likely learning about these concepts for the first time. The purpose of bounding the study in this way is to provide a focused model of how post-secondary biosystems engineering students, who are considered emerging adults, experience career development supports.

The study utilizes a constructivist grounded theory methodology, as described by Charmaz (2014). Grounded theory enables a careful examination of the data collected, which for this study is semi-structured participant interviews and specific student assignments, leaving room for themes and a low-level theory to emerge from the data. This is useful due to the gap in research in this area. Grounded theory does have limits, and in particular is impacted by the same limitations of any method that relies on data generated by self-reports: they represent the unique perspective of each participant, and may not be transferable to others. Still, constructivist grounded theorists would argue that there is no such thing as an accurate, perfect truth that can be reached through research and that it is more important to try to understand what the participants are telling us (Charmaz, 2014), which is the purpose of this study.

This study has additional limitations. It does not necessarily illuminate how a wider population of students, for example, those in non-professional programs, or even other engineering students, would experience these supports, since the participants' experiences is unique to themselves, this biosystems course, and this moment in time. Further, the study does not examine the experiences of the other stakeholders involved in the integration of career supports into the biosystems Design 1 curriculum, including the course professors, teaching assistant, and the career development professionals who have been engaged in implementing the career interventions. In future, studies into how career development could be integrated into other types of post-secondary programs and studies examining professors' and career development professionals' experiences of these processes are encouraged. Additionally, a quantitative study into the impact of classroom career development support, with a pre- and post-test, would provide further information on this process and its impact. While this study has its limitations, it will provide a critical first step in creating a low-level theoretical representation of student experiences of in-class career interventions in a professional post-secondary engineering degree program.

Summary and Conclusion of Chapter 1

In the modern context, where technological advancement is redesigning what modern careers look like, career development interventions offer proactive support to help university students strategize their careers. To mitigate possible barriers to students seeking support, career practitioners in post-secondary institutions have already begun integrating career development activities into broader course offerings at the institutions – a process that has not been studied closely. The purpose of this research study is to explore how biosystems engineering students experience career interventions in a compulsory first year design course offered in the first year of their program at the University of Manitoba. The systems theory framework of career development is the theoretical lens adopted by the researcher. Since there is limited research on this topic, a grounded theory investigation into the experiences of students who have engaged in integrated career development supports will be taken to develop a low-level theory to provide insight for this gap in the literature.

The remaining four chapters of this thesis are as follows: Chapter 2, Literature Review, covers the central focus in this study, career development of post-secondary students, and two cognate areas: emerging adulthood with a focus on engineering and vocational identity development, and reflection in experiential learning. The history of the area, as well as specific literature relevant to post-secondary career development and engineering are examined for each of these sections. Chapter 3 explains the constructivist grounded theory approach for the study and the data collection and analyses processes. Additionally, methodological limitations and how they were addressed are discussed. Chapter 4, Findings, will describe the participants, share my analysis, and outline the development of my emerging theoretical model. Finally, Chapter 5, Results and Discussion, will connect the emerging theoretical model to my research questions, to systems theory, and to the current literature, before sharing strengths and limitations, implications, and reflections and reflexivity.

Chapter 2: Literature Review

Through analysis of individual student interviews and student coursework, this study is designed to better understand the ways students experience career and identity development in a course with integrated career development supports. To set the context, the primary area of career development of postsecondary students will be explored. Two cognate areas will also be presented: emerging adulthood with a focus on vocational and engineering identity development, and reflection in experiential learning. The history of, and specific research literature in each area will be examined, followed by an overview and critique of the area. Literature related to career development, post-secondary students, and engineering education for each topic is presented.

Career Development of Post-Secondary Students

This section will cover the history of career development in Canada. It will then examine career development theories that have been applied to the post-secondary population. There will also be an examination of the career development of engineers, with a focus on skill development as related to the labour market. Finally, career development interventions in post-secondary settings will be discussed explicitly, looking at Career Services offerings, career development courses, and the integration of career development into existing classes.

History of career development in Canada and in Canadian higher education. Career development supports began in Victorian times, as industrialization changed the labour market and social service agencies began supporting unemployed Canadians in finding work (Van Norman, Shepard & Mani, 2014). This work continued into the economic changes of the Great Depression, with social service agencies continuing to advise the unemployed and provincially funded supports also being added (Van Norman et al., 2014). Though guidance counsellors were encouraged to bring vocational supports to secondary students, universities did not begin offering formal career support until the 1940s (Van Norman et al., 2014). Prior to this, students' only source for career guidance was faculty (Dey & Cruzvergara, 2014). Since then, career development support has become a common service offered in post-secondary institutions. In seeking participants for a 2017 study on Canadian post-secondary Career Services, Dietsche and Lees found Career Services department websites for 91 out of 95 Canadian universities, with only 4 institutions not having a web presence or department.

Career support in post-secondary institutions. On university campuses, students can seek help directly from their university's career services department. There is little research on the impact of these services, but research has been done on the scope of services offered. Across Canada, post-secondary career centres utilize a variety of approaches to student career development. In 2017, the Canadian Education and Research Institute for Counselling published a Canada-wide investigation into post-secondary career service models (Dietsche & Lees, 2017). Dietsche and Lees (2017) identified the scope of work done by career development professionals, distinguishing between career advising (providing career and educational information), career educating (providing tailored career information), career counselling (a therapeutic approach), career coaching (providing support in reaching career goals), and career consulting (creating and facilitating career development programming). The survey revealed that in reality, professionals working in career services had overlapping responsibilities, with the majority of practitioners providing career support in numerous areas as opposed to one single area (Dietsche & Lees, 2017). Individual career advising was the most used on-campus service by students across the country and the second most utilized service following online employment postings when off-campus and digital services were included (Dietsche & Lees, 2017). Career development is occurring on university campuses in numerous contexts: through one-on-one career support, groups offered by career services, stand-alone career classes, and integration into academic classes. Despite the prevalence of career development support, there is little research into students' experience of receiving this support or the overall process and impact. Further research is needed in these areas. The modules integrated into the biosystems engineering class were developed by career development practitioners at Career Services, University of Manitoba, who also offer support to students through individual career support. Much of the existing literature on the impact of career development courses, which will be explored next, looks at programming developed by career development practitioners.

Career development courses and embedding career support into existing curriculum. Catherine Maybrey, a Canadian higher education career development professional, advocated for Canadian post-secondary institutions to develop stand-alone career development courses for students in a widely circulated 2018 article for *Academica*. She argues that these courses could be cost-effective ways to reach more students, sooner. In her opinion, the model of individual career attention in Career Services offices cannot reach the growing number of students who require supports. Career development courses have existed for decades (Folsom & Reardon, 2003), and there has been renewed interest in their development. As discussed, at Cannexus 2019, three of the 164 presentations focused on developing career development courses and embedding career development into existing post-secondary curriculum (Cannexus, 2019). This work was shared by career development practitioners Kimberly Matheson and John Ault (University of Saskatchewan), Miguel Hahn and Leigha Covell (Queen's University), and Marisa Brown (Brock University), and Byung Oh and Esther Chung (University of Toronto Scarborough; Cannexus, 2019). Comparatively, the 2018 program had two presentations (Cannexus, 2018) and the 2017 program had none (Cannexus, 2017). Evidently, the interest in this topic is slowly growing in Canada, with practitioners currently developing in-class services and curriculums and sharing their experiences and successes with other practitioners through accounts of their endeavors.

Career courses have been linked to increases in positive measures such as career maturity (Ganster & Lovell, 1978; Smith, 1981; Ware, 1981; Carver & Smith, 1985), increased student retention (Folsom, 2000; French, 2013), increases in measures of career decision-making (Roberts, 2004; Reese & Miller, 2006; Scott & Ciani, 2008; Fouad, Cotter, & Kantamneni, 2009; Gallo & Roberts, 2019), increased career self-efficacy, or the belief that one can have career success and can make choices (Roberts, 2004; Fouad, Cotter, & Kantamneni; Gallo & Roberts, 2019), increases in vocational identity (Scott & Ciani, 2008), and positive changes to measures of academic performance (Folsom, Peterson, Reardon, & Mann, 2005). These courses have also been linked to decreases in more negatively viewed measures, such as a decrease in dysfunctional career thoughts (Reed, Reardon, Lenz, & Leierer, 2001; Osborn, Howard, & Leierer, 2007; Taylor, 2009) and decreased psychological distress (Belisle, 2005).

In particular, career development courses have been linked to increases in career decision-making self-efficacy. One study compared the career development of undergraduate students in an introductory psychology class with no career content (the control group) to the career development of students in a stand-alone career development course (the experimental group; Reese & Miller, 2006). A pre- and post-test using two assessments demonstrated an increase in career decision-making self-efficacy for students who took the career course (Reese & Miller, 2006), and also demonstrated the impact of in-class career development interventions for undecided students. In a similar study, Scott and Ciani (2008) found that career decision-making self-efficacy increased after students took a career course. Beyond this, the study found that students had a stronger sense of vocational identity once the course was complete (Scott & Ciani, 2008). However, since this study did not have a comparison group like the first study described, it is difficult to determine if the increase in vocational identity was due to the course or due to the natural, expected identity development that might have happened over time in this age group without the course.

In a one credit hour, six-week course, a pretest-posttest measure found a significant decrease in overall dysfunctional thinking related to career (Osborn, Howard, & Leierer, 2007). The course was facilitated by career development practitioners and covered the labour market, dealing with negative thoughts, career theories, decision-making, exploring personal qualities such as interests, values and skills, career information resources, and goal-setting (Osborn, Howard, & Leierer, 2007). Interestingly, the study measured a small increase in dysfunction for students who were categorized into the low-level dysfunctional career thoughts category at the beginning of the study. The authors note this has been demonstrated in other studies and suggest this might be because students who were not worrying about their careers and had the importance of career development brought to their attention when taking the course began reflecting more on their own development, which had a negative impact (Osborn, Howard, & Leierer, 2007). This finding on increases in career dysfunction could be addressed through qualitative interviews of participants, as in this thesis.

In an examination of a career planning course offered at Florida State University since the 1970's, Folsom and colleagues (2005) studied measures of academic success in a sample of 544 students, looking at changes over five years in students who took the course compared with students who did not. The results of the study were different for men and women. Male course participants had higher GPAs, fewer dropped classes, and took longer to graduate than those not in the course, while female participants in the course graduated more quickly than those not in the course (Folsom et al., 2005). This course has also been connected to student retention, with 81% graduation rate for students who completed the career development course, which is 12% higher than the university as a whole (Folsom, 2000). These are positive implications for career courses that go beyond career development improvements.

These studies have many thematic elements in common. The majority of studies on this topic used pretest-posttest, and some used comparison groups. All of these studies looked at for-credit courses. Though the courses had some theoretical distinctions, the majority followed typical career intervention models, including personal exploration, exploration of career options, career decision-making, and goal-setting. The majority also required students to write reflections. In other words, the interventions utilized the ingredients present in successful career interventions, as is suggested in Whiston, Goodrich Mitts, and Wright's (2017), and followed the career planning process (McKinnon & Johnston, 2014). Ultimately, these courses offer numerous benefits for students' career development.

While career development courses are linked to positive outcomes, these stand-alone courses, particularly those for university credit, do have limitations. First, in university programs governed by strict accreditation guidelines, such as the engineering program at the University of Manitoba, fitting additional career credits into the curriculum would be challenging, and a career course would likely have to be an elective as opposed to a requirement. Second, career courses are time intensive for students and the career development practitioners who run them: to merit the course providing credit towards a degree, it must have a certain level of instruction and graded assessments. This number of hours of instruction and homework might be ideal for career undecided students who would then have incentive to engage in career planning activities, but this might be excessive for students who are choosing between a couple of related choices or disciplines, or who have a career plan, such as is likely typical for engineering students, who have already chosen their profession. These more career-decisive students might still benefit from career supports to help them move forward, but a complete course is likely unnecessary and a waste of resources. Moreover, all newly proposed courses require approval from Senate to be added to the University of Manitoba's course offerings (The University of Manitoba Act, 2019), which takes significant preparation and senate deliberation, and courses are not always approved, as discussed in Chapter 1. As Career Services is not integrated as part of specific academic departments, but rather a stand-alone centre, this process would be even more complicated, as it would have to be demonstrated how the proposed career courses fit into each of the various academic programs, and certainly would not be a one-size-fits-all task. Finally, in the case of stand-alone career courses that are not for credit, career practitioners have cited difficulties in getting students to register, attributed to difficulties in informing potential students about these course options, or to students' busy schedules (personal communication, Cannexus, 2019). One way to address the limitations of stand-alone career development courses is to integrate career development activities into existing academic courses.

Integration of career development into post-secondary classrooms. In the Cannexus 2019 Programme already mentioned, three of the sessions pertained to the addition of career development supports into already existing courses and curriculum. Career Services at the University of Manitoba has invested in this model, through its collaboration with the biosystems engineering course that is being investigated through this study and through collaborations with other university professors in other faculties and departments, such as Kinesiology, Respiratory Therapy, Psychology, Computer Science, and Family Social Science (G. Langlais, personal communication, December 13, 2019). Beyond University of Manitoba, other career services departments are offering in-class supports. A Google search of career services departments turns up results on departments across Canada and internationally offering career programming in courses. Despite this clear interest, there is limited research on the impact of career development supports being integrated into post-secondary courses, with the exception of a few studies that have examined this process, as discussed next.

An Australian case study looked at the incorporation of occupational research and goal-setting into a first-year university information technology course (Tuffley & Antonio, 2013). In a survey including multiple choice and written responses, students reported feeling more engaged in their career futures and more motivated to complete their degrees after the course (Tuffley & Antonio, 2013). This study provides some insight into the positive impact of the integration of career development into a post-secondary STEM professional program, showcasing the ways career-related activities can be meaningful to the students who engage in them.

A second Australian case study provided a project outline of an online career development program that students could access independently and that professors integrated into their coursework (Thomson, 2010). The report highlights self-reported benefits as perceived by students, faculty, and staff, including the flexibility of the program, students feeling more prepared for the workforce, and professors feeling capable of integrating career development into their classrooms (Thomson, 2010). This study offers incentive for additional research on this topic, and demonstrates that this type of intervention has been initiated with self-reported positive impact.

Joy and colleagues (2015) connected learning outcomes within a course to competencies required in the world of work, then taught students how to conceptualize their learning within the world of work through activities and reflections. They called this process career integrated learning (CIL), which focuses on the integration of employability skills language into the classroom (Joy et al., 2015). In a survey of 450 students, 72% deemed the skills identification useful and many students gave positive written feedback (Joy et al., 2015). This study suggests that students respond positively to having career-related information brought into their classes. The large sample size offers promise for the impact of these kinds of interventions, and encourages further research to explore this process more.

The most closely connected research to this thesis was conducted by Bridgstock, Thomas, Lyons, Carr and Zelenko (2012), which explored integration of career development activities into a first year creative industries class in Australia. This paper is from conference proceedings, and the journal attached to the conference in which it was published no longer exists, so it is unclear whether this paper was peer-reviewed. The creative industries program integrated career development activities into classes, with a specific focus on identity development and linkages to the career planning process, including assessment of personal characteristics, occupational information, decision-making activities, and goal-setting. Using similar processes as those used to measure the effectiveness of stand-alone career courses discussed earlier, the researchers planned to measure how career decision self-efficacy increased and conduct qualitative focus groups. Unfortunately, this paper was only a proposal and starting point for discussion at the conference: no results were included and a published completed study could not be located. Despite this, again, this paper highlights that there is interest in and room for qualitative research into the integration of career development supports into post-secondary classrooms.

Themes and critiques of the literature of career development of post-secondary students. Studies exploring the career development of post-secondary students have various commonalities (see a table summarizing the highlights of this literature review in Appendix J). The majority of research on career development in post-secondary classrooms has been on stand-alone courses. The majority of these studies use a pretest-posttest design, some of which have a control group. These studies have showcased the positive influences of these courses, including: students' developed vocational identities (Scott & Ciani, 2008), increased self-efficacy, and improved career decision-making (Roberts, 2004; Fouad, Cotter, & Kantamneni; Gallo & Roberts, 2019). At the same time, it appears that these courses also reduce negative issues, such as dysfunctional career thoughts (Reed, Reardon, Lenz, & Leierer, 2001; Osborn, Howard, & Leierer, 2007; Taylor, 2009) and psychological distress (Belisle, 2005). Overall, the literature suggests career development courses offer effective career development for post-secondary students.

There is scant literature available on classrooms where career development interventions have been included in addition to program coursework. The information that does exist on this topic is primarily anecdotal, with practitioners sharing their experiences in conferences (e.g. Cannexus 2019) and articles (e.g. Thomson, 2010). Other articles are written by subject experts in the field in which the interventions take place (e.g., Joy et al., 2015). They offer insight into students' self-reported responses to career in the classroom, which appears to be positive, but only provide limited data generally through course evaluations. These articles offer promising groundwork for further study: if practitioners and instructors are using career development in the classroom, and are already sharing anecdotal successes, it would be useful to conduct explicit research to assess the impact. Further, if bringing career into the classroom without a focus on evidence-based career interventions or career theories has already been shown to be effective, this might suggest that evidence-based interventions, which have already been proven effective in stand-alone contexts, could provide further meaningful impacts for students.

Emerging Adulthood with a Focus on Vocational and Engineering Identity Development

Emerging adulthood is considered the period between 18 and 29 years of age (Murray & Arnett, 2019). The majority of undergraduate students at the University of Manitoba are in this age group, with approximately 89% of students falling within this range in Fall 2018 (University of Manitoba Office of Institutional Analysis, 2018a). This developmental stage is primarily documented in developed countries, where young people have the economic and social freedom to undergo continued exploration, identity development, and self-focused behaviour beyond adolescence (Murray & Arnett, 2019). This fairly recent developmental period has been widely integrated into developmental psychology, and is used to research and describe the experiences of young people within this specific age period (Arnett, 2019). Since a major part of the present study is focused on career development and change in students who will fall into this age group, it is important to explore this developmental stage more deeply to understand the student sample.

The review of the emerging adult literature covers the historical development and markers of emerging adulthood. The section on the markers of emerging adulthood will focus primarily on identity development, as that is most closely linked to career development concepts such as vocational and engineering identity. Other markers of this stage (namely instability, self-focus, feeling in-between, optimism) will only be mentioned for context and not explored as deeply. This review will serve as an introduction to the developmental needs of emerging adults and will discuss how previous research has explored identity development during this age span.

Historical development of emerging adulthood. Emerging adulthood was first proposed by Jeffrey Jensen Arnett in 2000, born out of significant societal shifts in Western, industrialized countries. Arnett argues there are four key historical shifts in the mid to late 20th century which led to the need for a developmental stage to represent people 18-29 years old: the technological revolution, the sexual revolution, the women's movement, and the youth movement (Arnett, 2019). The technological revolution transformed the economy, spurring a shift from manufacturing jobs to today's knowledge-based jobs requiring post-secondary education (Arnett, 2019). The 60's sexual revolution changed sexual norms, with contraceptives enabling sexual relationships before marriage, thereby increasing the age of first marriages (Arnett, 2019). At the same time, the women's movement brought about more opportunities for women to seek educational and career advancement; and the youth movement emphasized the positive characteristics of youth as something to be savoured and prolonged (Arnett, 2019). As all these changes came about, young people became more likely to attend post-secondary institutions and began waiting longer and longer to marry (Arnett, 2019). Gradually, a new demographic with distinct experiences developed. This demographic is captured in Arnett's (2000) conceptualization of emerging adulthood.

Developmental psychologists have characterized stages of human maturation using numerous models, many of which touch on the ages of 18-29. Arnett (2000) cites a few key scholars in the theoretical foundation of emerging adulthood, including Erik Erikson, Daniel Levinson, and Kenneth Keniston. Erik Erikson's (1968) theory of human development across the life course describes the developmental experiences of young people. Though Erikson does refer to a *prolonged adolescence* (Erikson, 1968) found in young adults in industrialized countries, Arnett (2000) notes that Erikson does not include this stage explicitly in his developmental model. Daniel Levinson's (1978) book examines development in adulthood based on the life stories of 40 adult men, suggesting distinct stages of life spanning from early adulthood to the *settling down period* to mid-life and the start of middle adulthood. In the *novice phase* of development, Levinson (1978) alludes to the distinct experiences of young male adults, focusing on the exploration and volatility of life for those 17-33, who are growing significantly professionally and personally. Finally, Arnett (2000) cites Keniston (1971), who theorized about this age group, calling the period *youth*. Keniston (1971) outlined acts of dissent in youth, focusing on the social movements of young adults of the time period. Based on these existing theories, Arnett (2000) carved out space for the new, more specific concept of emerging adulthood. This concept has been widely adopted. Since its publication in 2000, Arnett's original article has been cited nearly 13,000 times (Google Scholar analytics, 2019).

Markers of emerging adulthood. Certain experiences are more common for emerging adults, marking the developmental period with distinct characteristics. Specifically, emerging adults are often concerned with identity exploration, experience instability, are known for having a self-focus, feel they are in-between adolescence and adulthood and fit in neither, and often express hope and optimism when describing the possibilities for their future (Arnett, 2019). These themes of emerging adulthood have been discussed in a career context, with career development being a significant focus of the identity development, uncertainty, and hope experienced during this period (Severy, 2019). As emerging adults begin to understand who they are and experience complex feelings about their future, career exploration is a major part of this process (Severy, 2019). Since all of the participants in this study are emerging adults, understanding the elements that characterize personal identity development and career development of individuals in this stage provides a foundation for this study.

Identity. Identity exploration is one of the primary characteristics of emerging adulthood. The phenomenon has also been explored in various other models including Erickson's (1968) psychosocial development model, and Marcia's (1966), and later Crocetti's (2010) work on identity formation. Further, identity is a critical component of career development, with the concept of vocational identity, which is the development of an understanding of oneself in a career context (Brown & Hirschi, 2013), being linked to numerous positive life and career outcomes. For example, engineering identity has been examined within the context of the engineering profession. Identity research provides insight into this critical developmental component of emerging adulthood, thereby connecting to the experiences of the emerging adults who participated in this study. Historical models of identity formation, as well as vocational and engineering identity are discussed here.

Historical models of identity formation. In numerous developmental models, identity development is a critical task marking the transitions between adolescence, emerging adulthood, and adulthood (Broderick & Blewitt, 2015). Erikson's stages of psychosocial development outline the crises present at various age-bound stages, highlighting the major hurdles individuals must overcome to develop further. In particular, adolescence is marked by the struggle between identity and identity confusion, where individuals are said to either create an individual identity through experimentation with various roles or experience continued uncertainty about who they are (Erikson, 1968). Ultimately, Erikson (1968) suggests that it is during this period that identity is formed.

Marcia (1966) developed a model to further differentiate the experiences of individuals engaging in identity formation. The study examined identity related to work, religion, and politics. Based on semi-structured interviews of 86 college students, Marcia (1966) examined the levels of crisis (engagement in exploration and choice) and commitment (investment). This analysis generated a model of four possible identity statuses: *Achievement* (characterized by a commitment to a particular identity, such as an occupation, which has been made based on meaningful exploration and consideration of the possibilities); *Moratorium* (currently engaging in exploration without making any commitment); *Foreclosure* (marked by a lack of exploration but a high commitment, these individuals might have made their choice based on parental or societal expectations); and *Diffusion* (there is no active exploration and there is no decision; Marcia, 1966). This model has been criticized for being Western-focused, suggesting characteristics of collectivist societies are indicative of the negatively described state of foreclosure, despite parental and societal expectations being highly valued in these cultures (Cheng & Berman, 2012). The model also suggests identity development is completed before emerging adulthood, which has since been contradicted (Schwartz et al., 2013).

A later study by Crocetti and colleagues (2008) added to this model through an exploratory factor analysis on a diverse sample of 1,952 adolescents. The revised model is characterized by its cyclical nature, depicting opportunities for individuals to engage in revision as required: individuals undergo identity formation and maintenance (they explore and make choices based on knowledge of self) and also engage in reconsideration of commitment (engaging in further consideration and choice if the current choice is not fitting). This model keeps the exploration and commitment aspects of the four identity statuses and adds reconsideration.

Identity development extends into emerging adulthood. In an investigation of correlates of identity stability and instability, Crocetti and colleagues (2012) document identity instability in both the adolescent and emerging adult cohorts they studied. Even though this study does not explicitly refer to career development, vocational identity development is a major concern of emerging adulthood (Arnett, 2019). Crocetti and colleagues' (2012) model encompasses all identity development generally, including development related to career. It is clear that identity development extends beyond adolescence, meaning specific identity formation related to career development is also likely to continue into emerging adulthood. This positions identity development as an ongoing, fluid process, as opposed to a static achievement ending adolescence, as proposed by Erikson (1968).

Vocational identity. Vocational identity is “the development of a coherent view of oneself as a worker” (Brown & Hirschi, 2013, p. 309). Someone with a clear vocational identity is characterized by a thorough personal understanding of their own characteristics, including their interests, goals, values, and skills, with the ability to connect this self-knowledge to occupations (Brown & Hirschi, 2013). This construct appears in numerous theoretical orientations, including Holland’s theory of personality-environment types, career construction theory, and Super’s life-span, life space theory (Brown & Hirschi, 2013), all of which are integrated into STF (Patton & McMahon, 2014). It is also closely related to the processes underpinning Erikson’s conceptualization of identity (Turner & Lapan, 2013).

Strong vocational identity has been argued to be a critical factor in successful career decision-making, and career counsellors are often encouraged to support their career-undecided clients to clarify their self-knowledge and vocational identity in order to move forward (Rottinghaus & Hauser, 2013). A clear vocational identity is correlated with positive outcomes in numerous studies on adolescents, such as high school students selecting postsecondary majors more congruent with their personal characteristics (Leung, 1998), more realistic career plans (Sarriera et al., 2001, as cited in Turner and Lapan, 2013), higher self-esteem (Skorikov & Moore, 2001, as cited in Turner and Lapan, 2013), and acts as a mediator between reported life satisfaction and self-evaluations (Hirschi, 2011). Further, career interventions have been shown to increase vocational identity in participants (Johnson et al., 1981). Due to these positive correlates in high school students, further research on the experience of vocational identity development in post-secondary students as is in this thesis, is warranted.

Identity and STF. From an STF perspective, vocational identity has been understood as a narrative co-construction developed within a social and cultural context (La Pointe, 2010). A case study of Eeva, a 51-year-old Finnish woman sharing her career story, illustrated a narrative which reconceptualized her identity amidst changes throughout her career history (LaPointe, 2010). As Eeva told her career narrative, she shared what could be understood as diverse identities, but she wove them together through a narrative which connected her numerous contexts and experiences (LaPointe, 2010). This constructivist, narrative perspective provides agency to the individual in an uncertain modern world, where the individual may be unable to control many of the influences on their career (LaPointe, 2010). McMahon & Patton (2018) argue this is an example of STF, as Eeva's identity was "constructed and reconstructed across time and context" (McMahon & Patton, 2018). Vocational identity is thus fluid and influenced by the various systems and contexts surrounding the individual.

Identity development is also understood within a narrative in Sisa's story (McMahon & Watson, 2013). Sisa is 16 years old and South African, attending a school where he is a minority black student amidst a white majority (McMahon & Watson, 2013). Sisa shared a story of his identity in which he is influenced by context: his roles, his culture, his mother's expectations, and his language loss in an English-speaking school (McMahon & Watson, 2013). Sisa's vocational identity is situated within a broader political context, with themes from South Africa's history playing out in Sisa's mother's expectations of her son and in her desire for him to access opportunities her generation could not (McMahon & Watson, 2013). These contexts, which make up systems theory framework of career development, can be used to understand Sisa's identity and the story he tells about his career (McMahon & Watson, 2013). Ultimately when viewed from the perspective of STF, identity is situated within its context and becomes an understanding of the past as well as the "crafting" of a story of the future career (McMahon & Watson, 2013).

Engineering identity. An even more specific type of identity has been explored in engineering education research: engineering identity. Engineering identity is the constantly evolving notion of who and what an engineer is and does, encompassing personal features and professional competencies (Murphy et al., 2015). Morelock (2017) conducted a systematic literature review of engineering identity research covering 46 studies. Themes of engineering identity found within the studies include:

1. Engineering identity develops based on factors such as group membership, gender, academics, and occupational identities;
2. Engineering identity can be framed as a personal perception of oneself as an engineer;
3. Engineering identity can be understood as a personal perception of oneself as an engineer; and
4. Engineering identity stems from one's responsibilities and actions (Morelock, 2017).

Various factors have been reported by engineering students as contributing to their identity. Students describe their engineering identities as design-oriented, career-oriented, and there is a sense of commonality of identity among engineering students (Murphy et al., 2015). Engineering competence, interest, and recognition, as well as tinkering, analysis, and design have been shown to predict engineering identity development in engineering students (Choe et al., 2019). Engineering identity has also been deemed influential in students' decisions to remain in or leave engineering (Seymour & Hewitt, 1997; Danielak, Gupta, & Elby, 2014).

Though engineering students in the previous study identified shared characteristics, conceptualizing what it means to be a professional engineer in the world of work is much more complex and convoluted. In the modern age, amidst technological advancement and societal change, what it means to be an engineer has shifted. The idea of whom and what an engineer is has undergone significant discussion and debate (Murphy et al., 2015). Engineering scholars have discussed the variety within the conceptualization of engineering as an occupation, characterizing engineers as "skilled workers, project managers, applied scientists, designers, entrepreneurs, and more" (Christensen et al., 2015, p. v). Engineering is a diverse profession. Engineers personally identify with a plethora of characteristics, coming to the profession with diverse social, cultural, familial, political, and other identities (Marjoram & Murphy, 2015). Further, the professional specializations of engineers add additional diversity, with professionals being trained as one of many specific types of engineer (e.g., as a biosystems engineer) and then also working within a particular industry, of which there are many (Marjoram & Murphy, 2015). It is difficult to integrate all of this diversity into what it means to be an engineer, but a major portion of this identity is linked to the specific knowledge required to practice within the profession (Marjoram & Murphy, 2015). Many studies have identified the skills associated with engineering identity, ranging from technical expertise, to problem-solving to innovation (Morelock, 2017). In other words, engineering is often boiled down to the skills necessary for work.

Career development of engineers and the engineering graduate attributes. Engineering identity is tightly associated with the competencies required to practice in the profession (Murray et al., 2015). One way to identify these specific skills that are so closely linked to engineering professional development is to explore the Canadian Engineering Accreditation Board (CEAB) graduate attributes, which are twelve specific attributes programs must demonstrate their graduating engineers are competent in to retain accreditation (Engineers Canada, 2018). The attributes are as follows: a knowledge base for engineering, problem analysis, investigation, design, use of engineering tools, individual and teamwork, communication skills, professionalism, impact of engineering on society and the environment, ethics and equity, economics and project management, and lifelong learning (University of Manitoba, 2015). Since 2009, the need to meet accreditation requirements has made the CEAB graduate attributes a defining element of the redevelopment, refinement and continual improvement process of the curriculum (F. Delijani, personal communication, December 13, 2019). They represent a common set of competencies that all Canadian undergraduate engineers are expected to demonstrate, which could define a mutual starting point for new graduates' identities as engineers and for their professional development.

As the graduate attributes became imperative content in engineering classrooms, scholars in engineering education began publishing and presenting strategies for the development of learning outcomes and the assessment of students in line with the graduate attributes (e.g., Mann & Morrison, 2012). The majority of literature on the graduate attributes focuses on the classroom context, and very little positions the graduate attributes as central to engineer's employability. Specifically, there is room for further research on how students' can harness their own understanding of their engineering competencies to market themselves to employers, and to personally reflect on their own strengths and identify gaps in their current skillset.

CEAB graduate attributes in a career context. There has been some investigation into the ways that engineering competencies can be understood within a career context. Cooperative education programs have utilized the graduate attributes to ground students' reflection on their work terms. The co-op program at Dalhousie University had students create learning goals for their work term based on four graduate attributes of their choice (Coolen, 2011). Students assessed and reflected upon their learning through individual reflections, demonstration of their work, and through assessments from their supervisors, which could be collected in a portfolio (Coolen, 2011). Memorial University incorporated similar expectations into co-op work terms, having students reflect on their personal growth related to the graduate attributes then present their reflections alongside work samples in an ePortfolio (Spracklin-Reid, 2014). These studies demonstrate how the graduate attributes can be used for the conceptualization of engineering skill development beyond traditional classroom learning, with students using the criteria to assess their personal career growth. Further research could illuminate further possibilities for the graduate attributes in a career context and the ways students grow in their understanding of their skills over time.

The CEAB graduate attributes can also be understood as a skillset which can be used to communicate students' capabilities to employers. The Conference Board of Canada's Employability Skills 2000+ outlines the critical skills required for success in the world of work (The Conference Board of Canada, 2000). These include fundamental skills (the ability to communicate, use numbers, manage information, and think and solve problems); personal management skills (the ability to demonstrate positive attitudes and behaviours, be responsible, be adaptive, learn continuously, and work safely); and teamwork skills (the ability to work with others and participate in projects and tasks; The Conference Board of Canada, 2000). One study directly linked the CEAB graduate attributes to these employability skills, creating a skills framework to conceptualize academic engineering skills within the labour market (Seniuk Cicek et al., 2016). These connections are depicted in Figure 2.

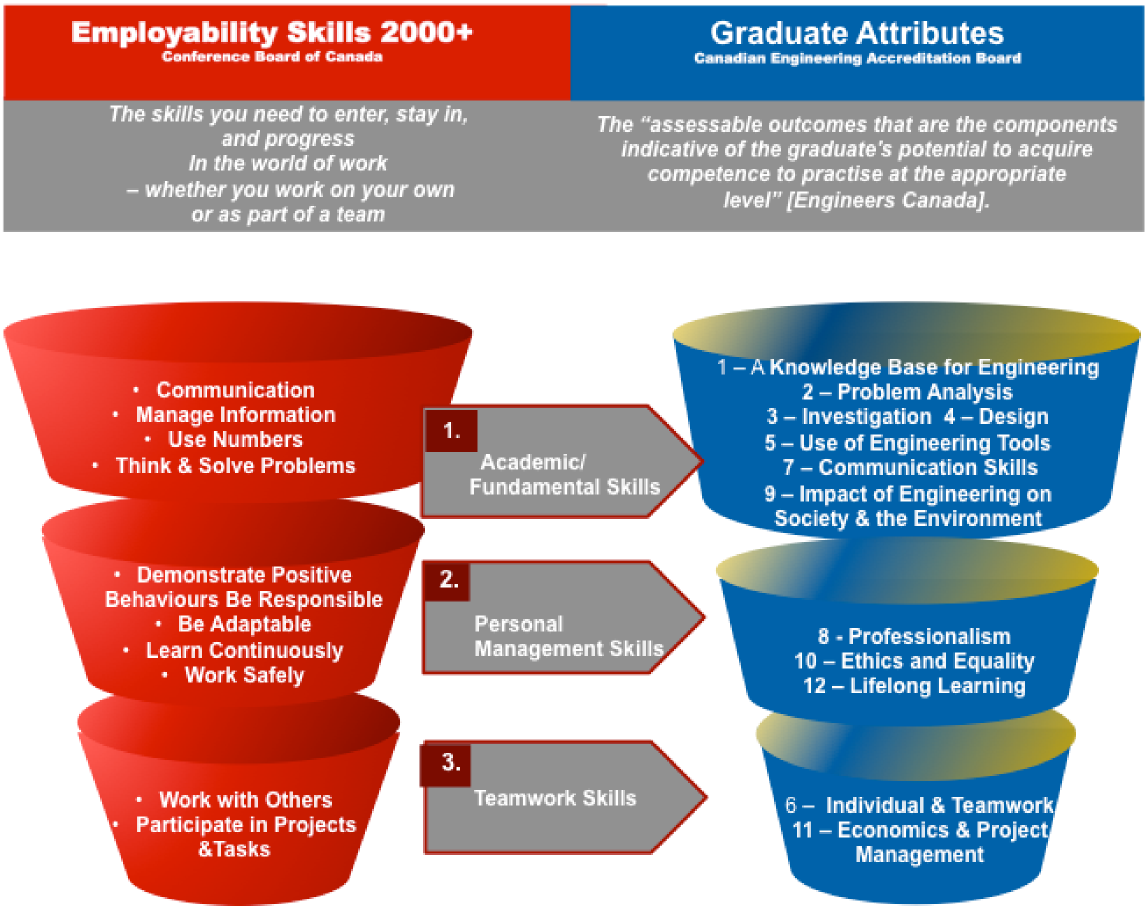

Figure 2. The employability skills 2000+ graduate attributes framework. From Seniuk Cicek and colleagues, 2016, p. 4, permission granted from authors.

The authors suggest that this framework can be used to support students in articulating their employability to hiring managers, in particular through the development of student portfolios, developed with the needs and language of employers in mind (Seniuk Cicek et al., 2016).

When graduating with an engineering degree, an individual should be equipped with a carefully curated set of attributes that prepares them for work as a professional engineer. These attributes can be linked to proficiencies that are sought by employers and can be applied in numerous environments. Thereby, to understand the career development of engineering students, it is critical to also understand the centrality of the specific skills in the engineering profession, and thereby, engineers' career development.

Engineering identity and gender. Engineering identity has also evolved with respect to sexism in the field, as the profession has been challenged to address this issue. Engineering identity has been historically masculine, and as more and more women enter the profession, what it means to be an engineer and what an engineer looks like has been pressured to change (Marjoram & Murphy, 2015). This can impact identity development. In fact, research suggests it is more challenging for female engineers to develop engineering identity than males (Morelock, 2017). Women have reported strategies to address the challenges of working in this male-dominated field, including careful impression management to demonstrate their professional competence and prove themselves to their colleagues (Hatmaker, 2012). Gendered tensions continue to exist within this male-dominated profession, but there have been increasingly louder calls to action on this topic (Marjoram & Murphy, 2015).

Faulkner (2015) has explored another gendered issue within this occupation: the notion of technical skill versus social skill as central or peripheral to what it means to be a "real" engineer. This can be connected to the 12 CEAB graduate attributes, which can be understood as encompassing both transferable (i.e. social) and technical skills (Seniuk Cicek et al., 2017). Within these distinct skill sets, social skills are positioned as feminine and technical skills are aligned with masculine identities (Faulkner, 2015). Further, it is often assumed that a person can be proficient in one but not the other: the engineering stereotype is of a technically competent but socially challenged male professional (Faulkner, 2015). Women are often assumed to be the more socially capable within the profession, though there is no evidence to support this stereotype (Faulkner, 2015). Faulkner (2015) urges engineers to make room for a more inclusive engineering identity, which encompasses not just technical prowess, but also social acumen, creating an engineering identity that champions hybrid strengths in all genders. These individual characteristics related to gender and skill can be understood as components of the individual within STF, with larger, overarching societal and cultural influences providing context to the experience of the individual (Patton & McMahon, 2014).

The Engineering and Geoscientific Act. As the concept of engineering identity is explored, it is important to note that the title “engineer” is protected by provincial legislation in Manitoba known as The Engineering and Geoscientific Act (2015). To call oneself an engineer or to practice protected engineering tasks without being an engineer is against the law. The Act protects the title engineer and the practice of engineering by giving power to provincial professional regulatory bodies such as Engineers Geoscientists Manitoba, which are responsible for setting the bylaws and code of ethics that dictate the practice of engineering (The Engineering and Geoscientific Act, 2015). These bylaws and ethics are provincial, but Engineers Canada was involved in creating their framework, supporting the provincial organizations, thereby ensuring there is a national culture and standard of Canadian engineering (Engineers Canada, n.d.a).

To become a professional engineer in Manitoba, one must complete a CEAB accredited engineering program, must log supervised engineering experience, and pass professional exams (Engineers Geoscientists Manitoba, 2017). The first step in this process is the completion of an accredited engineering program. The CEAB, with its control of the accreditation process and its ability to influence what is taught in schools is thereby shaping what it means to be an engineer in Canada, legally and practically. Though engineering identity can be understood as a personal experience, it is also a legally protected identity.

On top of this, the Engineering and Geoscientific Act protects the profession and empowers the professional association, a group of engineers, to regulate themselves. Ultimately, other professional engineers become the gatekeepers to this identity: one must meet very specific standards and maintain professional obligations in order to call oneself an engineer. They have the power to decide who can call themselves an engineer, how engineers are taught, and what it means to practice engineering. By retaining the power to accredit engineering programs through accreditation requirements, Canadian engineers maintain control of their professional identity. Ultimately, engineering identity is complex and evolving. It is subject to technological advancement, personal development, and it is also a professional identity regulated by law. It can be understood as a shared professional identity as well as an individually unique personal identity. As the students engage in career development supports within their biosystems engineering course, it is useful to understand engineering identity, as this may be developing for the participants as they grow and develop within their professional program.

Themes and critique of emerging adulthood with a focus on vocational and engineering development. For emerging adults, various pieces of their personal and professional development are of particular concern as they explore who they are and what they want out of life. This section covered the history of this stage as well as the specific markers of emerging adulthood, with an emphasis on identity development. (Find a table detailing the studies covered in this section, including key findings and critiques, in Appendix J.)

The beneficial correlates of vocational identity for adolescents provide a possible argument for career supports to focus on this age group. If career supports can help facilitate vocational identity development in emerging adults, the implications for these individuals are positive. While it is developmentally normal to only have a partially constructed identity as an emerging adult, moving forward with identity development is clearly an indicator of wellbeing.

Further, understanding what it means to be an engineer provides context for this study, which looks at emerging adults who are not only growing in terms of their overall identities and vocational identities, but more specifically figuring out their engineering identities. What it means to be an engineer is complicated and connected to specific knowledge sets as well as legal requirements. For emerging adults who are undergoing significant personal development, the development of their engineering identity, with all of the responsibilities and information that come along with this identity, is an added layer which is explored through this study.

Reflection in Experiential Learning

Reflection has been framed as an important component of effective learning and has been utilized throughout educational settings, including career education and career counselling. Multiple learning models integrate reflection, but this section will focus on reflection in experiential learning theory due to its prevalence in adult education (Kolb, 2015). Career theory also integrates reflection with career construction theory, constructivism, and happenstance learning theory, demonstrating reflection as an important process in career development.

Written reflections make up one of the data sources for this study. In their biosystems engineering course, students were asked to reflect on their experiences at various moments in the course. The specific instructions for these reflections will be detailed in Chapter 3. Reflection therefore becomes an integral component of the data collected for this study.

This section will cover the history of experiential learning theory, its applications to career development, and research on experiential learning in higher education, with a specific focus on experiential learning in engineering. This section excludes Kolb’s learning styles, biological research in experiential learning, and the structure of consciousness in experiential learning. It will only cover limited studies on experiential learning in contexts beyond higher education, as these topics are beyond the scope of this study.

Historical foundations of experiential learning theory. Experiential learning connects work, education, and personal development (Kolb, 2015). The basic premises for experiential learning are that individuals learn differently, they learn best through experience, and the way people learn develops over time (Kolb & Fry, 1974). The experiential learning cycle offers a process for effective learning, placing reflection as a key step in this process (Kolb, 2015). Modern experiential learning theory is based on work by John Dewey, Kurt Lewin, Jean Piaget and David Kolb (2015). It integrates work from research on higher education, organizational development, and cognitive development. In John Dewey's (1938) book, *Experience and Education*, Dewey advocates for higher education to cultivate "learning through experience" (p. 19). Dewey (1938) underscores the distinctions between traditional instruction and new education, discussing the movement from rote memorization of information shared from those "experts" above the student (i.e., "the sage on the stage") to the idea that education is a way to grow personally, with a focus on students' understanding of the context of, and reason for the acquired knowledge. The author argues that meaningful, well-organized experiences can provide the basis for more effective learning (Dewey, 1938). The legacy of Dewey's ideas can be seen in modern post-secondary institutions through co-operative education, work-study programming, apprenticeships, labs, fieldwork opportunities, and internships (Kolb, 2015).

In 1946, Lewin began developing techniques that would become the T-group theory and the laboratory method, which are training methods in which group participants collaborate in their learning without a specific leader (Bradford et al., 1964). In the first iteration of this training method, participants in training research were invited to discuss their experience of learning later in the same day, rather than the researchers relying solely on their own observations of participant learning (Lippit, 1949). These tools have since become common in organizational development and training, with experiential learning techniques such as role-plays, games, cases, and computer simulations being used to support adult learners at work (Kolb, 2015). These techniques are noteworthy in their reliance on not just experience, but on interaction with others for learning to take place. Kolb (2015) notes the impact of Kurt Lewin's contributions to training and organizational development to experiential learning theory.

Finally, Jean Piaget's research in cognitive development provides a further foundation for modern experiential learning theory (Kolb, 2015). Piaget's (1952) work on childhood cognitive development asserts that children progress through stages of cognitive development, moving from basic reflexes to complex understanding in which previous learning can be adapted to new situations. Kolb (2015) particularly highlights Piaget's notion that intelligence is not static: it grows and develops with experience. This in turn becomes a noteworthy aspect of experiential learning theory, which asserts that individuals learn by doing and can continue to learn and grow over time. This is particularly notable in the modern economy, where life-long learning is an essential skill for the agile, more employable worker (Royal Bank of Canada, 2018).

The experiential learning theory. A major suggestion of experiential learning is that applying classroom knowledge to the real world furthers and reinforces learning (Kolb & Fry, 1974). This model distinguishes itself from previous ideas about learning in that it positions learning as an experiential and social process as opposed to an outcome-based behavioural destination (Kolb, 2015). In other words, the journey is just as important as the destination for learners, with certain teaching methods positioned as more effective. Kolb's theorizations on experiential learning are broad, but this thesis will focus primarily on explaining the experiential learning cycle, with specific focus on reflection and how experiential learning is found in a post-secondary classroom setting and in hands-on learning outside of the classroom.

Experiential learning cycle. Of primary interest to this study is the experiential learning cycle. The experiential learning cycle is a way of conceptualizing hands-on, reflective learning. Kolb (2015) proposes (and the literature supports) that this is an impactful way to engage in learning, with many educators purposefully embedding the pieces of the cycle into their lesson plans. The cycle includes:

- *concrete experience* (full involvement in the experience),
- *reflective observation* (reflecting on the experience from multiple angles),
- *abstract conceptualization* (integration of newfound understanding into theories), and
- *active experimentation* (application of these theories; Kolb, 2015).

Of particular interest to this study is *reflective observation*, which is a tool with is found throughout career development theory and practice.

Reflection and career theory. Though not explicitly linked by their authors, numerous career theories utilize experiential learning techniques to support career development. These include career construction theory (Savickas, 2013), constructivism (Grier-Reed & Skaar, 2010), and happenstance (Krumboltz, 2008). These theories position career development as a process of gaining experiences, then reflecting on these experiences. Ultimately, career development can be understood as a learning process, as the individual learns about who they are and what they want from their career.

Career construction theory. Career construction theory "asserts that individuals construct representations of reality, yet they do not construct reality itself" (Savickas, 2013, p 147). Within this theory, an individual's career develops as a self-construction within a social construction, influenced and co-constructed by interpersonal connections (Savickas, et al., 2009). Ultimately, a career is built through experience and through reflection on that experience (Savickas, 2013). A career is a social act, emerging from interactions with others and reflections on these interactions. This can be tied directly to the experiential learning cycle, and is most closely parallel to *concrete experience* and *reflective observation* (Kolb, 2015).

Career construction theory has also been used to address the changing economy. As the realities of our labour market shift, workers can expect a degree of uncertainty as they make career plans. There is no longer the assumption that one will retire from the first company that hires them: most workers will have multiple job transitions in their lifetime, meaning they will be engaging in a continuous construction of a career narrative in relation to their own unique experiences (Savickas, 2013). The individual is the actor in, and author of, their own career story (Savickas, 2013). While this theory suggests the world around us has many elements outside of our control, there is room for personal interpretation of this world and for individual action. In other words, reflection can be a transformative experience in an individual's career.

Constructivism. Constructivist career counselling utilizes a variety of tools to support an individual in the construction and evolution of their identity, with the goal of building a personal story of a meaningful life (McMahon & Patton, 2004). The approach is not founded on "the idea that students need to be empowered to make one choice, but on the idea that students need to be empowered to make and see many choices as they construct meaningful life pathways and shape their future careers" (Grier-Reed & Skaar, 2010, p. 51). This approach has developmental roots, stemming from Piaget's theory of cognitive development (Grier-Reed & Skaar, 2010). In other words, career development is positioned as a learning experience, with previously developed “schemas” or worldviews being used to interpret unfamiliar experiences (Piaget, 1952). If these schemas don’t work, newly acquired information is used to transform worldviews that do not fit anymore (Piaget, 1952).

Specific techniques within the constructivist approach include narrative, construction, action, and interpretation, which work together to allow the individual to better understand and construct their identity (Grier-Reed & Skaar, 2010). This is done through a variety of reflections, discussions, as well as experiential learning opportunities grounded in planned happenstance (the notion that uncertainty and active exploration is beneficial for career development; Grier-Reed & Skaar, 2010). A key to this is to support students in identifying personal themes related to their strengths, interests, and values, which can connect to career possibilities (McMahon & Patton, 2004). Constructivist approaches embrace indecision, encouraging acceptance of indecision with a focus on further exploration and reflection, which can in turn facilitate future decision-making. As already mentioned, the theoretical framework of this study, systems theory framework of career development, is a constructivist approach.

Happenstance learning theory. Similar to constructivism, this theory suggests that decision-making should not be the goal as an individual moves forward in their career (Krumboltz, 2008). Instead, focus should be placed on engagement in experiential opportunities and then meaningful reflections on these experiences as clues of possibilities for satisfying lives and careers (Krumboltz, 2008). Planned happenstance involves putting oneself out there, harnessing unplanned events as opportunities to move forward, and creating new opportunities for oneself through purposeful interactions with others (Krumboltz, 2004). Ultimately, this approach embraces the uncertainty present in career development and encourages individuals to adjust their mindsets and behaviour to become successful and satisfied within this uncertainty. Happenstance learning theory suggests that it is through experience that careers are built. This theory utilizes all stages of the experiential learning cycle as the individual engages in and reimagines their career: *concrete experience*, *reflective observation, abstract conceptualization*, and *active experimentation*.

Experiential learning in higher education.

The impact of experiential learning in higher education. Experiential learning has been linked to better employability outcomes. A Statistics Canada report found that 83% of recent non-co-op graduates were employed full-time compared with 90% of those who graduated from a co-op program (Ferguson & Wang, 2014). These former co-op students were also more likely to report that their work was related to their education and earned higher salaries overall (Ferguson & Wang, 2014). Transferable skills sought by employers (The Conference Board of Canada, 2000) such as self-efficacy, leadership, interpersonal skills, and written communication skills are also typically higher among students who take on experiential learning activities such as service learning in and outside the classroom (Astin, Vogelgasang, Ikeda, & Yee, 2000).

Experiential learning has also been associated with student academic success. A longitudinal study of American university students engaged in course-based and extracurricular community service learning found a significant positive relationship between participation and academic success as quantified by writing skills, critical thinking skills, and GPA (Astin, Vogelgasang, Ikeda, & Yee, 2000).

Experiential learning in engineering. Experiential learning in engineering has been linked to positive outcomes in engineering classrooms (Giridharan & Raju, 2016), achievement of learning outcomes (Abdulwahed & Nagy, 2009), positive feedback of students, and increased students' reports of their perceived learning (Chen, Shah, & Brechtelsbauer, 2016). Kolb's theory has been used to describe the experiences of students engaging in engineering laboratories, and research has demonstrated that engaging in all of the stages of the experiential learning cycle within a laboratory is significantly correlated with reaching learning outcomes (Abdulwahed & Nagy, 2009). Other studies have found that hands-on, experiential learning activities in the engineering classroom garnered positive feedback from both instructors and students (Chen, Shah, & Brechtelsbauer, 2016). This was demonstrated more specifically when a student-proclaimed "difficult" mechanical engineering design course was redesigned to incorporate experiential learning principles through hands-on experience and reflection: the instructor reported improvements in student performance and course evaluation surveys (Li, Öchsner, & Hall, 2016). The previous evaluations had 26.5% of students rating the course as satisfactory, and after experiential learning was integrated into the course, the satisfactory rating was 67.7% (Li et al., 2016). Similarly, the percentage of students who agreed the teaching was effective rose from 29.4% to 71% (Li et al., 2016).

Experiential learning at the University of Manitoba Price Faculty of Engineering. Experiential learning has been applied extensively in engineering programs, from co-operative education programs to laboratories to student teams. At the University of Manitoba specifically, the Price Faculty of Engineering offers a co-operative education program in which engineering students can take four to twelve month terms within their programs to work in industry (Co-operative Education & IIP, 2019a). Co-op programs are examples of experiential learning (Kolb, 2019), as is exemplified by the University of Manitoba's program, which combines academic learning, industry exposure, and reflection (Co-operative Education & IIP, 2019b), all of which are components of experiential learning. A specific selling point of the program to employers is that it produces “industry ready grads” (Co-operative Education & IIP, 2019a), suggesting a link between experiential learning and the world of work. Still, the benefits of co-operative education are not available to all students. Some choose not to join and others join, but are unable to secure a co-op job (Sattler & Peters, 2013; Maybrey, 2018). Further, some students have personal barriers to accessing co-op, which has a significant time commitment and can delay graduation (Sattler & Peters, 2013). This means co-op cannot be the only source of career development for students: other avenues need to be explored to ensure every student can benefit from career support.

Experiential learning can also be found in student extracurricular engineering competitions at University of Manitoba, such as SAE competitions where students design and build vehicles (UMSAE, 2019). These hands-on experiences have been connected to skills required in the world of work. Upon reflection on their own experience with student design competitions in Europe, Gadola and Chindamo (2017) noticed that students were building industry-sought soft skills such as project management, leadership, communication, and teamwork. In a survey of twenty students who took part in a design competition, students used words like passion, collaboration, and learning to describe their experience (Gadola & Chindamo, 2017). Though outside the classroom, these experiential learning opportunities for engineering students have the potential to enrich their education, provide skills, and be the basis for the experiences encouraged in so many career development models.

Reflection and learning in STF. STF has also been used to describe learning in career development. McMahon & Patton (2018) argue that learning occurs within a system, as does learning about the self over time, which in turn influences one’s career. The authors explicitly refer to experiential learning theory, suggesting the experiences and reflections occurring within experiential learning theory can be understood as occurring within systems and have the recursiveness inherent in STF (McMahon & Patton, 2018). Even the school can be understood as a system in and of itself, situated within the context of the larger social and environmental-societal systems (Patton & McMahon, 2014). STF can therefore be used to understand career learning occurring in schools (Patton & McMahon, 2014), as is the present study.

An exploratory case study of Nozuko, a Black South African university student, showcased a narrative, STF approach to career counselling (McMahon et al., 2012). Nozuko discussed connectedness in terms of her family, culture, and socio-economic status. She also reflected on her experiences in conversation with her counsellor, identifying new perspectives on previous learning experiences and identifying opportunities for her future based on them (McMahon et al., 2012). This can be connected directly to experiential learning theory, where learning encompasses an interplay between doing and reflecting (Kolb, 2015). Finally, Nozoku made meaning of her career story and built personal agency, sharing about actions she would take for her career future. Through this process, Nozuko and her counsellor co-constructed a career narrative, situated within the complex context of Nozuko's life (McMahon et al., 2012).

Themes and critique reflection in experiential learning. Based on review of the literature, certain themes can be found within studies of experiential learning. (A table providing highlights of the major articles included in this section can be found in Appendix J.) Extensive research has connected experiential learning with academic success (Astin, Vogelgasang, Ikeda, & Yee, 2000), better understanding of engineering topics (Abdulwahed & Nagy, 2009; Li et al., 2016; Giridharan & Raju, 2016), and the development of skills sought by employers (Astin, Vogelgasang, Ikeda, & Yee, 2000). It is clear that the experiential learning cycle, as described by Kolb (2015), is a useful for higher education and can improve the student experience.

Within engineering, experiential learning is already a well-established means of teaching and can be found in classrooms, co-op programming, and student design teams. Further, since the experiential learning model fits with the importance of experience and reflection found in so many career development models, experiential learning is congruent with career development interventions. Overall, experiential learning not only supports students in their academic achievement, it can also be utilized in their personal development and career development - topics that are part of the focus of this thesis.

Overall Gaps in the Field and Contributions this Study Will Make to the Literature

Very limited research has been conducted on integration of career development supports into existing academic courses. The literature also lacks a qualitative approach to the study of this topic. However, there is growing interest in this topic and career development practitioners are already entering classrooms and providing career support. Stand-alone career courses have also already demonstrated positive impacts. Taken together, the positive implications of stand-alone career courses and the growing interest in incorporating career activities into the broader curriculum sets the stage for this research study. Through a grounded theory examination, this study takes an in-depth qualitative look at how career development activities are experienced in a first year biosystems engineering design course.

Further, the literature on emerging adulthood suggests that this period of development is closely linked to important career development factors, such as identity development. This will be explored in the context of this study. Though the literature sets the stage for the positive implications of career development courses through quantitative study, there is a lack of in depth qualitative research in this area and very little research on the integration of career development supports into existing classes. A qualitative study enables a deeper understanding of the experiences of students who receive this support in their classroom. In addition, this study is unique in that it focuses on the career development of students studying to be engineers. Specifically, the study adds to the literature by offering a grounded theory model of change for the career experiences of emerging adult participants in an engineering program.

Summary of Chapter 2

This chapter discussed the literature on the career development of post-secondary students, and in two cognate areas: emerging adulthood with a focus on engineering and vocational identity, and reflection in experiential learning. Within these areas, the history, career development, the post-secondary context, and engineering-related topics were covered. Specifically, the section on career development of post-secondary students explored how post-secondary classrooms have incorporated career supports. Additionally, the emerging adulthood cognate defined this stage and examined its markers, specifically digging into identity development, with a focus on vocational identity and engineering identity. Finally, reflection as framed by experiential learning was discussed in the context of higher education classrooms and on broader campuses, as well as the ways experiential learning has had positive impacts on student development, and its emphasis in engineering.

In Chapter 3, how grounded theory, the methodology for the study, is used to explore this topic will be explained, and the steps of the study outlined. This will include the specifics of the research design, the participants, a description of the career development supports that were integrated into the biosystems classroom, data collection processes, the process of data analysis, reliability and validity, ethical considerations, and methodological limitations.

Chapter 3: Research Method

This is a grounded theory examination of the impact of career development supports in a biosystems engineering classroom. This study aims to understand students' experiences of career supports within this course, with a particular emphasis on their personal and vocational development. This chapter will introduce grounded theory in detail, providing a historical overview and a justification for the choice of constructivist grounded theory, which has a more open-ended design than alternative grounded theory methods and focuses on social construction. The step-by-step process of using grounded theory to collect and analyse data will be detailed. The theoretical framework and the role of the researcher will be discussed. An overview of the career development supports that were integrated into the biosystems engineering course will be provided, as well as the reflection prompts students responded to as part of their coursework. Finally, there will be a discussion on the methodological limitations and ethical considerations of the study, and the ways these will be mitigated.

Grounded Theory

Historical overview of grounded theory. Grounded theory is a qualitative research method in which conceptual frameworks or low-level theories are built based on gradual, categorical analysis of qualitative data (Charmaz, 2014). It is particularly well-suited to research that wishes to explain a social process (Creswell, 2012). Glaser and Strauss wrote about their "discovery" of grounded theory in 1967. In their book, they outlined their systematic approach to qualitative research, providing the foundation from which modern grounded theory evolved. This initial approach to grounded theory is a process in which qualitative data is descriptively coded, theoretically relevant ideas are identified and grouped, and a deep dive into the data uncovers emergent categories until saturation is achieved (i.e., no new information emerges) and a low-level theory can be generated (Glaser & Strauss, 1967).

The epistemological orientation of this initial approach to grounded theory is positivist, where reality is “unitary, knowable, and waiting to be discovered” (Bryant & Charmaz, 2007, p. 34). This approach has been framed as a reaction to the widespread criticism of qualitative research from quantitative academics: grounded theory was initially positioned as a scientific, objective form of qualitative research (Bryant & Charmaz, 2007). The founding scholars of grounded theory eventually disagreed on how they conceptualized grounded theory, with Glaser (1992) maintaining the trajectory of initial grounded theory as an inductive method, and Strauss teaming up with Corbin to develop a more structured approach (Strauss & Corbin, 1998). The inductive approach focused on a more organic emergence of themes from the data, while the structured approach provided a stepwise recipe for the researcher to follow during analysis (Creswell, 2012).

Structured grounded theory, as developed by Strauss and Corbin, follows open, axial, and selective coding phases (Strauss & Corbin, 1998; Creswell, 2012). Once data have been completed and transcribed, the researcher reads through them to ensure familiarity with the content (Creswell, 2012). The researcher begins with open coding, identifying categories and subcategories throughout the data by labeling each line of data (Creswell, 2012). Next the researcher conducts axial coding, relating categories to a central category selected from the open codes and comparing categories to one another (Creswell, 2012). From here, the selective coding phase begins, meaning the researcher develops a theory based on the relationships identified amongst the codes (Creswell, 2012). Finally, a visual representation of the theory is developed to communicate the process that emerged (Creswell, 2012). To enhance the validity of findings, an independent coder analyzes each of these stages. This approach differs from Glaser and Strauss’s

(1967) initial conceptualization of grounded theory in that it provides a more structured means of developing a theory, with specific steps explicitly outlined. Later, social constructionists began challenging this positivist perspective championed by structured grounded theorists, arguing that reality is socially constructed, and thereby creating a method with less structure and more openness to multiple realities and perspectives, considered a constructivist approach to grounded theory (Bryant & Charmaz, 2007).

Since 2000, there has been significant debate among scholars around whether grounded theory should be objectivist (impartial research) or constructivist (“partial research; Bryant & Charmaz, 2007). This new perspective on grounded theory makes room for uncertainty, while still maintaining elements of the initial positivist framework (Bryant & Charmaz, 2007). Charmaz has illustrated a constructivist approach to grounded theory in her recent work, focusing on the complexity, diversity, and personal beliefs of participants through a more open-ended coding approach (Creswell, 2018). In contrast to this, Strauss and Corbin’s more systematic approach requires 20 to 30 interviews, field visits, and a structured coding process (Creswell, 2018). Further, the approaches differ in the way the researcher is positioned within the study. The systematic approach acknowledges the presence of researcher bias and strives for objectivity, providing specific steps for analysis while recognizing the existence of multiple possible truths (Mills, Bonner, & Francis, 2006). The constructivist approach rejects researcher objectivity entirely, focusing on the interplay between researcher and participant as well as the influence of the broader social context in the construction of the research (Mills et al., 2006). These two schools of thought provide distinct options for modern grounded theorists. Structured grounded theory will not be used for this project because Charmaz’s (2014) more open-ended, constructivist approach is more closely aligned with systems theory framework of career development, which provides the theoretical framework for this study. The following sections detail this approach and further explain the decision to utilize constructivist grounded theory.

Constructivist grounded theory. Constructivist grounded theory has a particular focus on accounting for context, suggesting strategies to attend to the subjectivity of the researcher, social influences, and interpersonal relationships in data collection and analysis (Charmaz, 2014). Though less formulaic than other forms of grounded theory, constructivist grounded theory still offers specific tools to engage in research. This method is fluid, proposing steps through which inquiry can take place, but leaving enough flexibility so the process is not necessarily linear, but rather iterative, with the researcher moving backward and forward in the process based on their interpretations. Specifically, constructivist grounded theory includes a theoretical framework, memoing, constant comparative methods, initial coding, focused coding, as well as theoretical sampling, saturation, sorting, and diagramming.

Theoretical framework. While grounded theory requires a certain degree of open-mindedness to allow for themes to have space to emerge from the data, a theoretical framework illuminates the general questions and broad interests of the study (Charmaz, 2014). It is important to disclose the theories and research literature that informed the research, but not be limited by this starting point. The researcher should remain open. Ultimately, the theoretical framework provides "a place to *start* inquiry, not to *end* it" (Charmaz, 2014, p. 31). In this way, constructivist grounded theory encourages the researcher to be open and reflexive about the theories which inform their perspective and potential biases. As the study progresses, if this theoretical framework does not fit the data, the researcher must rethink their theoretical framework and let their initial ideas go.

Memoing. Memos are entries written by the researcher at various points in the data collection and analysis process, where the researcher logs reflections, impressions, and ideas which can inform future analysis (Charmaz, 2014). Memo-writing encourages the researcher to stop and dig deeply into the data (Charmaz, 2014). Memos are used throughout the research process, from data collection to analysis to writing about the research (Charmaz, 2014). These written notes and reflections provide a clear pathway connecting the initial inquiry to the eventual theoretical framework that is developed (Charmaz, 2014). During analysis, memos can reveal gaps which might incite further data collection and they can also be used to move the analysis to a deeper, more meaningful space (Charmaz, 2014). Further, memoing requires reflexivity, providing the researcher (and third parties) with insight into their ideas, biases, and interpretations, and enabling the researcher to examine their own perspectives, make them transparent, and understand how these perspectives influence the research processes (Charmaz, 2014).

Constant comparative methods. Constant comparative methods is an approach to analysis used to continuously and simultaneously compare and analyse the data and codes at various levels (Glaser & Strauss, 1967). In this method of analysis, researchers compare "data with data, data with code, code with code, code with category, category with category, and category with concept" (Charmaz, 2014, p. 342). This means that data from various sources are being compared – between participants, between codes in one participant's transcript, and at a higher level, comparing the emergent themes. This process begins during the initial coding phase (which is described in the next paragraph) and continues as more data are collected, coded, and analysed. As the concepts become more abstract, higher level representations the process being studied, a low-level theory can emerge (Charmaz, 2014). Constant comparative method continues beyond the data analysis. Once a theoretical framework is built, it is connected to and compared with the literature, highlighting the ways in which the theory agrees with, builds upon, or opposes existing ideas (Charmaz, 2014).

Initial coding. The first step of analysis is initial coding. Initial coding occurs gradually throughout the data collection process, for example, occurring after each interview (Charmaz, 2014). The initial coding should be based on the actions within the data, not on analysis (Charmaz 2014). The data are closely read line by line, and annotated with initial codes by the researcher. These codes might be participants' words, phrases, or brief quotes taken directly from the data (called *in vivo* codes), keywords assigned by the researcher, or descriptions of the data (Charmaz, 2014). Gerunds, or words ending in "ing," are encouraged by constructivist grounded theorists in coding, as they can help the researcher stay 'grounded' in the moment of the action described by the participant (Charmaz, 2014). It is important to recognize that from a constructivist point of view, during this process, even as the researcher works to enable codes to emerge from the participants' point of view, the codes are being constructed by the researcher. This is because the researcher's *choice* of language – whether it be the participants' in vivo codes or the researcher's own words – imposes meaning (Charmaz, 2014). Any attempt to garner meaning from the transcripts is considered an interpretive act whereby the researcher is interacting with the participant in understanding and co-constructing meaning (Charmaz, 2014). Specifically, throughout the initial coding process, Charmaz (2014) suggests the researcher asks what the data are about, what the data suggests, what is left unsaid, whose point of view the data are from, and what category can be used for each piece of data. Through this process, the theoretical framework should be acknowledged as a theoretical starting point and let go of if it is not accurate (Charmaz, 2014). Ultimately, initial codes should be "grounded in the data" and act as a basis for later comparisons and analysis (Charmaz, 2014, p. 117). By engaging in this careful, descriptive process, the impact of the researcher's own preconceived notions about the topic can be acknowledged and potentially reduced, allowing the data to speak for itself (Charmaz, 2014).

Focused coding. In the focused coding phase, data between transcripts is compared to create codes that "are more directed, selective, and conceptual" (Charmaz, 2006, p 57), thus synthesizing the data. Throughout this process, memo-writing is used to track the researcher's thought processes, initial impressions, and developing analyses (Charmaz, 2014). This can help to mitigate bias by encouraging the researcher to be transparent. These focused codes, generated through constant comparative analysis, do not necessarily follow the initial coding process in a linear progression: the researcher moves between both phases as more data are collected, gradually developing codes for new data and then returning to initial codes to reinterpret them in the context of the new codes (Charmaz, 2014). Focused codes are more than literal representations of the data: they are based on the researcher's interaction with the data and should become abstractions that are able to describe numerous other codes (Charmaz, 2014). In other words, focused codes may not be literal representations of the data, instead offering higher level interpretations of multiple codes.

Theoretical sampling, saturation, sorting, and diagramming. Finally, theoretical sampling is conducted, which means data are analyzed through the lens of the already existing codes, digging into the categories that have emerged to further understand the data (Charmaz, 2014). If there are gaps in the researcher's understanding, participants may be contacted to provide clarity through further member checks (Charmaz, 2014). The purpose of this is to help the researcher to gather more detail, check, and adjust categories, eventually allowing the researcher to identify connections between categories (Charmaz, 2014). Through this theoretical sampling, the researcher begins to tentatively develop theoretical categories (Charmaz, 2014). Memoing occurs throughout this process as the researcher wrestles with and reflects on the variations within categories and seeks more information from participants based on what emerges from the data. Once theoretical saturation has been reached, which means that no further insights are emerging, memos can be sorted by category and diagramming is used to depict the processes at play (Charmaz, 2014). Diagrams are visual depictions of the theoretical categories and how they connect to one another, and may provide insight on directionality or how closely related categories are (Charmaz, 2014). Depending on the results, a process model may be depicted, mapping movement between categories (Charmaz, 2014). Eventually the memos and diagrams are integrated in logical, coherent ways, which can help provide context and support the write up of the project (Charmaz, 2014). It is important to note that the constant comparative method is not linear, with the researcher moving back and forth between techniques and stages of the research process (Charmaz, 2014).

Rationale for the use of constructivist grounded theory in this study. Since there is little research on university coursework infused with career development supports, particularly using qualitative approaches, a qualitative study provides deep insight into the student experience from the student perspective. Grounded theory in particular is suitable because there is currently no theoretical representation of this experience. This qualitative approach enables researchers to delve into the experiences and views of participants to discern what participants' share (Creswell, 2018). These commonalities in the students' experiences, grounded in the data, enabled the researcher to create a theoretical framework to guide future research on this topic (Creswell, 2018).

In Charmaz's approach to grounded theory, which is less focused on structure, the values and experiences of participants take centre stage (Creswell, 2018). This is appropriate for research in career development because, as discussed in previous sections of this theis, individual values, perspectives, and experiences are critical to career decision-making. Further, systems theory framework of career development, the theoretical framework adopted for this study, positions career development as a social process where the individual's unique experience is central. For these reasons, constructivist grounded theory as suggested by Charmaz (2006) is appropriate, aligning well with the constructivist views of career development posited by STF. A constructivist grounded theory approach enabled a methodical analysis of the data while respecting the complexity of the social processes woven into career development.

Research Design

Research questions. The research is guided by these questions:

Central Question: Through exposure to in-class career development supports in a biosystems engineering course, what influences students' vocational identity development?

Secondary: How do students experience their identity development over time in the course?

Secondary: How do students perceive supports and barriers over time in the course?

Career development support in the biosystems course. All students taking the biosystems Design 1 course in Fall 2019 have engaged in career development supports as part of their required coursework. These supports were derived from a series of evidence-based modules developed by a team in Career Services at the University of Manitoba that are based on the developmental needs of emerging adults, effective career development strategies, and career theories demonstrated in the literature. They were tailored to focus on career information related to biosystems engineering, as is the practice whenever Career Services provides programming in classrooms. The specific supports were offered over five classes spread across the term, and included a module on embracing a career mindset, a career planning module over two classes, an informational interview module and assignment, and a seminar on resumés and competency gaps. Students were also asked to build a Professional Skills Portfolio that utilized reflection in five activities that included two reflective letters, one at the onset of the course and one at the end, and a reflection on their informational interview experience. I facilitated all but one of these career supports in my role as a career consultant with Career Services, with all but one supported by one to two other career development practitioners from University of Manitoba, including the Director of Career Services and Business and Professional Development Consultant from the Price Faculty of Engineering. Through these supports, students had opportunities to engage in career development reflections on decision-making, personality, interest, and career values (Amundson et al., 2005). There were lessons on why and how to engage in reflection in the context of creating a career portfolio, conduct occupational research, and plan ahead for job search success. An additional networking opportunity with a professional working in the biomedical field was offered to students in the course during a lunch and learn. Ultimately, the goal of the career development supports was to assist students in exploring their personal and engineering identity, and in understanding how their skillsets connect to the labour market.

Embracing a career mindset. This first module offered to the biosystems engineering students in September 2019 was developed to support University of Manitoba students in setting the stage for successful careers and is based on happenstance learning theory, hope-filled engagement, career construction theory, and constructivism (Langlais, Balakrishnan, Mac, Peto, & Groeneveld, 2019). The language of the module is steeped in the constructivist and happenstance approaches to career development, with continuous calls for exploratory opportunities, encouragement to let go of the conceptualization of careers as linear, and to embrace unplanned events. As advanced in constructivism (Grier-Reed & Skaar, 2010) and happenstance learning theory (Krumboltz, 2008), career exploration through work and volunteer experience is recommended as a way to learn about the self and the world of work. Further, as is suggested in career construction theory, the fluid and social nature of a career journey was highlighted throughout the module (Savickas, 2013). The module also encourages career storytelling amongst peers, which is connected to the narratives found in constructivist career counselling (McMahon & Patton, 2004). In addition to this module, students were introduced to the career service supports on campus, including the individual services offered at Career Services and within the Price Faculty of Engineering. Reflection was covered in the context of career planning and opportunities for reflective discussion were provided. Finally, career goal-setting was introduced.

Career planning. In a two class (2 x 50 minutes) series focused on career planning in October 2019, students were supported in answering the question “What can I do with my biosystems engineering degree?” This was a tailored version of a career planning workshop regularly offered by Career Services at the University of Manitoba (Balakrishnan & University of Manitoba Career Services, 2019). The workshop began with discussion of personality, interests, and subject preferences. The Holland code was introduced and informally assessed through a worksheet, supporting students in creating a vocabulary for their interests and suggesting relevant occupations (Nuata, 2019). Educational opportunities beyond their current program were discussed, including education that can proceed after their biosystems engineering degree, such as prosthetist training, medical school, or graduate study in engineering. Through this career development support we explored the interdisciplinary nature of biosystems engineering and the broad options for graduates of the program both within and beyond engineering, building on the course content covered by the professors of the course, and supporting students in conceptualizing and defining their profession. Career information was a major component of these classes and students were taught how to do occupational research, which is a key ingredient of career planning (McKinnon & Johnston, 2014; Whiston, Goodrich Mitts, & Wright, 2017).

Informational interview. An informational interview is defined as a career conversation with an individual of interest, where one individual asks questions of a professional about the professional's work and career journey. Informational interviews provide opportunities to gather career information, and they also create a networking opportunity. One of the assignments for students in biosystems Design 1 was to conduct an informational interview with someone whose career was of interest to the student. Before conducting the interviews, students were taught how to conduct informational interviews professionally and were then supported in creating questions based on their career values through a 50-minute career development module offered in October 2019 (Balakrishnan et al., 2019). Students later in the term (November 2019) presented this information to their peers, sharing what they learned about the profession they chose through a TedX Talk, and reflecting on their experience in a one-page written response.

Career values. Career values can be understood as the personally important factors people desire in their work: the parts of their work that fulfill them and keep them going back (Rounds & Jin, 2013). Career professionals seeking to match their clients to appropriate occupations often assess these motivational factors (Rounds & Jin, 2013). *Job-security, helping others, social interaction, work-life balance,* and *status* are a few values represented in card-sort assessments such as the Knowdell career values card sort (Knowdell, 2004).

A values card sort (MacPherson & University of Manitoba Career Services, 2018) was used to help students articulate what they are looking for in their careers as they explore their options within and beyond biosystems engineering. Values were also used to support students to consider the questions to ask their professional during their informational interview. By grounding their questions in career values, students were encouraged to think about how their values connect to the world of work. Overall, this activity was designed to give students a vocabulary to describe what it is they seek in their work and to help them to weigh their values when making career choices.

Goal-setting and resumé gaps. This career development support was offered by Lynda Peto in November 2019. In this class, students were invited to begin to assess their career journeys and plan for the future. They were supported in reflecting on their learning in the course and connecting skills built in the course to a co-operative education job posting. Students were also asked to identify skills they still needed to build and to list academic and extracurricular opportunities which could facilitate this learning. This served as an opportunity to celebrate and reflect on their progress while also identifying gaps in their experiences and identify opportunities to address these gaps before graduation.

Instrumentation

Student assignments: Professional Skills Portfolio and reflection prompts. As part of their course requirements, students built a Professional Skills Portfolio which included two reflective letters and a reflection on their informational interview. These reflections were designed to encourage students to reflect on how class content and activities connect to the engineering profession. The assignments of students who give their informed consent to participate in the study were analysed using constructivist grounded theory.

Reflective letters. Reflective letters bookended the course. The writing prompts for these letters were as follows:

Beginning of term letter prompt**:** How did you come to be in Biosystems Engineering? What do you understand about Biosystems Engineering? How does who you are – your knowledge, skills, and values – fit or not fit within the profession? Tell me about the career that you aspire to after graduation?

End of term letter prompt: What do you understand about Biosystems Engineering that is different than what you understood at the beginning of the term? How does who you are – your knowledge, skills, and values – fit or not fit within the profession? How is the career that you aspire to after graduation different now?

Reflecting on the informational interview. Students were asked to write a reflection on what it was like to participate in the informational interview and what they learned. The reflection prompts were as follows:

- What might you like / dislike about the job your mentor has? How does the information you gathered connect to what you know about yourself (your values, personality, interests, and/or skills)?
- What surprised you?
- What did you notice you had in common with your mentor? How do you differ? Do you think you would you would have similar responses to your interview questions if you were in their position? Explain.
- How satisfied do you feel your mentor is with their current work? How might this impact your impressions?
- What (if any) new perspectives on the industry did your informational interview bring?

- How did this interview impact your understanding of biosystems engineering? Engineering as a whole? The professional world (i.e., industry)?
- What, if anything, did you question about your career plans as a result of your informational interview?
- What did you learn about the knowledge, skills, experiences, or courses required for the role that you have in mind?
- How has what you learned impacted your overall career plans?
- How can you apply what you learned to your education and career? Consider specific steps you could you take to put these ideas into action.

Interview protocol. An interview protocol was developed to explore participants' experiences with the career interventions in the biosystems engineering course. Specifically, the questions were developed based on the study research questions, in line with the primary and cognate areas this study covers, and within the context of the theoretical framework adopted for the study. A table aligning the interview questions with the research questions can be found in Appendix C.2 and a table aligning the questions with STF can be found in Appendix C.3. The questions are as follows:

1. Tell me how you came to be in biosystems engineering.
2. During Design 1 this year, you met with a professional to talk about their career. Tell me about that experience.
3. What did you understand about biosystems engineering when you came into this class? What do you understand now?
4. How do you imagine your career after graduation when you came into this class? How do you imagine your career after graduation now?

5. What are you doing to prepare for your career future?

6. What was the biggest thing you learned about your career during Fall 2019?

7. What people influenced your career in Fall 2019?

   Follow up: How did they influence you?

8. Walk me through the peaks and troughs of Fall 2019 and Design 1.

   Follow up: What, if anything, got in your way in terms of your career development? What, if anything, helped you be successful?

9. Tell me about your skill development.

10. Tell me about the ways the world around you has influenced your career. You might think about things like the labour market, where you live, or global events.

11. How have events in Design 1 and/or outside of this class impacted your career development?

12. Did any chance events happen to you during Fall 2019? Tell me about that.

13. Is there anything else you'd like to share/you'd like me to know?

The central focus of this study, the career development of post-secondary students, and two cognate areas, emerging adulthood and experiential learning, also informed the design of the interview protocol. All of the questions inquire about the career development of post-secondary students. Information about the various experiences of students in terms of their educational development, career planning, professional understanding, and skill development are requested, which are all associated with career development. Though the cognate area of emerging adulthood is not explicitly inquired about, questions do align with this cognate area in that development and growth are major characteristics of this life stage, all of which could emerge from the line of questioning developed. There are also multiple questions which could illicit discussion of engineering identity. Lastly, the cognate area of reflection in experiential learning aligns with all questions, since the participants were asked to reflect upon their experiences throughout the interview.

Finally, in keeping with the overall design of this study, the questions were also created based on the theoretical framework adopted: systems theory framework (STF) in career development. The notion of time and continuous change inherent in STF is present throughout the interview protocol, as participants are asked to tell the story of their time in the course and reflect on their conceptualization of their career future. Additionally, the questions are open-ended and gave students room to talk about their experience in whatever way they see fit, without imposing order or a linear conceptualization of career trajectories, as is appropriate within the constructivist perspective of STF. All of the questions are focused on the individual as central to career development, while the questions about the informational interview and about experiences in class inquire about social context.

Study Site

This study targets students who are currently enrolled in undergraduate Biosystems Engineering at University of Manitoba. This department is situated jointly within the Faculty of Agriculture and Food Sciences and within the Price Faculty of Engineering, which houses four other undergraduate engineering programs: Civil, Computer, Electrical, and Mechanical Engineering (Beddoes, 2019). It is also linked to the Faculty of Agriculture and Food Sciences,

As of fall 2018, the combined undergraduate programs had 1,807 enrolled students.

Biosystems Engineering is the smallest of these, with 140 students (Office of Institutional Analysis, 2018b). It also has the highest percentage of female students, at 41%, as compared to 21% in the Faculty as a whole (Office of Institutional Analysis, 2018b).

The Bachelor of Science in Engineering (Biosystems), like all engineering programs at University of Manitoba, is accredited by the Canadian Engineering Accreditation Board (Beddoes, 2019). The biosystems engineering program integrates biology with engineering, and offers specializations in biomedical (the application of engineering to healthcare), bioresources (the application of engineering to biological resources, such as renewable energy, products, and food production), and environmental (the application of engineering to environmental issues (University of Manitoba Academic Calendar, 2019b). The degree begins with a preliminary engineering program, common to all engineering majors. Once students transition into Biosystems, they are expected to complete program core courses and a number of electives (University of Manitoba Academic Calendar, 2019a). A unique characteristic of this program, which is being harnessed by this study, is the Biosystems Engineering "Design Spine," a series of four biosystems design courses which students generally take consecutively and over three years as they progress through the program (Seniuk Cicek, 2017). These common courses create touchpoints where career development can be integrated, allowing students to be exposed to career development supports during each year of their program. This study focuses students in the first course in the design spine, Design 1, and the longitudinal study will follow these students through the three remaining design courses and into their first year as alumni.

Biosystems Engineering Design 1 (BIOE 2900) covers a wide range of topics related to design and communication. The course calendar describes the course as follows:

> An introduction to the professional discipline of Biosystems Engineering and the

> philosophy of systems thinking that is used by the Biosystems engineer. Students will be introduced to several principles (i.e., safety engineering, human factors engineering and biomimicry) that should be considered during the design process, and will be given opportunity to apply these principles to design problems. The course will provide opportunity for students to develop technical communication, project management and teamwork skills (University of Manitoba Academic Calendar, 2019c).

Students enrolled in the course have completed the preliminary year of engineering, and are typically in their second year of engineering education and first year of their biosystems engineering major (University of Manitoba Academic Calendar, 2019b).

Participants

Participants for the study are the biosystems engineering BIOE 2900 Design 1 course cohort, which was offered in Fall 2019 (N=36 students), all of whom are emerging adults (ages 18 to 29). Eighteen students agreed to having their coursework analyzed for the study; and N=7 students participated in individual interviews. This sample size is typical for a grounded theory study (Creswell, 2018). Interview participants were invited to share demographic information including age, gender, whether they are an international or domestic student, and work and volunteer history (see Appendix C.4). This information was gathered because these components of the participants' identities have implications for their stage in life and the systematic influences which contribute to individual career development, as outlined in STF.

Dr. Jillian Seniuk Cicek, one of my thesis co-advisors and the principal investigator on the larger research study that my thesis sits within, is also the co-instructor of this course, along with Dr. Danny Mann, Department Head of Biosystems Engineering. This means that Dr. Seniuk

Cicek graded students who participate in this study. To ensure students did not feel pressure to participate vis-à-vis the instructors, or that Dr. Seniuk Cicek and Dr. Mann will not bias the study by being aware of which students are participants, and ensure students know that Dr. Seniuk Cicek and Dr. Mann will not know who did, and did not volunteer to participate in the study, I handled student recruitment as part of my role as Dr. Seniuk Cicek's Research Assistant.

Participants were recruited while in the BIOE Design 1 course in December 2019. I attended a class on December 2 and made an announcement about the research project after the principal investigator, Dr. Seniuk Cicek, and Dr. Mann, left the class for the day (see Appendix D.1 for a script of the announcement). Students were given the Letter of Informed Consent (Appendix E) describing the study in more detail, and were invited to take time to read it carefully and consider participating. On December 6, I returned and gave students the opportunity to ask questions, and then I collected the informed consent. I collected these forms from every student so students did not know who in the class agreed and did not agree to participate in the study. (See Appendix D.2 for a script.) Once course grades were finalized and the grade appeal period was over and my proposal was defended, I collected participant coursework from the teaching assistant. In December 2020, I sent an email to students who agreed to participate in the interview, including a copy of their signed informed consent for their records (see Appendix D.3). I arranged interview times, scheduling a time for us to meet via video conference or phone.

Data Collection Process and Interview Protocol

Student assignments. Permission to conduct the study has been granted by the Dean of Engineering (see Appendix G) and ethics approval has been obtained from the University of

Manitoba Education Nursing Research Ethics Board (see Appendix I). As per ethics, interested students gave their written informed consent for their coursework to be reviewed, as described in the Participants section. I provided a teaching assistant, who signed an oath of confidentiality (see Appendix F.2), with the list of participants, and the teaching assistant gave me the coursework of the student volunteers. I created a master codebook (which is stored securely in a locked cabinet in my locked office), in which each participant has been assigned a number which they will be identified by for the duration of the study. Then I blacked out all identifying information on students' coursework, such as names and student numbers, with a marker, photocopy the pages, destroy the originals, and use the photocopies for analysis. Student coursework included two reflective letters, and two written reflections. The coursework is a component of their class, for which students have already been given course credit. No additional compensation was provided to students for volunteering to include their coursework in the study. Ultimately, the narratives in the letters and reflections provided textual data for the grounded theory analysis (Creswell, 2012).

Individual Interviews. Students consenting to participate in the individual interviews were contacted once grades were entered and the appeal period for Design 1 was over and this proposal was defended. In December 2020, a mutually agreeable interview time was scheduled to take place via video conference or phone. I conducted semi-structured in-depth interviews approximately one hour in length. The questions were designed to encourage participants to share their stories of career exploration, identity growth, and skill acquisition during their time in the Design 1 course. The interview protocol is included in Appendix C.1.

Upon meeting for the interview, before getting into the deeper conversation, students were reminded of the informed consent process and their right to withdraw from the study without consequence or penalty, and the right to choose not to answer any of the questions. They mailed a $25 gift card to thank them for their time, which they were told to keep even if they choose to withdraw from the study during the interview.

The interviews were audio recorded using a smartphone app or the video conference recording tool, then transcribed. Any identifying information was removed or altered and the original audiotapes were securely destroyed immediately following transcription. Participants were assigned a number within the study, by which they will be referred throughout the study, in lieu of their name. As recommended by constructivist grounded theory, analysis began immediately as data are collected. Though no changes were necessary, if initial analysis suggested changes to future interview protocols was appropriate and necessary, an amended interview protocol would have been drafted and sent to ENREB for approval before further interviews took place. Throughout each interview, I took field notes on my impressions and observations, providing an opportunity for triangulation during data analysis. (Find the formatting set-up of a field note in Appendix B.) Memos were also written during this process, immediately following each interview. These were reflections based on what was felt or understood during the research process from the researcher’s perspective (Charmaz, 2014).

Dr. Seniuk Cicek did not conduct individual interviews or have access to the names of the individual interview participants at any time throughout the duration of the study, and beyond. Potential participants were informed of this verbally and it is stated on the informed consent letter.

Data Analysis

Grounded theory analyses, as described by Charmaz (2014), was used to interpret the data. Specifically, students’ coursework and individual interviews were analyzed using

Charmaz's (2014) framework for coding, beginning with detailed, line-by-line initial codes and eventually generating focused codes based on the patterns that emerge. The data analysis process began as interviews were conducted, allowing for gaps in the data to become clear and deeper exploration of critical topics in subsequent interviews to occur (Charmaz, 2014). This means that I conducted initial analysis and memoing after each interview. Since the coursework was completed in class and not shared with the researcher until the course and the appeal period was over, all of these data were received at once. Therefore, the analysis began after the coursework was received, and continued through each set, which thus enabled gaps in the data to become clear and deeper exploration of critical topics in subsequent coursework to occur.

Analysis. Constant comparative methods were employed throughout analysis, during all phases of coding, through the development of the theory, and in connecting that theory to the literature (Charmaz, 2014). This means that I moved back and forth between these phases of analysis, guided by the data. I started with the two reflective letters. As I transcribed and compiled the data, I memoed on my initial thoughts. I paired the letters for each participant so that I analysed their reflection from the beginning of the course and their reflection at the end of the course as a unit. I chose to do this due to align with the time component of STF, allowing letters bookending the course to exist as two parts of one whole, at the start of the course and the end. As data was collected, initial coding occurred gradually, after each interview was conducted and transcribed, and after each set of coursework was analyzed. I read the data line by line, annotated with initial codes, and engage in reflexive memoing. As I gradually progressed to focused coding, my codes became more abstract, and I continued to engage in memo-writing. Eventually, theoretical sampling allowed me to develop tentative theoretical categories. If needed, I would have contacted my participants for additional member checks to clarify my understanding of their experiences, but I had enough information, so this was not required. I continued to memo and then sort these memos categorically, which in turn allowed me to develop diagrams to depict the process that emerged.

Memoing. Memoing is critical for reflexivity and for the analysis process, acting as a tool to illicit theoretical sampling (Charmaz, 2014). For this study, memos were written regularly in a digital journal at key points of the research process, with dates and contextual information included. Reflections included my personal and professional views of the research process, preliminary thoughts about the data, expectations for the study, new ideas as they emerged, and perspectives on topics such as engineering education, career development, career counselling, for example.

As I memoed throughout the research process, I engaged with the following ideas as appropriate to enrich my reflections and ensure I am thoroughly examining my interpretations:

- Personal and professional meanings of the topic to the researcher,
- Preliminary ideas and expectations of findings,
- New emerging ideas,
- Perspectives and experiences of engineering students,
- Perspectives and experiences of career counsellors, and
- Perspectives and experiences of researchers in the field.

I engaged in reflexive memoing during data collection, throughout data analysis, while writing up my findings, and while disseminating my findings. Find examples of my first memo in Appendix A.

The Role of the Researcher: Positioning of Self

Within constructivist grounded theory, it is important for the reader to know about who I am as a person, professional, and student in order to contextualize my personal perspective on this research topic. Within constructivist grounded theory, research is understood as a social and interpersonal process in which the interplay between the researcher and the participants and between the researcher and the data cannot be ignored (Charmaz, 2014). By being reflexive and transparent, I can set the stage for more valid inquiry in which my audience and I are aware of the influence my perspective has on the results of this study.

I am a career consultant working full-time at Career Services, University of Manitoba since 2015. Before this, I worked there part-time for three years as an undergraduate student, providing career information and supporting resource creation. I have a deep passion for career development and have advanced my own assumptions about post-secondary student career development through the extensive in-depth conversations I have had with students and other practitioners on the topic. As a career development practitioner, I identify within a post-modernist theoretical lens and prefer experience-based, open-ended work. Beyond this, I am currently working on my master’s in Counselling Psychology, which has given me further opportunity to develop as a person and a professional. As a counselling psychology student, I have been exposed to additional theoretical frameworks and learned about numerous techniques for supporting people through personal and career counselling, which in turn informs my understanding of career development. I must be aware of these perspectives in my analysis, as they could bias my interpretations. Various safeguards have been incorporated into this study to mitigate this risk, which will be discussed within the subsections, Reliability and Validity.

It is also important to share that although I am not a professional engineer, I do have significant personal exposure to engineering. My husband is a mechanical engineer who is an Instructor in the University of Manitoba’s Price Faculty of Engineering, teaching courses in biosystems and mechanical engineering. My father-in-law is also a mechanical engineer, and is a Professor who teaches in the Price Faculty of Engineering at the University of Manitoba as well. This has informed my understanding of what it means to be an engineer and an engineering student, specifically in the context of the Price Faculty of Engineering at the University of Manitoba, as many family dinners have been accompanied by spirited conversation about engineering, engineering identity, engineering careers, and what it is like to teach prospective engineers at the University of Manitoba. This exposure has built my personal assumptions about what engineers are like and what students' experiences in the Price Faculty of Engineering involve. To mitigate the potential for my bias and/or my assumptions impacting the results of this study, I utilized memoing throughout the research process (as is described in detail in the Method subsection). Memo writing was an ongoing process throughout the study, logging my reflections, interpretations, and ideas throughout data collection and analysis (Charmaz, 2014). This is an important tool in the grounded theory design selected for this study and served as a record of how codes, categories, and theories emerge, as well as a tool for engaging in the research process and identifying and mitigating potential biases (Charmaz, 2014).

There is also the possibility that my familial connection (i.e., my husband and my father-in-law), which has been shared with the biosystems engineering cohort targeted for this study, (and which is evident in my last name, which I share with my husband and father-in-law), could impact the participants' interviews. Although confidentiality was stressed, students may have chosen to give me different responses based on their knowledge of my family. It is challenging to know how this might have impacted the study - with students perhaps thinking I understood their answers more due to my exposure, or saying what they think I would expect or want to hear, or sharing responses that they (mistakenly) may think I'll share with my family, or withholding criticisms that they might be uncomfortable sharing. As a researcher in the Price Faculty of Engineering, I straddle the line between "insider" and "outsider." As a counselling psychology student and career development professional, my educational and professional background is in the social sciences. But having married into a family of well-known engineers in the Price Faculty of Engineering at the University of Manitoba, I am tugged closer to the "inside" than another social scientist might be, and thereby I must be cognizant of these connections.

Reliability and Validity

Credibility. Credibility is how confident we can be in the trustworthiness of the findings of a qualitative study (Lincoln & Guba, 1985). The findings of this study have been improved through triangulation (more than one data source) and member checks (Creswell, 2012). By analysing both interview transcripts and coursework, more than one source of data has been used to understand students' experiences. Field notes taken during the interviews provide an additional source of triangulation.

Transferability. Since this is a qualitative study with a small sample size, the findings cannot be expected to be "generalized" to other environments, as expected in a quantitative study. Rather, findings are looked at for "transferability," which is the applicability of the findings to others' experiences. By writing "thick descriptions" of the findings, vivid, detailed descriptions which help the reader to understand how the results might connect (or not connect) to other situations, readers will be given enough detail to consider how the results are applicable to their own experiences or work (Lincoln & Guba, 1985). This enabled transferability of the study through the emergence of a low-level theory.

Dependability. Dependability exists in a qualitative study when there is consistency and enough information and oversight to believe that the findings could be repeated (Lincoln & Guba, 1985). To ensure the results of this study are dependable, I engaged in reflexive memo-writing throughout the analyses, tracking my thought process so as to provide an explanation for the theory that emerged (Lincoln & Guba, 1985). This process provided me with feedback, as well as enabled my work to be audited, which held me accountable for my decisions (Koch, 1994).

Confirmability. If the criteria for credibility, transferability, and dependability are met within this study, so too will confirmability be reached (Lincoln & Guba, 1985). Confirmability occurs when the results are as neutral and free from researcher bias as possible (Lincoln & Guba, 1985). By clearly justifying the theoretical and methodological decisions throughout this paper, the stage is set for confirmability (Koch, 1994). The study will be further confirmed when the thought-processes behind the analyses are shared (i.e., disseminated) (Koch, 1994). The final low-level theoretical model and results of this study will be shared with participants upon completion, giving them the opportunity to provide feedback, adding an additional layer of confirmability to the study.

Ethical Considerations

One critical ethical consideration that must be managed during this study is that Dr. Jillian Seniuk Cicek, the principal investigator for this project and the larger study in which it is situated, is one of the co-instructors for the BIOE Design 1 course, which is the study site for this research. This means Dr. Seniuk Cicek is responsible for grading students who participate in this study, and thus is in a position of power with the students. To ensure students did not feel pressured to participate or not, I handled student recruitment. Dr. Seniuk Cicek (and Dr. Mann, the other co-instructor) will never be aware of who does or who does not participate in this study.

A list of participants who volunteer their coursework for the study was given to a teaching assistant (who signed a pledge of confidentiality) so the teaching assistant could provide the work to me. Dr. Seniuk Cicek did not conduct any individual interviews or have access to the names of the individual interview participants during my study, at any time during the longitudinal research study, or thereafter. Potential participants were informed of this verbally and in the informed consent letter.

Potential Methodological Limitations

This study is impacted by potential methodological limitations. One constraint is that theoretical saturation may be challenging to reach due to time restrictions, that there may be too few interview participants, or that participants may not volunteer their coursework for the study. Further, this study involved the co-construction of a narrative between the researcher and the participants (Reismann, 2008). In particular, as an individual who practices as a post-secondary career consultant and has a passion for career development, and as someone who is married into a family of engineers who are employed in the Price Faculty of Engineering at the University of Manitoba, I needed to be reflexive and understand that my biases may impact my interview conversations and my coding. In order to mitigate this, as I interviewed my participants, I was very aware of my personal biases and worked persistently to avoid leading my participants and enable them to share their own views by taking field notes and memoing. At the same time, the constructivist grounded theory approach recognizes that it is impossible to be absolutely objective; my theoretical lens, as stated in Chapter 1, influenced my perspective on this project. Therefore, I have been and will continue to be transparent in my perspective of the career planning process, my interest in postmodernist perspectives on career development, and in my perspectives on being and becoming an engineer in the conceptualization, design and dissemination of this research study.

Summary of Chapter 3 and Conclusion

Chapter 3 contained the research methods of this study. Specifically, grounded theory was discussed historically, and structured and constructivist grounded theory were compared. Constructivist grounded theory was outlined, covering memoing, constant comparative methods, initial coding, focused coding, theoretical sampling, saturation, sorting, and diagramming. Next, a justification for the use of constructivist grounded theory was presented in line with the social nature of career development and the constructivist and post-modern interventions utilized in this study. The research questions and STF theoretical framework were revisited, and data collection procedures and the interview guide were presented. The career development interventions integrated into the course were explained. Chapter 3 also explored the ways in which the grounded theory constant comparative method was used to analyse the data, and how reflexivity was utilized to increase confidence in the findings of this study. Reliability and validity were examined with a focus on credibility, transferability, dependability, and confirmability. Finally, specific ethical implications and methodological limitations were discussed, and the ways in which these issues were mitigated.

Chapter 4 will cover the Findings of this thesis, beginning with a description of the participants who shared their coursework and those who were interviewed. Next, I will describe the steps I took to analyse the data, before outlining the phases of my emerging theoretical model and final model, Becoming a Biosystems Engineering Student.

Chapter 4: Findings

Introduction

This grounded theory study of the impact of career development supports in a biosystems engineering classroom aims to understand students' experiences of career supports within this course. This chapter will begin with a description of participants, describing the 18 students who shared their coursework and the seven who participated in interviews. Next, the steps I took to analyse the data will be presented, followed by a detailed account of how I developed the emerging theoretical model. The two initial phases of my model and the themes I identified in the data, timelines I created to organize the data, and finally the final model, Becoming a Biosystems Engineering Student, will be shared.

Description of Participants

Participants were recruited from the Fall 2019 cohort of Design 1.

Coursework. Eighteen students volunteered to share their coursework. Detailed demographic information about each participant is not available, since coursework participants did not complete at demographic questionnaire. However, all participants described in the interview participants section did complete a questionnaire, and they all donated their coursework. Further, many participants described themselves in detail in their reflections, so that will be summarized here at a high level to preserve confidentiality.

All participants were emerging adults, approximately 18-29 years of age, who were enrolled in Biosystems Engineering at University of Manitoba. About two thirds of the participants appeared male, while the remaining third appeared female. In the descriptions below, I will use the pronoun "they" when participants did not explicitly disclose their gender in their interview demographic questionnaire or by talking about their gender in their reflections. Many participants disclosed they grew up in Canada, while others shared they were attending university as international students. Participants came from Winnipeg, rural Manitoba, other provinces, and other countries. The majority of participants wrote about an interest in science and math that began before attending university. Participants were considering diverse career options related to health, biomedical engineering, agriculture, and environment.

Interview Participants. Interviewed participants shared the majority of characteristics with the students described in the coursework section above. One key difference was that no international students volunteered to be interviewed for this study. Initially, ten students volunteered to be interviewed, but only seven booked interviews when contacted.

Analysis

The first consideration in the analysis process was determining the order to analyse the data. This study had multiple distinct data: the interviews of (N=7) participants, the reflective letter written at the start of term (N=18), the reflective letter written at the end of term (N=18), and the reflection on each student's informational interview with a professional (N=18). Based on constant comparative methods utilized in constructivist grounded theory (Charmaz, 2014) and recursiveness component of systems theory framework (Patton & McMahon, 2014), there is no correct order for analysis, as long as all data is cross-compared. STF highlights the interconnectedness and messiness of the system careers exist within (Patton & McMahon, 2014). While there is a system, it is far from linear or step-by-step. Recursiveness is a primary component of this framework, meaning all parts influence all other parts. With this in mind, there is no "right" way to move forward in analysis. A researcher can simply move through the data in a way that makes sense in the moment, while respecting the recursiveness inherent in the system (which will happen naturally through constant comparative methods). Similarly, Charmaz (2014) recommended constant comparative methods. Applying this method to this study, it would mean comparing each participant's individual assignments to other participants assignments in the same category, to cross-compare the assignments from different categories to those in others, and to compare interviews with other interviews and with the assignments.

After familiarizing myself with the data while reading, transcribing, and preparing the reflections and interviews for analysis, I decided to begin with the reflective letters, since each participant had completed a set and they contained the most detailed information about their careers and experiences in the course. This created a strong starting point to get a sense of each participant's journey to biosystems engineering and their experience within the course. Due to the notion of time within STF (Patton & McMahon, 2014), I decided to start by pairing each participant's start of term letter with their end of term letter, thereby creating a comparison across time for each participant when answering a similar career question. I conducted line-by-line initial coding, using gerunds, working my way through each student's first letter and then their second letter, memoing throughout the process. I then moved on to the next participant. As I memoed this process, focused codes began to emerge. I used constant comparative methods, rereading my initial codes and the student reflections, and memoing what I noticed. I created a document of the focused codes and supporting quotations to better cross-compare the participants.

Next, I analysed the informational interview reflections. I completed initial coding while memoing, and began to notice focused codes as my analysis progressed. I also memoed on commonalities I noticed between the informational interview reflections and the reflective letters. I created a document of the focused codes and supporting quotations, and compared this more closely with what I found in the reflective letters. At this point, I met with my co-advisors and presented my analysis process and preliminary findings and received guidance on my next steps. I also met with my committee and presented on my progress and received suggestions to move forward with my analysis.

I then began analysing the individual interviews, following a similar process: initial coding, memoing, and noticing focused codes emerge as I compared the participants against each other and noticed commonalities with my previous analysis. Once I had completed the initial and focused coding on the interviews, I began to look more deeply at each participant's story. I compared each participant’s story individually, looking at codes across the span of their coursework and their interviews (if available). Due to the importance of time in STF (Patton & McMahon, 2014), I created an individual timeline for each participant based on what they shared. For many participants, this timeline stretched back to high school or earlier, as they described their career in their reflections and interviews. This allowed me to compile all data available for each participant, comparing all data for that individual. This also gave me the ability to compare each full timeline against the other participants’ timelines, providing a more complete picture of the emerging model.

At this point, I began to notice bigger, more theoretical ideas. To better grasp the information being presented by the participants, I wrote out the focused codes and main ideas from multiple timelines on scraps of paper and moved them around to consider how the ideas fit together across time. I also doodled on paper and digitally, rearranging and linking concepts and gradually progressing towards a clearer model of the theory. I mapped concepts overtime and also sketched the concepts within a graphic similar to the STF design to better understand how they fit within my theoretical framework. Once I had moved through one iteration and onto a second draft of my model and begun to solidify it further, I met with my co-advisors. I presented my draft model and received feedback, refining the model further. Finally, I reread my initial and focused codes, and reread my data, then further refined my model into its final form.

Emerging Theoretical Model: Experiencing the Career Curriculum

This section will outline the progression of my analysis, through the phases which eventually got me to the final model. Model Phase 1 includes the initial and focused codes which emerged in the reflective letters, informational interview reflections, and interviews. Model Phase 1 also includes a description of the timeline I created to better understand participant's journeys and the initial sketch I created of my emerging theoretical model. In Model Phase 2, I demonstrate the ways I began to better organize the emerging theoretical model, by connecting it visually to STF and incorporating more movement in my draft model. Finally, I will present the final model, Becoming a Biosystems Engineering Student.

Model Phase 1. The first step in building an emerging theoretical model was to identify and organize initial and focuses codes. This section will cover the initial and focused codes which emerged from the coursework (reflective letters and informational interview reflections) and from the interviews.

Analysis of reflective letters. I analysed the reflective letters as a paired set for each participant, looking at their letter written at the beginning of the course and then their letter written at the end of the course immediately after. As a reminder, the prompts were:

Beginning of term letter prompt**:** How did you come to be in Biosystems Engineering? What do you understand about Biosystems Engineering? How does who you are – your knowledge, skills, and values – fit or not fit within the profession? Tell me about the career that you aspire to after graduation?

End of term letter prompt: What do you understand about Biosystems Engineering that is different than what you understood at the beginning of the term? How does who you are – your knowledge, skills, and values – fit or not fit within the profession? How is the career that you aspire to after graduation different now?

I began with initial coding line by line, using constant comparative methods to compare participants first and second letters. As I continued to use constant comparative methods, memo, and generate initial codes on each participant, focused codes became evident. The following focused codes began to emerge: *stumbling into biosystems, refining existing career ideas and discovering more career options, movement from an academic description of biosystems to an industry description, a high school interest in math and science, helpers and "green people,"* and *increasing labour market awareness.* These ideas, supported by examples of initial codes and quotations from participants, follow in this section.

Stumbling into biosystems. Many of the students ended up in Biosystems Engineering without prior planning. For these students, Biosystems was not their first choice of program, or they ended up in the program without knowing much about it or the career options. As I completed line-by-line initial coding, relevant codes within this concept included, "Knowing little about biosystems," "Entering biosystems unexpectedly," and "Stumbling upon biosystems."

Participant 18, in his first reflective letter, caught my attention with the use of the word "stumbling," which became the in-vivo initial code that eventually evolved (through the memoing process) into a focused code capturing this larger idea. As he put it, "Stumbling upon the department of biosystems engineering, and realizing that the vague description about engineering solutions to problems involving biological systems really represented a choose your own adventure of sorts was an a-ha! moment."

For some students, biosystems was not their first choice. Participant 3, in their first reflective letter said: "I came into Biosystems engineering a bit unexpected as I applied to all engineering departments and got into Biosystems. I came into Biosystems knowing so little about it and I'm learning more and more." Participant 17 has a similar experience, originally planning on civil engineering:

> I ended up in the department of biosystems engineering after 2 years in the faculty of engineering as a first-year student. I had initially planned to become part of the civil engineering department, but after a poor first semester with myself having to drop both calculus one and linear algebra. I was unable to recover my GPA from the low start I had had. This caused me to reevaluate what possible departments I had hope of being admitted to, with some hope held that I could squeeze into civil on the bottom of the average. This didn't happen and I ended up in the biosystems department.

Multiple students wrote about not knowing much about biosystems engineering in their reflections. Participant 16, in his first reflection, came to this realization while writing, "I think I am just realizing how little I know about this field." This progressed for Participant 16, whose second reflection included a detailed description of his career options:

> I now understand that Biosystems Engineering is a very broad field that varies from workplace to workplace. Initially I thought of it as a narrow field, focused on only designs, machines & tools. It can be that, though depending on where I go with my degree it doesn't have to be.

In Participant 10's first reflection, they share, "My understanding of what Biosystems Engineering actually includes is fairly surface level." Participant 11 echoes this in their first reflection, writing, "My understanding of Biosystems Engineering is quite shallow."

Refining existing career ideas and discovering more career options. Another noteworthy shift which emerged, involved participants clarifying their career future. For some who came into the course with existing career plans, this meant refining their career goal or opening their minds to options they were unaware of previously. Undecided students also shared an opening up of options, sometimes maintaining their uncertainty, but identifying options within an open-ended career future.

Initial codes included, in letter one, “Not knowing biosystems career options” to “Knowing I want to work in environmental engineering” in letter 2, “Having no career plan” in letter one to “Having more career ideas” in letter 2, and “Aspiring towards innovation and medical advances in technology in career” in letter 1 to “Noticing other options beyond biomedical engineering – equipment for people” in letter 2. Through memoing and constant comparative methods, these ideas became the focused code *Refining existing career ideas and discovering more career options.*

Participant 5 discussed the refining of her career options. In her first letter she said, “I don’t know yet what I want to do after graduation and what career options are open to a Biosystems Engineer.” Then in her second letter, spoke about how her career idea “has not changed in my head so much as evolved into a more concrete idea.” More specifically, she explained:

> I now know that I want to specialize in Environmental Engineering within Biosystems, after gaining a better understanding of the types of projects that are involved within the specialization, such as water systems and wastewater treatment, natural resource management, and environmental impact of engineering.”

Participant 6 also experienced this shift, saying in their second letter, “Before taking this course, I had no profession I aspired to after graduation. Now I feel very interested in building commissions and look forward to learning about engineering jobs.” Another example of a student who refined their career plans was Participant 9, who shared:

> The career direction that I had in mind at the beginning of the semester hasn’t changed drastically but through this class, it definitely narrowed, specifically the type of career I would like in the future. I found this out through listening to my teammates TED talks and getting background information on the people they interviewed. I found that Environmental engineering is something I am interested in, and reinforced my thoughts of working in that field.

Other students who came to the course with existing career ideas discovered further options after their time in the course. As Participant 10 put it, “My career idea has not changed much, but I am more aware of my other options after taking this course. I still hope to becoming involved in conservation or environmental remediation, and this course has improved my ability to do so.” Participant 14 also noticed the number of options available, writing:

> Picking Biosystems Engineering does not close doors, but rather keeps so many of them open. I feel as though I have learned a lot to help me in my future career/profession. The career I look forward to now is still in the biomedical realm, but what has changed is what I imagine biomedical to include. I will no longer limit myself in thinking I only want R & D. What I want now is to try something new and see where it leads me.

Participant 4 also identified additional career pathways, writing, “Before this semester I was dead set on working with biomedical equipment, but I’m now not opposed to the idea of designing equipment for children or people in need of assistance.”

For some participants, this shift opened more options though they still were unsure about their specific goals. As Participant 2 put it in their second reflection, "The career I aspire to after graduation is still uncertain, however, I now have a few more ideas." Along this same line, Participant 3's second reflection said:

> The career I'm aspiring now is still somewhat vague because I still need to know more about the engineering industry. Though now I'm more open-minded about what I can do as a job and just to try to jump in to see whether I enjoy it or hate it so much.

This focused code showcases students' progression towards a more refined and open-minded image of what is next in their careers and living with uncertainty.

Movement from an academic description of biosystems to an industry description. The language participants used in their first letters, compared to their second letters, also suggested a shift. In initial letters, students often described biosystems by speaking about the school subjects involved or the academic specializations offered within the program at University of Manitoba. Then, by their second letters, they were using language related to industry, career directions, and job titles. As participant 3 explained in their second letter, "At the beginning, I was not sure of my aim in Biosystems Engineering. I knew about specializations and minors, but not to the extent of engineering careers."

This idea emerged gradually. Throughout the initial coding process, letters were coded with codes such as "Moving from academic understanding of biosystems to practical or labour market understanding," "Knowing about academic biosystems, but not the career options from biosystems," and "Perceiving biosystems as a mix of biology and engineering." As these codes continued to emerge, and I memoed on the process, I developed a focused code to describe the process I was observing, “Movement from an academic description of biosystems to an industry description.”

This movement is described by Participant 8 in their first reflection**,** “Biosystems Engineering incorporates biological aspects into engineering. Within this department, students can specialize in Biomedical, Environmental, or Bioresource streams.” This contrasts with their second reflection, where their description of biosystems shifts to an industry-focused perspective:

> The career I originally pursued is still the same but now I have learned which industries I can work within. I had wanted to do Environmental Engineering and assumed I would be working for the government. I have learned through this course about the consulting industries which also fits the profession I aspire to do very well.

A similar progression is evident in Participant 14’s reflections. In reflection 1, she described biosystems using language directly from the university’s academic calendar:

> I understand Biosystems to be the study of engineering from a biological point of view. Biological aspects are ever changing as the world changes and do not always follow rules and laws the same way concrete and steel do. Biosystems covers biomedical, agriculture, environmental, and bioresources.

Participant 14 explicitly mentions this shift in her second letter, saying, “I feel like I still understand Biosystems and what it is in a school setting, but what I learned, is the doors it can open for me in terms of career.”

This listing of the specializations occurred in multiple first reflections, but second reflections demonstrated a shift to more career focused language. As a final example of this, Participant 11 described biosystems, saying, “I know that it encompasses a lot of job opportunities and branches out into variety of specializations but understanding the very core of Biosystems Engineering is difficult for me." By their final reflection, though, they discussed having a better grasp of the field, writing, "Through this course, I had gained a better understanding of the job opportunities available to Biomedical Engineers."

A high school interest in math and science. For many participants, being capable of and interested in math and science provided a starting point for their journey to engineering. They explicitly related their career decision to these academic abilities. For example, Participant 13 shared, "My favorite classes were always the maths and sciences, hence what drove me towards engineering."

For Participant 11, being skilled in math and science was an important part of career planning:

> As a high school student, I was always proficient in math and the sciences. It was relatively easy for me to understand concepts and ideas relating to the mentioned subjects. I used this as a stepping stone to narrow down my choices of what I wanted to pursue.

Participant 5 connects her desire to study engineering with her favourite subjects from high school:

> At the start of Grade 12 I had not decided what path would be best to pursue after graduation, but by this point I was aware of my interest in learning about how things work, science, math, and the environment. I decided to apply to the Faculty of Engineering at U of M because I figured, what could be better than pursuing science other than studying the application of scientific knowledge to problem solving in the real world? I had made up my mind to give engineering a chance.

As in the previous focused code, this connection of high school subjects to career decision-making anchors students in their student identity and perspective.

Helpers and "green people." The final focused code that emerged had two opposing sides to it amongst participants. For many students, the idea of helping others and helping the environment was a major contributor to their decision to pursue biosystems engineering. Conversely, a couple students did not have this ambition, which they connected to not fitting into the program. Examples of initial codes supporting this focused code include "Wanting to help the environment," "helping others through work," "valuing helping others," and "fitting in."

Participant 4 explained in their first reflection, "I have always wanted to help people, by making their lives easier, or by helping them medically." Participant 8 also described helping in their first reflection, "I have also been interested in helping the environment my entire life. As a child, I used to bike around my community to pick up litter on lawns and parks." This idea also came across in Participant 12's second reflection, "Growing up surrounded by family and relatives in the medical field has made me realize that I want to make a difference in this world and help others." Finally, Participant 13 captures this helping sentiment in their first reflection, writing, "I have always been inspired to help people and care."

At the other side of this theme's spectrum are the students who see themselves as different from the helping majority in biosystems. As Participant 1 put it in their first reflection:

> I believe most of who I am fits with engineering. However biosystems seems different. As much as I want to help people, most of my knowledge or skills that have been passed on have been to make me better in the world not necessarily benefit others.

They double down on this concept in their second reflection, stating:

> My skills & values do fit with the profession yet I still believe we are far away from a society that can use alternate or reusable sources for everyday things. The knowledge I have fits with the profession but I still think I could use this knowledge to benefit myself in other ways other than saving the planet.

Participant 6 felt similarly to Participant 1, but has begun to see their place in biosystems by their second reflection, explaining, "I feel this course made me realize Biosystems is not just the department for rejects or green people, but for those who want to work more with others." This quotation provided the in-vivo initial code which eventually went on to capture the larger concept present in the focused code, *helpers and "green people."*

Increasing labour market awareness. When comparing each student's first reflection with their end of term reflection, there was indication that students had progressed in terms of their awareness of the labour market. One component of this is a growing awareness of agriculture jobs. This also connects to the previously mentioned code, *refining existing career ideas and discovering more career options,* where students also indicated an increased awareness of employment options connected to their education.

Student's interest in and awareness of agricultural occupations increased by their second letters. Though many students listed the agriculture specialization in their first letter, no students indicated they aspired to work in this industry at the start of the term. Participant 4, who made no mention of agriculture in their first letter, writes about discovering this option in letter two, "I now know that biosystems is quite close along side agricultural engineering and that it is quite design based rather than technically + mathematically based."

Similarly, Participant 13, who planned to be a biomedical engineer and continues to plan to work in this field, did not mention agriculture in her first letter. In her second letter she shared, "I can now see how growing up in a rural community has shaped my skills and values, but is also gives me insight into the agricultural side." She closed her letter with:

> Another thing I noticed, most likely stemming from my rural background, my interest in agricultural engineering has grown substantially. With that said, as of right now, I still aspire to do biomedical but who knows if it will stay that way?

Participant 17's interest in agriculture also grew. They explained, "From this course I have come away with a greater interest in the agricultural and environmental fields than before, which I feel widens the scope of what occupations would be satisfying after graduation."

Participant 2, reflected about increased labour market awareness in their second letter:

> The value of the multifaceted education of a Biosystems Engineer is something that I understand more now. I know at the start of the term that Biosystems Engineering presented a broad [unknown word] of science to be learned but was unsure of the "market value" of a Biosystems education within the workforce. Speaking with my mentor was very helpful in highlighting their "market value" as well as some personal growth values that a rounded education enforces.

It appears that students better understood the employment outcomes and labour market associated with their education by their second reflective letter.

Analysis of informational interview reflections. After initial coding was complete for the reflective letters, and a couple focused codes had emerged, I began analysing the informational interview reflections. I started with line-by-line initial codes, memoing throughout the process. I used constant comparative methods during this analysis, referring back to the reflective letters and memoing about connections I noticed. When this was complete, I began identifying focused codes in both the reflective letters and informational interview reflections.

Numerous initial codes were written during this phase. Examples for each focused code can be found below. Focused codes include: *discovering the value of relevant experience, openminded careers and "bouncy career paths," becoming more connected to Biosystems Engineering, connecting schoolwork to industry,* and *refining existing career ideas and discovering more options.*

Discovering the value of relevant experience. Students wrote about realizing they needed certain experiences to reach their career goals. This knowledge came directly from the professionals they interviewed, who advised students about the importance of experience in the workforce and for learning about one's own career interests. Students spoke about recognizing the importance of experience and gave specific examples of the experiences they planned to seek out based on their conversation with their mentor. A few examples of relevant initial codes are: "needing more experience for this job to be an option", "valuing work experience", "applying to relevant experiences", and "being directed by experiences".

Participant 1 wrote about learning from experience and requiring experience to be employable, "My career plan seems to be alright at the moment however I can only learn from experience. That being said, in my opinion to be able to qualify for this job I need more experience from outside factors." Participant 13 had a similar takeaway. She wrote about discovering how small the local biomedical market is, which in turn motivated her to set herself apart with experience. She wrote, "Overall, my new impression of the industry is that it can be challenging to get the specific job you want, so it's essential to build up your resume during your university years." Participant 3 also received this advice, writing:

> Honing your communication skill while still studying is so valuable to prepare getting into the engineering industry rather than just studying and get good scores. Get work

> experience as soon as you can and get involved in the community (volunteering and student club).

Many students wrote about very specific next steps they would take to gain further experience. Participant 12 said:

> I learnt that for me to progress through my education and career, I need to get involved with what is happening in the biomedical field. I need to start attending seminars, for example, the Biomedical Engineering seminar which is held bi-weekly at the U of M. I need to read more journals, books on the research done in the biomedical field and volunteer more so I can gain more experience and connect more with people in my field.

Another participant, Participant 16, was invited to continue the connection with his mentor to identify experiential opportunities. He wrote, “I was encouraged to contact him when I have time to get information on volunteer opportunities to gain insight on the field. This way I should become informed, gain experience, and have helped out the community in some way.”

Finally, Participant 17 planned to act on the advice they received by getting on campus experience:

> I feel that I will apply the lesson of trying to widen my experiences by taking steps to join more clubs in school, and taking part in more of the career development opportunities provided by UMES and the other student groups.

The recognition of experience as a central requirement in the workforce was the strongest theme that emerged in any of the sections of this research project. Nearly every participant wrote about requiring experience in their reflection on their informational interview.

Openminded careers and “bouncy career paths.” Students learned about the career paths of their mentors through their informational interviews and many noticed they were not straight lines. They also discovered the vastness of options available to them with biosystems engineering. Mentors disclosed that their careers took unexpected turns and did not end up where they could have predicted. They also shared information about career options applicable to biosystems graduates. Initial codes informing this concept include: “expecting the unexpected in career”, “advising there is no perfect career”, “being motivated to go outside my comfort zone”, and “having many options in a career in biosystems”.

The sentiment behind this focused code is captured by Participant 3 who wrote the foundation for the in-vivo code, “bouncy career paths”:

> My mentor did not plan to be an Ag. Eng right from the start. He had a bouncy career path. He wasn’t the typical student who got into University at the age of 18, goes into engineering and graduate then get a job. When I heard his story it’s more like he just goes with the flow of life and rides on. […] The unexpected was to be expected and you just have to make the best of it.

Advise around open-mindedness in career planning also came from Participant 2’s mentor. Participant 2 talked about the advice he received, writing:

> I asked my mentor how he felt about his current position fit him. His response was very wise; he told me that the pursuit of a ‘perfect career’ is an expensive one. I think he meant that it pays off to follow things you like doing, even if they aren’t perfect because you may never find the perfect career.

Along this same line, Participant 13 learned about how graduates branch out to work in various industries:

> However, I did learn that engineering as a whole is accepting of all different kinds of specializations, as my mentor said some of the people who graduated from biosystems now work in different fields, such as HVAC.

Students also wrote about the breadth of options in their career options in biosystems engineering. Participant 14 said, “These interviews showed me that the biosystems field is enormous. I just picked one area, biomedical, and there are still drastically different avenues that can be taken.” Conversely, Participant 4 wrote about how different career pathways can end up in the same place:

> When my mentor started his post-secondary education, he followed a biology and science pathway, whereas I want to follow a more mechanical and design-oriented pathway. The difference in pathways might slightly change the way I will help others, but it will not change the final result.

Participant 10 also discovered more about their career options. They wrote, “When interviewing [mentor’s name], I gained a knowledge of the engineering industry and what type of career a biosystems engineering degree could allow me to have.” Similarly, Participant 6 said, “I realized that there were more types of engineering jobs than I thought existed.” Overall, participants learned about the careers of other engineers and connected the openness of options to their own career path.

Becoming more connected to Biosystems Engineering. The informational interview reflections contained plenty of information about students feeling more connected to their profession and more comfortable in biosystems engineering. This focused code came from initial codes such as: “staying in biosystems and not changing to mechanical”, “catching the excitement of my mentor”, and “improving impression of engineering”.

Some participants chose to stay in their program based on their informational interview or felt more confident in their choice of biosystems. Participant 4 stated, “Before this school year, I was not sure whether I was going to switch to mechanical or not, but now after this semester and my interview I feel more inclined to pursue a career in biosystems engineering.” Participant 6 also felt more confident in her program, writing, “I realized that even though I went into biosystems without having the passion for it, I may have stumbled onto the department that was perfect for me.” This also connects to the focused code, *Stumbling into biosystems* from the reflective letters.

For some participants, speaking to another engineer allowed them to see themselves in biosystems and engineering and increased their excitement for their field. As Participant 5 put it:

> After talking with my mentor I have gained a better understanding of the field of systems engineering, how I can use the systems knowledge I am gaining from pursuing a degree in biosystems engineering, and what a male-dominated work environment looks and feels like as a woman and a minority. I have a better idea of how I can use my systems-centered degree, and after talking to a passionate and enthusiastic woman in engineering who loves her job, I feel excited about pursuing a career that focuses on my personal interests and passions in biosystems engineering.

Participant 11 also felt more excited after learning about their mentor’s job. They wrote:

> Having the opportunity to tell my future patients and clients what can be done to help them with their problem, knowing I will be part of the solution, makes me even more excited to continue my studies and constantly quench my thirst for knowledge.

Similarly, Participant 19 caught the excitement from their mentor. They wrote:

> I feel my mentor is very satisfied with his current work. He is overjoyed by his groups work and the positive impact they are attributing to the team through their work. It has given me excitement and interest in specializing in Environmental Engineering in regards to conducting Environmental Impact Analyses.

These quotations highlight the ways students saw themselves in the stories of their mentors and began to feel more excited about where biosystems engineering could bring them in their lives and careers.

Connecting schoolwork to industry. Participants made connections between their academic program and the world of work as they reflected on their conversations with their mentors. A few initial codes that informed this focused code are, "understanding how protocols I learned in school connect to work," "applying learning to co-op and school," and "seeing what my mentor has learned in school."

Participant 3 reflected on the foundational skills gained in school, which will be paired with on-the-job skills, "When competing in an industry, you're competing based of what you can do, not your degree. Graduating from university, you're expected to have covered the basics of engineering. From there you'll learn much more at work."

For Participant 8, the informational interview helped her to understand the value of her coursework in the world of work:

> While I spoke to [mentor name 1] and [mentor name 2], a lot of the courses that were required for me to take in my degree began to make sense as to why I needed to complete them. For example, an anthropology course I had previously completed but was required for my degree never made sense to me. I learned that when dealing with different clients,

> anthropology is useful to understand their backgrounds and why they might act the way they do.

Similarly, Participant 11 connected the protocols they learned in school to what their mentor did in her job, writing, “I found this aspect of her job very intriguing as protocols are always mentioned in several engineering classes but rarely ever discussed in detail as to how they are kept tabulated for companies.” Participant 10 also began to see the connection between engineering academics and the workforce. They began to consider how their interview could give them a new perspective on courses and projects:

> I do not think that our conversation has changed my ideal career path, but it has made me more aware of the work that will be necessary in a project management focused engineering job. I hope to be able to apply the knowledge I gained about communication and documentation to my future design courses and extra-curricular design projects.

This theme has similarities to the previous focused code, *Movement from an academic description of biosystems to an industry description.* Ultimately, as participants reflected on their informational interview, they wrote about seeing their coursework in a new, more industrial, light.

Refining existing career ideas and discovering more options. The idea of refining existing career options or discovering more is not as strong in these informational interview reflections as in the reflective letters, however, it emerged as part of constant comparison, supporting the focused code of the same name from the letters. Initial codes supporting this include: “having a clearer direction”, “being unsure previously about taking engineering jobs after graduation”, and “feeling unsure now”.

Participant 6 captured a sentiment which could have also fit beneath the *Becoming more connected to Biosystems Engineering* or *Openminded careers and "bouncy career paths."* They wrote:

> After the interview I did not have questions about my career plans, as I was unsure of where I wanted to go. However, I did have a clearer direction on how I wanted to take my career. I have a greater desire to work in the field, as before I was not sure whether I would even take an engineering job after I graduated.

Participant 9 wrote about feeling they were on the right career path, though they still felt unsure about their precise career path:

> After the interview, although I found out really fascinating things, I am still unsure about what kind of workplace environment I would like to work in. After this interview, I learned many things such as the workplace environment, what kind of work they do, and many other things. One thing for certain that I found is that I believe I'm on the right path in my career, and that this path that I'm taking is my true passion.

For Participant 17, the informational interview confirmed their career path while clarifying details of their options:

> As for the impact on my understanding of industry engineering, I feel that it was not really changed any more than it is already listed here. I already knew of the wide range of opportunities present for engineers after school, but the details of some of those roles, such as consulting was clarified through this interview. I also felt that this interview didn't put my career plans into question.

Finally, Participant 19, more ideas emerged after speaking to their mentor:

> What I have learned from the informational interview has impacted my career plans by making me have an open mind about Master programs that I may be interested in, or research I can do with a professor conducting work in a sustainability, or microbiology.

Overall, this focused code connects the informational interview codes directly to the reflective letters, showing a major common thread emerging from both, which will therefore be important in my final model.

Analysis of the interviews. Once I had completed the initial and focused coding on the reflective letters and informational interviews, I moved on to analysis of the interviews. The interviews, though conducted with fewer participants, has the most detailed data and therefore more focused codes emerged. Codes include: *stumbling into biosystems, comparing biosystems engineering using deficit language, making a career plan, making career decisions based on courses, connecting with others in biosystems engineering, enforced career curriculum,* and *a call to action.*

Stumbling into biosystems. This idea appeared in the written reflections and the interviews. As students told the story of how they came to be in biosystems engineering, they talked about being unsure about what program to pick and considering other engineering options, choosing biosystems based on not liking anything else, biosystems being their second-choice program, struggling in first year, and having little information about biosystems when they chose it. A few initial codes that lead to this focused codes are: "choosing my second choice of biosystems," "considering mechanical engineering," and "attending another university program".

Many of the participants considered other areas of engineering before ultimately ending up in biosystems. Participant 8 shared, "And also I just wanted to do a lot more design work because I actually considered doing like computer or electrical engineering, but I decided nah that's way too hard for me." Participant 18 had chosen computer engineering before deciding it was not for him:

> So in, in 2018 I got into engineering, then summer 2019 I decided to go into computer engineering because I took an introductory class on computer engineering. But then I decided that I didn't want to stare at a screen more than a few hours a day anyway. So my second option would have been biosystems engineering anyway.

Participant 13 also considered other areas of engineering. She said:

> Well like I was always thinking 'cause I want to go to the medical industry and then I took, I think it was like statics, it was one course. And I was like I kinda like this. And I was like maybe I haven't really thought about all the different types of engineering. And then I saw, like I think that's when the BMED team first formed was kind of right around then. And I was like no, that's where we're going like that's what I want to do.

Participant 2's journey to choosing biosystems is similar to Participant 8's, seemingly through process of elimination. He chose biosystems because it was the least boring, selecting it at the last minute. He explained:

> I was going to choose between mechanical and biosystems and then I kind of chose biosystems basically just on like a gut feeling because mechanical engineering [laughs] basically just sounded more boring. […] From there I just narrowed it down to biosystems 'cause I figured it would be a little bit more interesting just for the coursework rather than the career option.

Participant 5 also chose biosystems through process of elimination. She said:

> Um, so yeah, biomedical engineering, and I decided like once I did first year that I want to do something involved with the environment. Um, so I went into biosystems. I was

> like okay like I know what I don't want to do and not interested in anything else in terms of engineering so that was kind of like the easy part of the decision for me.

Other participants took a longer time to find engineering and biosystems in particular. For Participant 14, entry to biosystems came after initial plans to go into medical school or graduate school. She had a degree before starting engineering:

> I wanted to be a doctor and I was waiting to get in and I didn't want to wait around without doing something else and biomedical engineering looked very interesting. But I couldn't go directly into the graduate program and so I thought I would try biosystems and see how I liked it. And now I'm here.

Participant 18 also did not go straight into Biosystems Engineering. He explained:

> After high school I took a couple years off and then I came to U of M and just did U1. I didn’t really have a good sense of what I was gonna do. At that point I thought neuroscience. And then I ended up moving into the city into the [place] so I thought I don't know what I'm doing so I guess I will go to [school], it’s like a 2 minute walk from home. So I did a year in physics or a year and a half I guess at [school] and then I mean I've kind of always been thinking about engineering. I think the reason I didn't go straight into engineering was 'cause that was what pretty much every single one of my friends from high school was doing.

For both of these students, engineering was not the initial plan, though they ended up in biosystems eventually.

For a couple of the participants, first year engineering was a difficult experience. Participant 5 described her first year as a time of uncertainty where she almost left engineering:

> Like first year was hard and kind of a struggle and I definitely considered kind of during that time like dropping out of engineering and going into science or going into doing something else. So I kind of like promised to myself that I would finish my first year and get through first year and then like give biosystems a try. If I hated it then I could always like switch into something else, but definitely during fall 2019 I took biosystems design 1, I took some other biosystems courses and I actually enjoyed like all of the biosystems courses that I was taking which kind of I don't know just like convinced me that it was something that I wanted to do. Whereas some of the first year engineering courses I definitely didn't enjoy. Like I took the introductory courses for all the other departments and realized that I wasn't interested in pursuing a career like any of the other department. So yeah. There also isn't a Biosystems like introductory course officially unless you consider like design 1 engineering 1430. So yeah, I wanted to give biosystems a try and fall 2019 was definitely when I was like okay this is something that I want to do.

Interestingly, Participant 5 did find her place in engineering once she learned more about biosystems in her second year. She described not having information in her introductory classes to help her with this decision. At other points in her interview, Participant 5 talked about her grades dropping in first year compared to high school. Participant 8 had a similar experience in first year engineering. Her grades rose once she entered the biosystems department. She said, “And also like once I finally was in the Department of Biosystems I feel like I excelled in like all my schoolwork just because it was something I really like was interested in.” Participants seemed to find the first-year engineering program quite different from their experience in biosystems.

A final component of students who "stumbled" into Biosystems were those students who spoke about entering biosystems engineering with little information about what it was. For example, Participant 8 was unaware of the environmental option in biosystems for two years of engineering education:

> Um, so I think before I even got into university, I knew I wanted to do engineering, but I wasn't sure what type of engineering. And at one point I considered environmental engineering, but I didn't know that U of M had a like environmental program within like the departments. And I guess I didn't really want to do civil engineering and that's the only one I knew about but I didn't know that biosystems also had an environmental option. So I actually went through my first two years like undeclared.

Participant 5 also did not have a lot of information about the specifics of biosystems engineering when she chose her major:

> I didn't really have like a clear idea of what it was and I felt that after first year like I still didn't really, I felt like I still hadn't given biosystems a shot and I still don't really know. Like everything that I had heard about biosystems interested me, but I still hadn't really had like a solid introduction to what biosystems was all about. And even just like looking at the classes I was like okay these, and this isn't like introduction to electrical engineering this isn't thermodynamics I was like this sounds like learning about plants in biology as well as like I don't like taking more math courses and like kind of going deeper into like science and math but like the biology side of things which was what I was more interested in definitely appealed to me, even after first year was hard.

Participant 16 also lacked clarity in the specifics of biosystems engineering, admitting he did not research much:

> Uh so initially I didn't really understand that much. I knew there was a medical, resource, and environmental portions. I didn't actually look at it, look into it that much. I just figured it would be a good fit. Yeah, I didn't really think about it that much initially actually.

This concept of "stumbling" into biosystems engineering has multiple layers, with students talking considering other engineering departments, choosing biosystems using process of elimination, biosystems being their second-choice program, struggling in first year engineering, and having a lack of information about biosystems when they selected it. This also connects to the reflective letters, where this focused code initially emerged. These concepts have in common that they showcase students ending up in biosystems engineering as opposed to definitively choosing the program based on research and purposefully directing their educational journeys toward it.

Comparing Biosystems Engineering using deficit language. For many participants, the language used to describe Biosystems engineering is one of comparisons. They compare their program to other engineering disciplines in order to say what it is by explaining what it is not. This deficit language is clear in these examples of initial codes which lead to this focused code: "being less similar to mechanical engineering," "seeing skills of other engineering departments," and "listing the specializations that don't come from biosystems engineering."

Participant 2 described his program by comparing it to mechanical engineering and biology, explaining, "Well I think I saw it as less similar to mechanical engineering and a little bit more similar to biology but it seems to be more similar to mechanical engineering than I had expected which is nice." He later went on to describe how biosystems engineering students differed from the students in mechanical engineering:

> I think [laughs] for example Mechanical Engineers are often kind of dry and they like I think that's sort of a thing they they don't mind doing like… you know like the numerical methods class? It's kind of a dry and repetitive and like algorithmic and I notice that everyone I talked to in biosystems kinda hated that class as well. Because there seems to be something that something shared between the biosystems students for the most part that lends them towards more holistic ideals kind of. A little bit a little bit more a little bit more human I guess. I don't know, you know what I mean like not to put down any mechanical engineers but a lot of the people I've seen in and talk to in and know from mechanical engineering are sort of a little bit more robotic I guess.

Participant 2 is finding unity amongst biosystems engineering students based on how they differ from students in another program.

Participant 5 also used deficit language, explaining how her program is not like other majors in engineering:

> And even just like looking at the classes I was like OK these, and this isn't like introduction to electrical engineering this isn't thermodynamics I was like this sounds like learning about plants in biology as well as like I don't like taking more math courses and like kind of going deeper into like science and math but like the biology side of things which was what I was more interested in definitely appealed to me, even after first year was hard.

Participant 8 also compared Biosystems to other departments:

> So I guess biosystems is more humanity-based in a way compared to the other departments and I think that's what drew me a lot more to biosystems. And also I just

> wanted to do a lot more design work because I actually considered doing like computer or electrical engineering but I decided nah that's way too hard for me.

For Participant 14, she initially understood biosystems engineering in terms of what it is not, in comparison to mechanical and civil engineering, then went on to understand the ways biosystems overlaps with other fields:

> I think my understanding was that it kind of… It had been described to me as everything that isn't mechanical electrical or civil [laughs]. And kind of learning from a bio standpoint. But what I understand now is a little bit more like it is actually like all of those components. Um, so biosystems actually allows you to, to learn how to be a civil, mechanical, somewhat electrical, and coding engineer, but how to do that from a bio biological perspective which I think is really cool for going out especially if you're interested in biology. You could enter any of those fields but have that bio expertise.

In seeking language to describe biosystems engineering, students tended to lean on comparisons with other departments, thereby illustrating their program in terms of what it lacks or how it overlaps with other types of engineering.

Making a career plan. As participants discussed their careers in their interviews, they described how they were formulating their career futures. This involved becoming comfortable with career uncertainty and keeping options open, clarifying career options, discovering more options, and planning to get relevant experience. Specific initial codes included: “being okay with not knowing,” “realizing careers don’t have to be rigid,” and “seeing more career options.”

As students explained how they imagine the career journey ahead of them, many did not know what the path would look like, but they felt okay with this uncertainty. Participant 2 stated:

> I don't know it's kinda hard to say. Like I I'm just kind of trying to choose the best option so of the options that I can see directly in front of me. And then just see where that takes me 'cause like there is a bunch of stuff that I can think that I would like but I feel like regardless of of your broader plan if you just take the best of the options in front of you, you'll end up somewhere that you like anyways.

Participant 5 also felt okay with being unsure, “And I’d say that like I still don't have a clear like sense of what I want my career to look like, which I feel okay about at this point like based on the fact that I still have a couple years to go.” Participant 14 also talked about keeping her options open:

> I am trying to to get my foot in the door in like any possible place even if it seems slightly unrelated to what I thought I wanted to do. I think like just being open to anything, even if it's out of my comfort zone.

She was already employing this practice of putting herself out there, which she explained in her interview and reflections came after her experience with the informational interview. She explained how she was already seeing results from her open-minded approach to career, which spurred a job offer:

> I had it was kind of like I talked to one person and asked if they knew someone to talk to and then they sent me to someone else and I talked to them and asked them if they knew anyone to talk to and then after I talked to someone else and then that person was like hey my friend needs an intern at this company. And it was just like so random but worked out so well in that sense. And it took a while after that. I didn't actually get hired till the following February, but just the way that that kind of like the class spurred the discussion

> with people and then the people I ended up at an internship in [place] so that that was like quite a chance event.

Participant 16 shared the ways the informational interview taught him about the fluidity of careers, saying, “But I do know there are different scales to work at and he kind of showed me that a career doesn’t have to be rigid, or one type of job anyway.” He went on to talk about this further, explaining:

> And [city planner], just made me not want to go into city planning, or at least not right now. And kind of helped me realize it does not matter exactly what degree I get, I see that careers can be pretty fluid.

For these students, careers could be understood as flexible.

Other students clarified their career paths, knowing what they wanted to do more specifically, or identifying additional options within biosystems engineering. Participant 5 shared how the class impacted her career exploration:

> Yeah I see coming into the class I was coming out of first year and I really didn't know what I wanted my career to look like or like what it was gonna be all about. I think that this class helped me to kind of get excited about engineering, to kind of get into biosystems engineering, which was really nice.

Participant 16 also found some specific career ideas, compared to when he started the course:

> So initially I didn’t really think about it at all. I just figured I would have some kind of initial job that fit well enough and then I’d eventually move onto a job that I would enjoy more anyway. Now I do have a few ideas of what I want to do.

This participant also expanded on how many more options he had than he initially thought:

> I am not quite as limited as I thought that I was. I thought that getting an engineering degree would be one of the better degrees anyhow for me to get job wise. And I still do think that. But I think that once I'm ready I will have options anyway. Yeah, I'm just not as limited as I thought I was. Like even if I want a job more design-related, not engineering, I could definitely still get that.

Participant 8 spoke about a similar experience, saying, "I think that within that class I like just brought in so many like possibilities for me that I didn't know about so that's why I'm probably so unsure because there's so much that I didn't know about."

In Participant 13's interview, she spoke about going from thinking she had two occupational options in Biosystems, to having many more:

> Um I definitely kind of when I thought about Biosystems I was like you're either doing like plants soily environmental stuff or you're gonna do the medical field. Like it was like there is only those two ways of going and I found like it's more of a dynamic like you can just graduate with a Biosystems degree, you don't have to specialize, you can choose and do all of them and you can also do the ag side. I, like, there's the weight, like there's just a lot more options than I realized when I went in. Like in my brain Biosystems, you do plants or you do the medical. Like it was like there was nothing. But there's like a lot of different things that you can actually do with it.

Participant 14 also came to this realization, stemming from her informational interview. She shared, "I didn't realize there was like a number of pathways to take in your career already so that was cool to find out."

As students learned about their career options, they also learned more about the local labour market. For students interested in biomedical engineering, this knowledge informed their next steps. Participant 2 described his understanding of the tight biomedical labour market and the high number of students interested in the field:

> Uh, I was pretty pessimistic about the potential for job opportunities though like I said it wasn't really really worried about it but it's not that I wasn't thinking about it. I just figured like if you're looking for a secure job that's probably not the engineering department that you would go into. But now I feel like that's less of a barrier then I would've thought initially, but I still do think that it is a barrier because especially in like biomedical I think well first of all that's like a small field to begin with. And that's pretty, like, I remember in design one last year they asked like who is interested in biomedical and pretty much everybody put up their hand. And like from what I understand it's a pretty small field and everybody I've talked to in in mechanical or electrical almost wants to go into, even computer, wants to go into biomedical. So I think there's a bit of a problem because if, if you run a company that does some sort of biomedical technology development you need a bunch of engineers. If you need something done electrically you'll hire an electrical engineer. If you need something done with like fluid flow you'll hire mechanical engineer. I don't really see an entry level place for biosystems engineer. If you need biology, you'll hire a biologist. So I see that being a barrier, but I think it could be good in like more of a management position because you have like a understanding of of the disciplines, the specific disciplines.

Based on this information, this participant began exploring other career options:

> Well I I think that, um, sort of a feeling of needing some kind of financial stability definitely influenced my decision to go into engineering. Like part of what I was mentioning before but definitely also the financial stability aspect so I guess you could

> say that the labour market is not, is, is underperforming with respect to my expectations and so I figured it's sort of important to, um, yeah get something that can give me some sort of leg to stand on. I would say that that's a pretty big factor.

Participant 13 also noticed the labour market challenges for biomedical engineering:

> I just I don't really know, like, I was always kind of just imagined like jobs would be there 'cause biomedical's always something that is an important thing, medical's a big thing. But like especially in Winnipeg like it's very tight knit, there's very few jobs for it. Like the company that I want to go to said they maybe take a co-op student in the summer, but like sometimes they don't and it's like, oh, like you don't even take one student? Like so it was just kind of like there's so many people I know who want to do biomedical. It's just like, oh, like this is going to be hard to find a job, here at least. Like maybe it's better in like Toronto, but I live in Winnipeg, so.

However, for Participant 13, this knowledge pushed her towards working harder to increase her chances of being employed as a biomedical engineer:

> I definitely, like, I was planning on getting involved but I was like I need to start putting myself out there and giving myself a better chance. Like I need to start doing different things and having my resume be more dynamic or something than someone else's to show that I have different experiences, that might be useful. And maybe get better at interviewing 'cause I get a little nervous in those.

Along this same trajectory, other students talked about wanting to support their career plans with appropriate experiences. Participant 8 shared:

> I feel like my goal is to get experience within like engineering industry. So I am in co-op program right now and I've been trying to find co-op positions to help me gain experience

> for these careers. I have not gotten a job yet so it's just just trying to gain some experience and improving my resume too hopefully get my foot in the door.

Participant 14 also talked about getting her foot in the door:

> I am trying to to get my foot in the door in like any possible place even if it seems slightly unrelated to what I thought I wanted to do. I think like just being open to anything, even if it's out of my comfort zone.

Just as in the focused code *Discovering the value of relevant experience,* discussed in the informational interview analysis, students recognized they needed experience to support their career goals. Further, this focused code is quite similar to *Refining existing career ideas and discovering more career options*, as described in the analysis of reflective letters above. Ultimately, this code captures the ways students perceived their career options and the actions they are taking to move forward with their plans.

Making career decisions based on courses. When participants spoke about how they came to be in biosystems engineering, they often used academic language. They used their coursework to determine they wanted to go into engineering and to specifically select biosystems. Initial codes in this section include: "using my electives to choose," "being good at science in high school," and "enjoying my coursework." For example, Participant 2 chose biosystems because the program itself seemed interesting, "From there I just narrowed it down to biosystems 'cause I figured it would be a little bit more interesting just for the coursework rather than the career option."

Participant 5 also identified a career path based on a class:

> I'd say just like when I got into university like and then kind of started taking classes like I realized that environmental courses were more what I was interested in. And that I

> wanted to learn more about environmental topics as opposed to like like human biomedical topics. And I kind of went into, like, I was like, K whatever electives I want to take, like that's the specialization that I like plan to do. And I was just more interested in taking like the environment courses and kind of like delving deeper into that side of it.

She described how she tried courses, which in turn informed her next steps, "Yeah, it's definitely like a trial-and-error process, so, then, I'm like okay, I'm enjoying these classes, then that's something that I wanna pursue."

Similarly, Participant 16 discovered a passion for the environment through a class:

> From a class I had taken after the design class, the environmental impact on the environment. That class made me think about the environmental impact analysis type of job, working either locally or nationally to study the effects or potential effects of the project on the environment.

While he found specific occupational options from his coursework, he also removed options based on his classes. He described how a Design 1 project helped him realize he is not interested in agriculture, saying, "I definitely know don't want to work in farming industry, that's for sure. Especially not with blueberries. The project wasn't bad, it's just that it made me realize it's not what I want to do with my life."

Connecting with others in biosystems engineering. As students looked back on their time in Design 1, they shared a progression towards becoming more connected with biosystems engineering and the people within the program and profession. They described themselves as similar to the engineers they interviewed and talked about belonging in biosystems. Numerous initial codes informed this focused code, such as: "identifying with a woman in engineering," "making friends in biosystems engineering," and "becoming comfortable talking with people in industry."

Participant 5 particularly valued speaking with another woman in engineering. She wants to "follow in a similar career path" as her mentor. This sense of belonging is captured in this quotation:

> So I think that like talking to women engineering has been really interesting to just see that like they're in engineering they can do it. They like find their place in engineering and they actually want to stay in there right. It's not something that they feel like they have to, that they have like an obligation to do. They're not in it for the money. Like it's something that they're actually passionate about. So I feel like seeing women in engineering, it's just like really inspiring for me, 'cause it yeah it just like kind of solidifies the fact that like it's something that I can do and something that I'm like actually interested in doing.

Other participants found belonging amongst their peers in biosystems. Participant 2 shared:

> I think well actually I would say that 2019… so that would have been my 3rd year, I don't know. I feel like I didn't really have many many friends in Biosystems engineering and I feel like last year because it seems like everybody was taking pretty much the same courses I got to know a lot more people that were in the same program and I feel like that actually had a pretty reasonable effect because a not only that I have a lot more in common with the students that are in biosystems than the students that are in like mechanical or electrical, in in general anyways. So I kind of that did feel good as like an affirmation that maybe I should be in this department.

Participant 5's friendships in the program were also influential:

> I'd say like I mentioned this before but also like my friends in engineering were influential but also like motivating for me to like I don't know just like continue to be interested in engineering. And I'd say other friends within biosystems as well as other departments. Yeah, I mean, I enjoy studying with other people I think that it makes it more interesting.

She appreciated seeing other people struggling but getting through, which helped her to stay motivated and feel capable:

> Yeah, I'd say like probably after first year just talking other people who were in engineering like and going through the program at a similar place but I was there like in maybe like further along in the program than I was. Like talking to other people and realizing that like they had also struggled in aspects of engineering, that like they had like doubt when they're like, okay is this what I want to do, but then they kind of kept going with it based on, I don't know like different factors, like either interesting work experience or stuff like that. It definitely was like good for me to hear that other people also found it difficult, but it wasn't too hard right that it was still something that we could do.

Participant 14 also found her classmates helpful in her career, connecting with them as part of the career curriculum activities in class:

> I know we did like a networking with our classmates which was kind of cool to realize that like everyone could be that connection for you and it doesn't have to be someone that you think seems fancy or special.

Enforced career curriculum. Students described having competing priorities which often limited the time available for career development. A few initial codes I based this focused code on were: “appreciating an enforced career curriculum,” “using an assignment as an excuse to network,” and “getting a jump start on my career.” Participant 2, in particular, shared he valued the “enforced” career curriculum:

> But it was definitely a good experience and like even at the time it kind of felt like a good experience 'cause like nobody wants to do the, you know, go out of their way to reach out to some stranger or whatever, but like it was good to have that enforced in the curriculum to push me into working towards a career I guess.

For participant 5, the stress of school was a barrier to career development:

> Yeah it's really not even design one specific but definitely school stress. I mean I think that's something that's like, usually like, if I'm like interested in doing something for my career development or like doing extracurriculars, like kind of in the back of my mind I was like OK, like how is this going to impact like my studies and like the scores that I'm doing, right? Unfortunately, I would say that school stress is kind of a constant like factor that I'm considering during the semester. But yeah, I'd say that was like the only real thing that that like got in the way of me doing more career development. ‘Cause if I did do more career development it probably would have affected like, I would have just taken on too much right, I wouldn't be able to handle more work.

By having to prioritize a school assignment, Participant 5 made time for career development:

> Like I think that talking to people in industry is like a really important thing and I don't do a lot of that like I don't do a lot of that outside of like talking to these two people in this class. So it was really nice to have that incorporated and not something that I had to like kind of like add to my schedule or go and like reach out for on my own if that makes sense.

For Participant 14, the informational interview provided a handy excuse to build a network:

> I think it was I got more comfortable with it but I think initially it was also nice to instead of just like emailing someone being like, hey can I hear about what you do, it was nice to have the intro of like, I'm doing a project for school and I'd like to hear more about what you do to help me in my studies kind of thing. And that felt more comfortable than right off the bat just be like, tell me about you and like also I want a job, but I don't know how to say that so I'll just. It was just a more comfortable way to go about it and then once you have that starting point passing along or like asking for more contacts to talk to was like a little bit easier of a lead up.

She also struggled with the balancing school and career development:

> I think during school, school for sure gets in the way. Like finding jobs on the side while you're trying to pass all your classes can be tough and they were for sure like, didn't feel like I had time to apply for jobs for the summers. And that was tough to to like feel that applying for jobs is worth it even if I don't do as well in my classes.

Similar to Participants 2 and 5, Participant 14 appreciated being “forced” to engage in career development as part of her coursework:

> I think in that class like the career development portion really forced us to actually go out and do some of that which I think in in your degree sometimes you can kind of hide in school and push that towards after your degree. So I thought that was really helpful that it got us got us like a jump start on it right away.

For Participant 16, the career activities incorporated into Design 1, encouraged him to think about career development more deeply, eventually leading him towards accessing individual career support and reconsidering his plans:

> So one of the things was, I think that, I can't remember exactly what it was, but we were supposed to look up potential jobs we would want to do in the future, or potential career paths anyway. Um, so one of the things I was interested in back then was biomedical, working with developing prosthetics. Then after talking to, I can't actually remember who it was, oh it was [Career Consultant] from Career Services. After talking to her, I realized working with prosthetics was not something I would want to do. Even though I would be working a lot more with people, I think, with just problem solving really. That was one of the bigger things that I wanted to do back then anyway. I think it was mostly that part of the class, where we had to actually think about what careers we would want to go into after graduation. If it wasn't prompted I probably would not have thought much about it.

By engaging in career development as part of their studies, participants shared that they were able to prioritize career development and engage in career planning in ways they would not have without prompting.

A call to action against the climate crisis. As has already been described in the analysis of the reflective letters, many biosystems students disclosed that they care deeply about the environment and feel compelled to address the climate crisis in their work. This is evident in the initial codes I wrote on the interviews, such as: "wanting to address the climate crisis," "improving the climate crisis by working with industry," and "doing something about the climate crisis." Participant 18 put it succinctly, saying, "So I mean global events, there's, we have a climate crisis. Whoa. [Laughs] Gotta do something about that. That that's a big one."

Participant 5 also answered my question about the impact of global events on her career development by talking about the climate crisis:

> Yeah in terms of like more global events I think that like I'm definitely driven by like a desire to help like benefit the environment as opposed to hurting it. So like even just like seeing the damage to the natural environment and climate change and everything that is happening to our natural world, I think that that's I don't know about influential to my career but definitely like something that I'm passionate about working towards.

Participant 8 also spoke about wanting to address this large problem:

> I think a lot of things are in just like what I want to do like specially in environment and just like the whole climate crisis that I found actually significantly like impacted like what I want to do in my career because I wanted what I did as an engineer to be meaningful. I thought it, like, environmental engineering, was the way to go. Any other things that influence your career, from around you, figure it like it was just mainly like the whole yeah just like climate crisis and global warming and how basically like, process could be improved within big companies rather than like individuals I don't know if that really made sense but yeah.

Finally, Participant 14 was influenced by the climate crisis in her career planning:

> I definitely, definitely, like environmental issues have influenced my, how I view my future career. It's a little bit hard to apply sometimes to biomedical engineering 'cause it's not directly related, but I think being able to design good and efficient things for people and therefore like reducing waste.

This focused code emphasizes the way many biosystems students came to the program. They were compelled to address climate change and improve environmental issues.

Timelines. Once I had completed focused coding, I wanted to get a deeper understanding of how each participant experienced the course as part of constant comparative methods. I went through all of my data again, this time looking at all of the data or each participant as a set. As I did this, I built timelines for each participant, recounting how they progressed in their careers as described in their reflections and interviews. This allowed me to ensure I was incorporating the concept of time in my analysis, which is part of systems theory framework (Patton & McMahon, 2014). It also forced me to compare among participants, as expected in constant comparative methods (Charmaz, 2014). The timelines are quite descriptive, so I will not share any complete timelines here in order to maintain participant confidentiality. Instead, I will share some generalities, amalgamate participants, and share how this informed my understanding of the data.

First, a major component of this analysis is the earliest career recollections shared by participants. Of the 18 participants, all but 4 wrote or spoke about growing up as part of their career story. This included recounting childhood and high school interests in science, familial career influences, always wanting to help others or the environment, and the impact of growing up on a farm. By reorganizing the data in this way, I noticed the ways participants understood their journey to biosystems and what they identified as influential in their career choices.

The other ideas I noticed in the timelines only confirmed what I already wrote about in the analysis in interviews and reflections. The timelines drew attention to the processes present and allowed me to think more specifically about the processes the students described. These in turn influenced the sketch of my initial model, which is described in the following section.

A summary of all themes as two charts. To make the themes easier to digest, I compiled them into two charts. First, I created a chart which lays out the themes by data source: Reflective Letters, Reflections on Informational Interviews and Interviews. I then began sorting similar themes together, across all data sources. This allowed me to draw connections between each of the themes and synthesize the information further, moving towards themes and ideas which encompass all of the data across the study. First, here is the chart by data source:

Table 1

Themes by Data Source

Reflective Letters	Stumbling into biosystems.
	Refining existing career ideas and discovering more career options.
	Movement from an academic description of biosystems to an industry description.
	A high school interest in math and science.
	Helpers and "green people."
	Increasing labour market awareness.
Reflections on Informational Interview	Discovering the value of relevant experience.
	Openminded careers and "bouncy career paths."
	Becoming more connected to Biosystems Engineering.
	Connecting schoolwork to industry.
	Refining existing career ideas and discovering more options.
Interviews	Stumbling into biosystems.
	Comparing Biosystems Engineering using deficit language.
	Making a career plan.
	Making career decisions based on courses.
	Connecting with others in biosystems engineering.
	Enforced career curriculum.
	A call to action against the climate crisis.

From here, I amalgamated these, sorting them into connected themes across the study: stumbling into biosystems, career planning and career information, course-based career planning, deepening understanding of and identification with biosystems engineering, and climate action and helping others.

Table 2

Amalgamated Themes

Amalgamated Theme	Reflective Letters	Reflection on Informational Interviews	Interviews
Stumbling into biosystems.	Stumbling into biosystems.		Stumbling into biosystems.
Career planning and career information.	Making a career plan.	Discovering the value of relevant experience.	Refining existing career ideas and discovering more career options.
		Openminded careers and “bouncy career paths.”	Increasing labour market awareness.
		Refining existing career ideas and discovering more options.	
Course-based career planning.	Making career decisions based on courses.	Connecting schoolwork to industry.	A high school interest in math and science.
	Enforced career curriculum.		
Deepening understanding of and identification with biosystems engineering.	Comparing Biosystems Engineering using deficit language.	Becoming more connected to Biosystems Engineering.	Movement from an academic description of biosystems to an industry description.
	Connecting with others in biosystems engineering.		
Climate action and helping others.	A call to action against the climate crisis.		Helpers and “green people.”

Model Phase 1: An initial sketch of an emerging process. Based on focused codes which emerged during my analysis, I began to sketch a few initial ideas to describe the movement and processes participants shared in their reflections and interviews. I began by placing ideas from my analysis in boxes and moving them around using PowerPoint, considering various relationships between the concepts. In these notes, the acronym BS refers to biosystems.

I started with the concept of helping others and the environment, which participants had discussed in their reflections and interviews. I arranged these ideas in close proximity to each other like this:

Figure 3. Initial sketch of the concept of helping others and the environment.

Next, I started to think about movement I was seeing in terms of language used to describe biosystems engineering and participant’s career paths. I sketched out movement from deficit language to more specific language about biosystems engineering. I also noted a progression from academic language to labour market focused language.

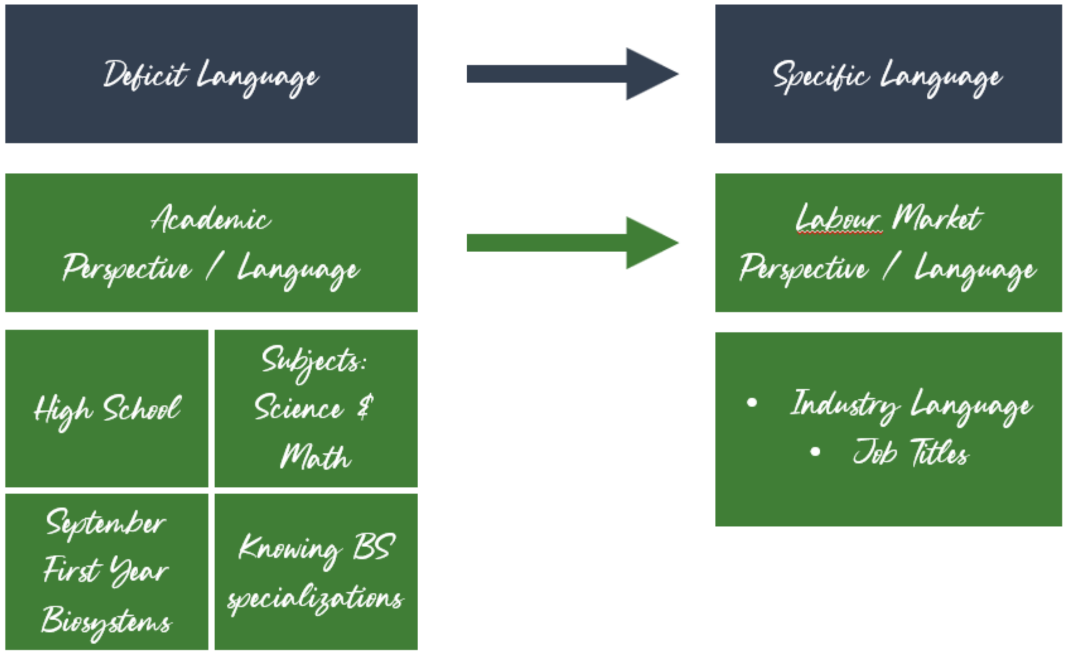

Figure 4. Initial sketch of language used to describe biosystems engineering.

I also wanted to capture the transitions students disclosed in their reflections and interviews. For students who came into biosystems planning to work in the biomedical industry, the discovery of the tight labour market and other options in biosystems, appeared to influence their career trajectory and the options they saw for themselves. Further, for students who wanted to do other educational programs but did not get in, the "chance" event of not getting into a first-choice program brought them to biosystems engineering. I used a lightning bolt to connect to the aspect of chance noted in systems theory framework (Patton & McMahon, 2014).

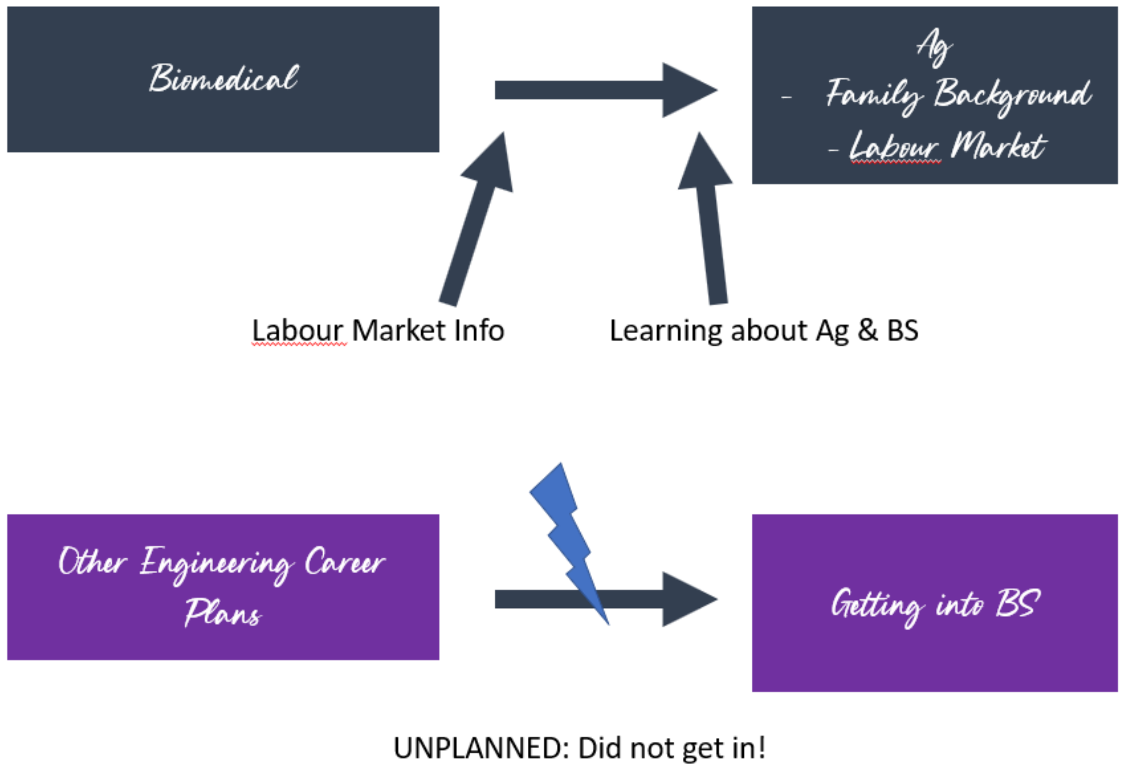

Figure 5. Initial sketch of unplanned events impacting career progressions in biosystems engineering.

When writing the timelines, I noticed a distinction between two types of students who entered biosystems. One group "stumbled upon" biosystems, while the other had a very specific reason to enter the field, wanting to make a difference in healthcare or the environment.

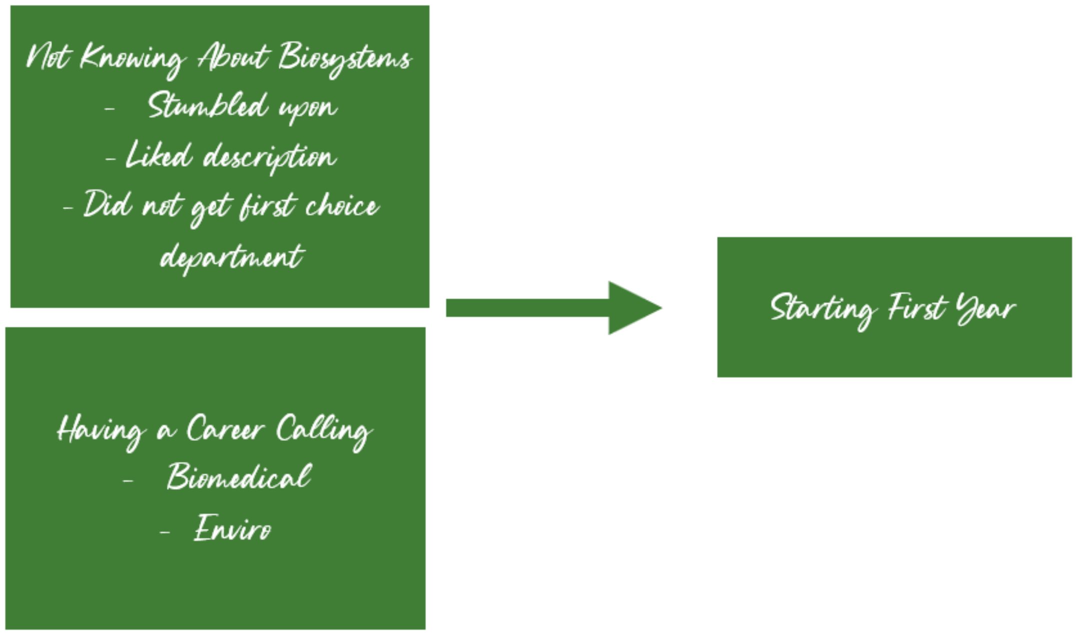

Figure 6. Initial sketch of stumbling upon biosystems vs. having a career calling.

I also noticed movement along career planning pathways. Some students progressed from general career ideas to more specific ideas. Other students who came into the class without a career plan, developed a plan or became comfortable with being open-minded. I also saw students who did not choose biosystems as a first choice, like a student who did not get into their first-choice department and used the term “reject” in describing that experience, and then seeing options for themselves in biosystems.

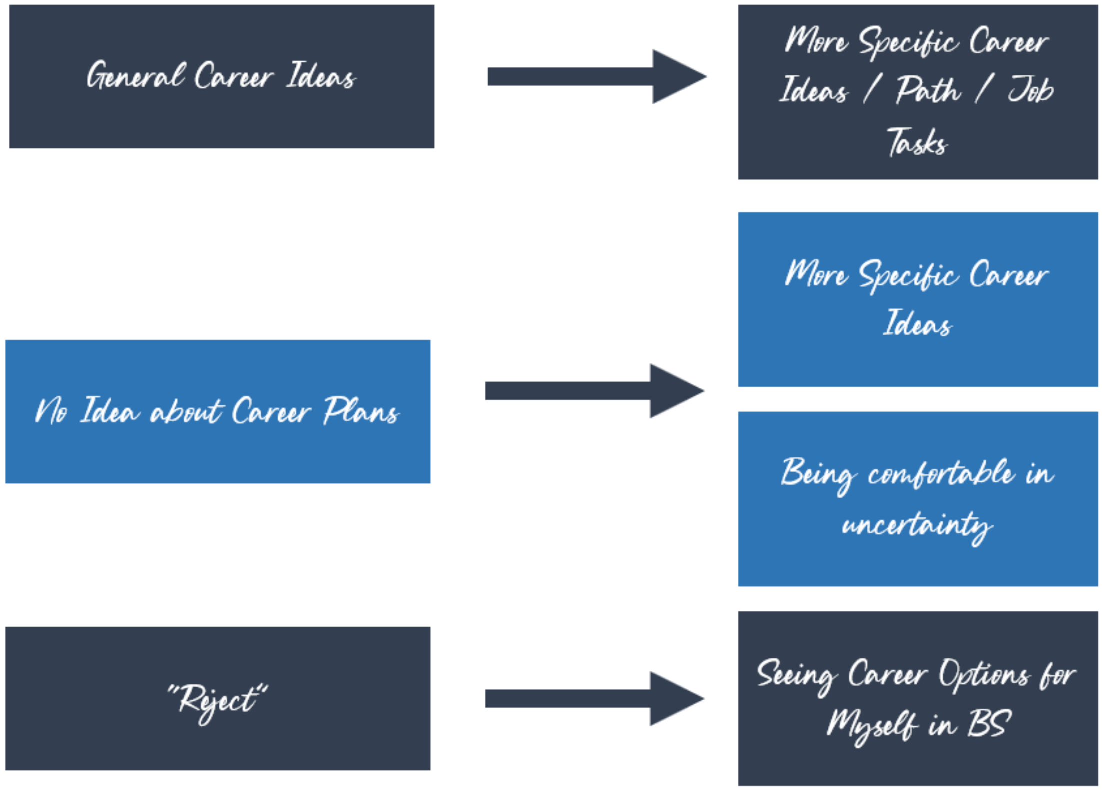

Figure 7. Initial sketch of how students came to be in biosystems engineering.

I then began to think about how other progressions I noticed fit together. There were multiple concepts that seemed to develop for participants, as they moved towards career specificity and connection. This sketch captures my initial thoughts on this:

Figure 8. Initial sketch of progressions along multiple domains over time in the course.

I also continued to wrestle with the ways growing up influenced career development. I compiled these ideas like this:

Figure 9. Initial sketch of influences when growing up.

Finally, the participant timelines drove home the distinct impact that mentors had on the career development of students. The themes in this area were particularly impactful, with students speaking about the impact of their informational interview in not just their reflections on that experience, but also in their reflective letters and interviews.

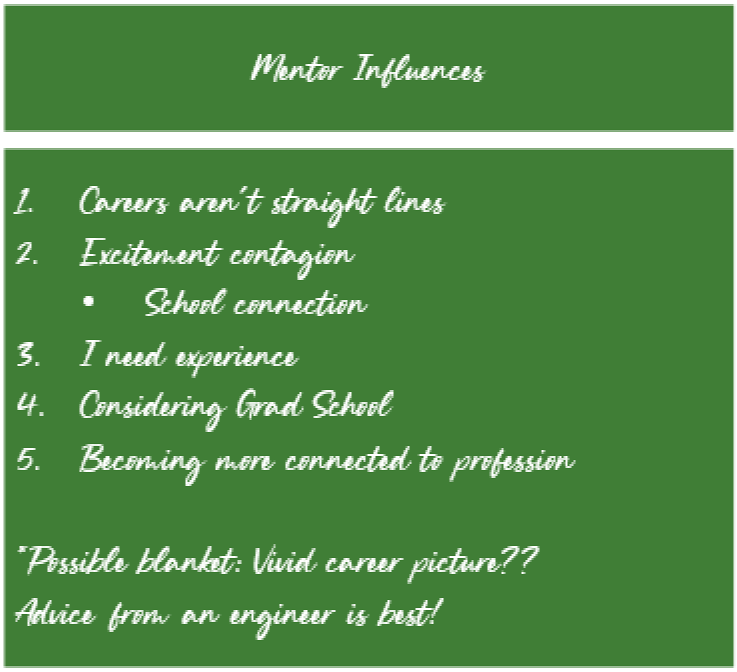

Figure 10. Initial sketch of the influences of the career mentors.

These initial, rough sketches, allowed me to think about the processes emerging from the focused codes and timelines. I began to conceptualize the transitions and progressions that happened to students over time. I then took time to reflect and memo on my thoughts, giving myself a few days to sit with this information before moving onto the next phase of my model.

Model Phase 2. Once I had completed my initial sketches of my analysis, I began to consider ways to compile these ideas into a cohesive model. My first attempt at this involved connecting the emerging ideas in my analysis to the systems theory framework by sketching the ideas onto a graphic similar to STF (Patton & McMahon, 2014).

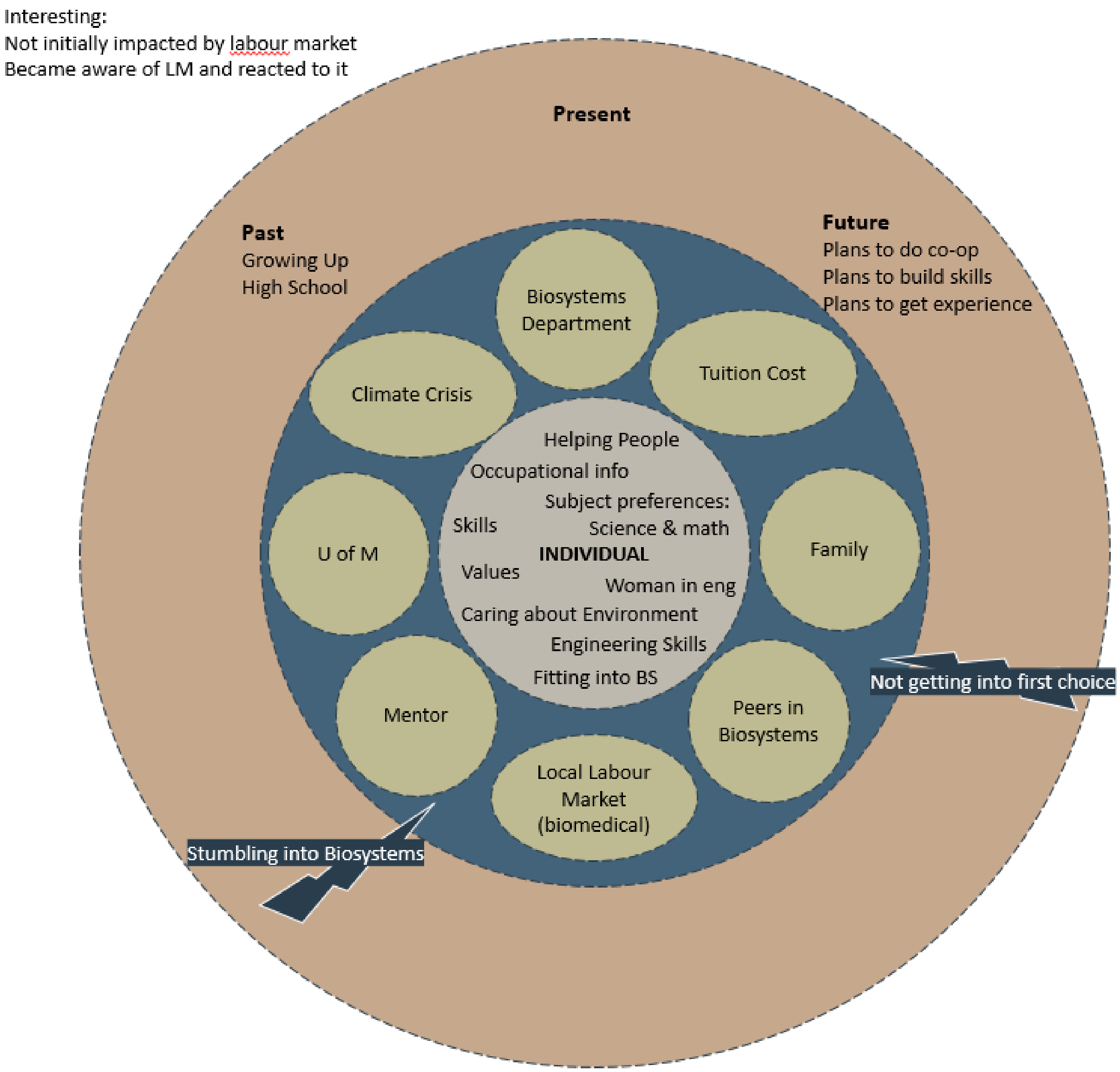

Figure 11. Connecting findings to STF visually.

Though I did not use this graphic in my final model, this exercise allowed me to think more deeply about how the data connected to STF and how the emerging codes fit together.

Next, I compiled the information I noticed in my STF sketch with the ideas I compiled in the first phase of my model development.

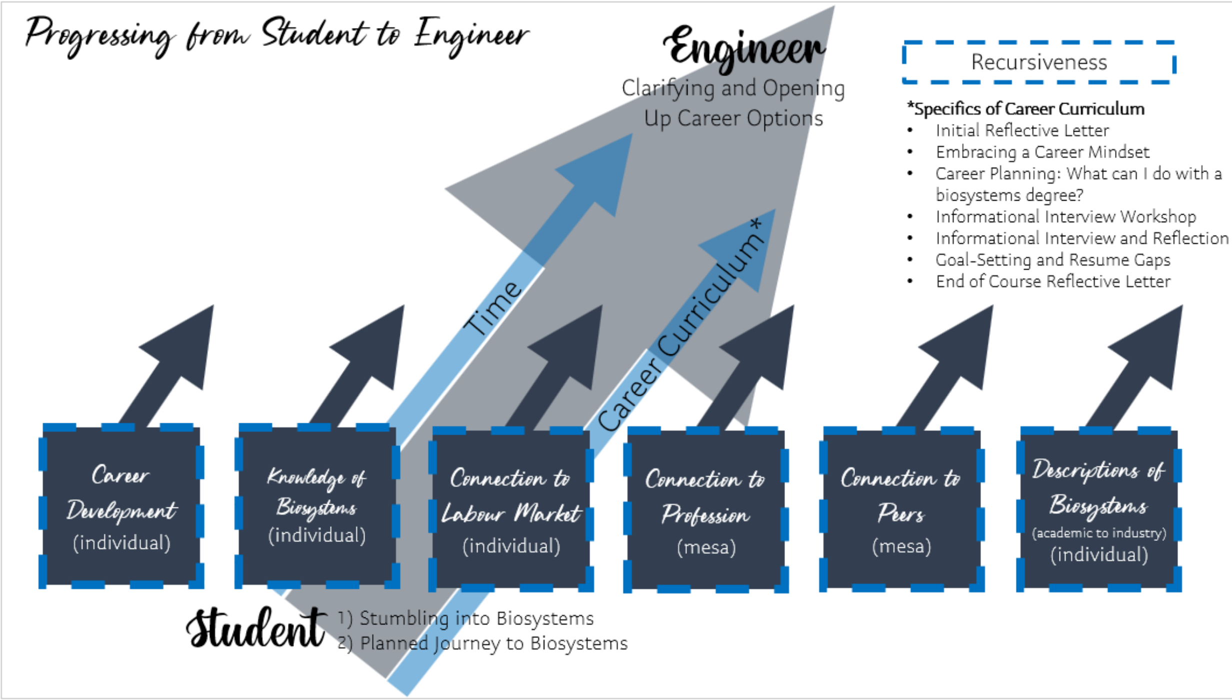

Figure 12. Movement and progression along multiple domains, from student to engineer.

My intention with this model was to show the participants growing across multiple dimensions, as described in the boxes above. I noticed the transition from student to engineer connected all these ideas, so I placed a larger arrow over the model, demonstrating this overarching progression. I also attempted to show progression over time, the impact of the career curriculum on career planning, and recursiveness.

Final model: Becoming a Biosystems Engineering Student. I met with my co-advisors, sharing the first two models described above. Our conversation gave me quite a bit to think about, allowing me to further refine my model and come to my final depiction of my findings.

The emergent theoretical model offers a depiction of the findings of this study. This section will walk the reader through the overarching ideas of systems theory framework and the career curriculum which influenced this model. It will also detail the main ideas in the model: the student starting point, progressing to engineering, career development, knowledge of biosystems, connection to labour market, connection to profession, connection to peers, and descriptions of biosystems (academic to industry).

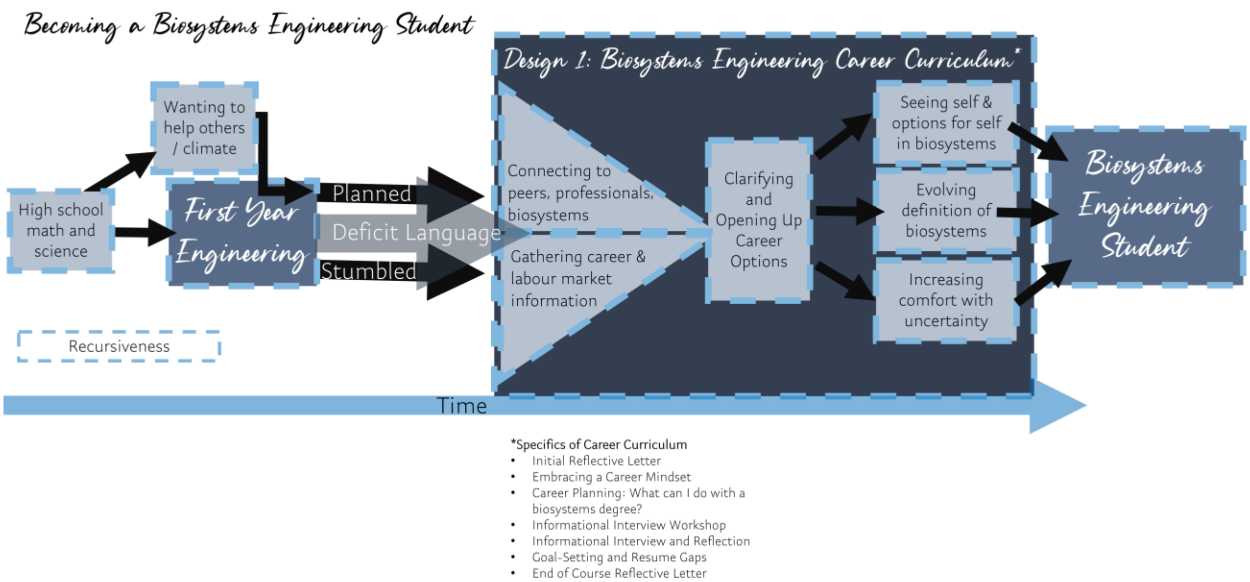

Figure 13. Emerging theoretical model: Design 1: Becoming a Biosystems Engineering Student.

Overarching ideas. The final model depicts the progression towards identification as a biosystems engineering student, with students enjoying high school math and science before coming into biosystems from the two main entry perspectives identified in my analysis: stumbling into biosystems or arriving with a specific plan to study biosystems (typically helping others through biomedical engineering / healthcare or combatting the climate crisis). For all these students, it was difficult for them to describe biosystems engineering, with students often relying on deficit language to explain what biosystems engineering is not or by describing it in terms of the academic requirements. As students enter their Design 1 class in biosystems engineering and are exposed to the career curriculum (represented by the dark blue box), students begin connecting with others about their profession and gathering labour market information. This exercise seemed to inspire students to think about their options more broadly as they clarified and opened up options. This experience flows into students seeing themselves in biosystems, defining biosystems, and building increasing comfort with uncertainty. The model, which emerged from grounded theory analysis, shows a progression towards a deeper identity as a biosystems engineering student as students experience the career curriculum.

Systems theory framework. Aspects of STF are also incorporated into this model. Each concept is marked with a dashed line, indicating recursiveness (Patton & McMahon, 2014). This is within the overarching concept of time, which operates alongside the career curriculum incorporated into Design 1, which also progressed over time. Chapter 5: Findings and Discussion will position the findings within STF more thoroughly.

The student starting point. The student identity is a primary component of this study, with participants speaking and writing about it extensively throughout their reflections and interviews. Students indicated that a high school interest in science and math made them consider becoming engineers to apply this interest in their education and work. This brings students into first-year engineering, as depicted in the model, which is common to all prospective engineering students, no matter their intended major. At the beginning of the class, student reflections tended to use academic language to describe their interests and what biosystems engineering is. An example of this, is how students wrote about how they came to be in biosystems in their first letter. As has already been discussed, the language used by participants tended to be academic. They wrote about loving math and science in high school as a starting point to their eventual choice to take engineering courses. They even described biosystems engineering in academic terms, referring to the specializations within their programs to describe what Biosystems is. These concepts became the focused codes in the letters: *Movement from an* *academic description of biosystems to an industry description* and *high school interest in science.* As students described how they came to be in biosystems engineering, two major starting points for students emerged: stumbling into biosystems and a planned journey to biosystems.

Stumbling into biosystems or a planned journey to biosystems. Stumbling into biosystems emerged as a focused code in both the reflective letters and the interviews, highlighting its significance in this study. It thereby is framed as a starting point in this model, as one of the two entry points into the biosystems engineering program. As already described in the analysis detailed in the section Model Phase 1, students shared that they had entered their program based on a “vague description” (Participant 18), having “shallow” understanding (Participant 11), or found their enrollment “a bit unexpected” (Participant 3) after applying to multiple programs. For some students, biosystems was not their first-choice program, while others seriously considered other programs before ending up in biosystems (Participants 8, 13, 18). Students who took this path “stumbled” into biosystems as opposed to purposefully and thoughtfully selecting it based on their interests or career goals.

Planned journey to biosystems. In contrast to students who "stumbled" into biosystems, another distinct pathway which emerged was a planned journey to biosystems. Students who spoke about this had specific career goals and interests which brought them to the decision to study biosystems engineering. This is highlighted in the interview focused code, *a call to action against the climate crisis* and the reflective letter focused code, *helpers and "green people."* As these corresponding sections of the previous analysis have already detailed, many students sought biosystems as a way to "help" people (Participant 12, 13) or "make the world better" (Participant 1). They wanted to make a change to health or the environment, feeling compelled to access engineering education to be qualified for work that could make these changes. This unique motivation is detailed as an offshoot of the model, influencing those who planned to enter biosystems and not those who stumbled into biosystems.

Deficit language. For all students, whether they stumbled into biosystems or entered the program with a clear career plan, there was a struggle to describe biosystems engineering. Students relied on deficit language, describing what biosystems was not, particularly in comparison to other engineering disciplines. This is linked to the student identity already discussed, with participants relying on academic language to describe biosystems engineering, grounding the biosystems engineering identity in course offerings or program specializations. Ultimately, students relied on explaining differences between biosystems engineering and other programs using deficit language or using language directly from the academic calendar as opposed to using clear language to describe biosystems engineering as a profession.

Design 1: Biosystems Engineering Career Curriculum. The career curriculum provides a backdrop to the participants' experience in Design 1. As described in the analysis of the interviews in the *enforced career curriculum* focused code, students saw the career content as impactful and useful. This is a qualitative study, meaning causation cannot be inferred. However, students did explicitly mention that they would not have engaged in the career development activities without the integrated course programming. Further, the informational interview portion of the curriculum was particularly impactful according to participants. Of course, some areas of progression may have happened with or without the career curriculum, and may have been part of typical career and personal development of engineering students. None the less, the fact students explicitly referred to career content as impactful, suggests it did play a role in the overall development of students.

The career curriculum is represented in the model as labelled within the dark blue box, encompassing other experiences in the course. The curriculum was facilitated the identity development which happened in the course, with students specifically referring to aspects of the curriculum when discussing how they grew and changed over the schoolyear. During the period of time that students were in Design 1, they connected to others, gathered career information, clarified and opened up career options, saw career options, defined biosystems, and increased their comfort with uncertainty.

Connecting to peers, professionals, biosystems and Gathering career and labour market information. As students entered the Biosystems Engineering program and began to engage with the career curriculum integrated into Design 1, they were expected to connect with others and gather career information as part of their course assignments. In the diagram, these processes are happening simultaneously, moving students towards the next component of their experience of the curriculum.

Connecting to peers. Students connected to their peers through the career assignments and activities, as well as through other projects in Design 1. It is also significant to note the importance of peers to the participants, an idea which emerged in the interviews through the focused code *connecting with others in biosystems engineering*. As students progressed in their education, they relied on their peers and felt comforted by being similar to other students in their program.

Connecting to professionals. As time passed in the course, students became more connected to professional biosystems engineers. There is a clear before and after marker in time related to this concept, since the supporting focused codes both emerged from the informational interview reflections: *becoming more connected to biosystems engineering* and *openminded careers and "bouncy career paths."* The participants shared that speaking to another engineer made them feel excited, motivated, and provided real, vivid examples of the professional options available to them by hearing the story of a professional engineer. Seeing oneself as similar to an engineer appeared to help students to feel more connected to the profession as a whole and helped them to identify with being an engineer.

Connecting to biosystems. As students began to connect with their peers and professionals and learn more about biosystems engineering, they became more connected to biosystems itself. This is evident in the code *becoming more connected to biosystems engineering*. At this point in the model, students are beginning to see themselves in the profession and are beginning to feel connected to their profession.

Gathering career and labour market information. Students were expected to conduct occupational research during in-class career activities and to prepare for their informational interview. Once students were interviewing their mentor, they also received additional career and labour market information. These activities provided a vehicle for students to gather relevant career and labour market information, allowing them to understand the experiential requirements for jobs of interest, identify employers, understand available jobs, more deeply understand the day-to-day of occupations, and to learn about the demand for and salary of various positions. This notion is emphasized in the reflective letters through the code *increasing labour market awareness* and in the reflections on the informational interview through the codes *discovering the value of relevant experience* and *connecting schoolwork to industry.*

As participants progressed in the course, they expressed a deeper connection to the labour market (which is also related to the next step of the model, clarifying and opening up career options). For students, this involved the student's perception of the labour market as much as the reality of the labour market. Participants expressed this explicitly in their reflective letters, as demonstrated in the *increasing labour market awareness, moving from an academic perspective of biosystems to an industry perspective,* and *refining career ideas and discovering more career options* focused codes. The quotations supporting these codes demonstrate students' increasing awareness of the employment opportunities relevant to their skillset and their ability to write using industry focused as opposed to academic focused language, positioning themselves as potential workers in the labour market.

Clarifying and opening up career options. As students became more deeply connected to the peers, professionals, their program, and as they gathered information, they began to clarify and open further career options. This was described in the analysis of the reflective letters and informational interviews through the focused code *refining existing career ideas and discovering more career options,* and in the interviews through the focused code *making a career plan.* As students reflected on their time in the course, there was a marked progression from their initial reflective letter their letter at the end of the course. Students also shared this progression as they reflected on their career in their interviews.

For the stumblers, who came into biosystems engineering without a clear plan, this was an awareness of options that was not present at the beginning of the course. For those who planned to enter biosystems engineering, there were multiple ways options opened. For some, this involved understanding the smallness of the local biomedical engineering and planning accordingly, while for others it meant learning about and considering new options that they had not thought about before. Still other students learned more about their own specific path and used this information to make thoughtful career choices to support their goals.

Seeing self and options for self in biosystems. Once students were aware of their career options, they began to see themselves within biosystems engineering, connecting their skills, values, interests, and goals to the profession. This is evident in the language students used to describe themselves and their profession and is evident in the codes *becoming more connected to biosystems engineering, refining career ideas and discovering more options, making a career plan,* and *connecting with others in biosystems engineering.*

Evolving definition of biosystems. At the beginning of the course, the definition of biosystems engineering seemed illusive for students. As students progressed in the course, students indicated a progression in their knowledge of biosystems engineering. This progression is evident as students became more aware of how their skills translate to the labour market and what is required for success in the labour market, as in the reflective letter focused codes *refining career ideas and discovering more career options, movement from academic descriptions of biosystems to an industry description, increasing labour market awareness*; and the informational interview focused codes *refining career ideas and discovering more career options*, *discovering the value of relevant experience, becoming more connected to biosystems engineering,* and *connecting schoolwork to industry;* and the interview focused codes *making a career plan, comparing biosystems engineering using deficit language*, and *connecting with others in biosystems engineering*. In each of these codes, participant quotations demonstrate students becoming increasingly aware of what biosystems engineering is, the skills they have to offer, how to build relevant skills, and build further connections to professionals and peers. This knowledge is all about what biosystems is and who biosystems represents. This could also be reframed as confidence in biosystems, as many students expressed an increased confidence in their ability to find meaningful employment with their program as they became more aware of the options available to them.

Students also changed the language they used to talk about biosystems engineering. This emerged from the focused codes in the reflective letters*, movement from academic description of biosystems to an industry description* and *a high school interest in science;* and in the interviews, *making career decisions based on courses* and *comparing Biosystems Engineering using deficit language.* Students conceptualize their interests in academic terms, particularly at the beginning of the course in their first reflective letters, where they used the academic specializations within their program to describe what biosystems engineering is. They also used academic experiences, such as those in high school and university courses, to inform their career decision-making. As students begin to better understand what a biosystems engineer is, how their coursework connects to industry, and the specific career options available to them, they tended to use industry focused language to describe their career journey.

Increasing comfort with uncertainty. As students began to understand that there might be limited options in some sections of the labour market and that uncertainty and zigzagging is inevitable in all careers, they began to develop comfort with this uncertainty. They realized that it is normal to have a "bouncy" career path and that they could be okay with ambiguity and openness in their careers.

Biosystems engineering student. From the more general high school and first-year engineering student end of the spectrum depicted in the model, students progress towards identifying as a biosystems engineering student as they moved through the career curriculum. In particular, there was a clarifying and opening up of career options, as denoted in the model. This has already been discussed extensively in the previous analysis. Specifically, the focused codes, *refining existing career ideas and discovering more career options, increasing labour market awareness, making a career plan,* and *connecting with others in biosystems* connect to this concept. Overall, this model demonstrates the gradual progression from student to a more specific identity of biosystems engineering student which was facilitated through multiple interconnected, recursive experiences.

Summary

Chapter 4 began with a description of participants, before explaining the specific steps I took when analysing the data. I explained the process of developing the emerging theoretical model, detailing the specific initial and focused codes I found during phase 1 of analysis as well as the initial drafts of my phase 1 and 2 models. Finally, I presented the final model, Becoming a Biosystems Engineering Student, and detailed the roots of each piece of the model, connecting it back to my analysis. In Chapter 5: Findings and Discussion, I will provide further detail on the on my emergent theoretical model, connecting it directly to my research questions, systems theory framework, and the current literature. I will cover strengths and limitations of the study, the implications of the findings for career development professionals and engineering educations, implications for future research, and share about my reflections and reflexivity.

Chapter 5: Findings and Discussion

Introduction

Chapter 5 delves deeper into the findings of this research study into the experiences of biosystems engineering students who had career development integrated into their required coursework. I will begin by connecting the emergent theoretical model to my research questions. I will also further connect the emergent theoretical model to Systems Theory Framework. I will then discuss the findings in relation to the literature, with particular focus on the three cognate areas discussed in Chapter 2: career development of post-secondary students, emerging adulthood with a focus on vocational and engineering identity development, and reflection in experiential learning. Strengths and limitations of the study will be covered. This will be followed by a discussion of the implications of the findings for career development practitioners and engineering educators, as well as for future research. Finally, I will end this chapter with a section covering my reflections and reflexivity.

Emergent Theoretical Model and the Research Questions

The goal of this study was to understand the experiences of biosystems engineering students taking a required course with integrated career development content. A theoretical model of this experience emerged, showing students progressing towards identifying more deeply as biosystems engineering students as they engaged in the career curriculum over time. I will now connect these findings to the initial research questions.

Central Question: Through exposure to in-class career development supports in a

biosystems engineering course, what influences students' vocational identity development? The career development supports influenced students as they made their way through their first year of biosystems engineering, contributing to their vocational identity development as biosystems engineers and biosystems engineering students. The curriculum provided space for students to connect with professional mentors, gather career and labour market information, and connect their interests, values, and competencies to employment options, which in turn played into their understanding of themselves as biosystems engineering students. Students recognized there are a variety of career identities within biosystem engineering and that there are countless directions they could take. These broad variations in options bring in an element of uncertainty to students' careers. Still, students did not seem to feel concerned about this. They shared they were comfortable with their careers not taking predictable, straight pathways. This comfort appears to be a direct result from the career interventions brought into the course, with lectures and discussions that stressed the value of happenstance in a chaotic labour market and career mentors who echoed this sentiment.

As students began to understand the inherent uncertainty that is woven into all career journeys, they began to consider how various factors might influence their life and to plan accordingly. For the students who entered biosystems engineering with a specific career plan, there was new awareness of the labour market. Particularly, students who initially intended to become biomedical engineers, began to understand the competitive labour market in Winnipeg. For some, this knowledge encouraged them to buckle down and do everything possible to increase their chances of reaching this goal. For others, this newfound labour market awareness encouraged them to let go of their initial goal to become a biomedical engineer and begin to consider other options. The career interventions appear to have facilitated this awareness, giving students space to uncover this reality through career assignments and then to respond to it. Students were therefore able to plan accordingly for their future and make thoughtful decisions or changes to their plans earlier in their time as students, as opposed to potentially discovering this upon looking for work at the end of their program. Students who stumbled into biosystems were also connected to labour market information and given an opportunity to think deeply about the next steps in their career journeys. These students changed their approach to careers. Where before, they were being pulled along by uncertainty and ending up in places they did not intend, by the end of the course they were finding their place in biosystems engineering, understanding that the twists and turns in their career to this point were normal, and considering how they could be planful amidst this uncertainty. Both the planners and stumblers came to a point where they were able to understand their options, incorporate labour market information into their plans, and plan thoughtfully for their future while expecting the unexpected.

Other factors were also influential as students navigated their first year of biosystems engineering. Students identified their mentor, who they interviewed as part of the informational interview assignment, as particularly influential. In reflecting on this conversation, students recounted becoming more connected to their profession, more motivated to access relevant experience, and better understood and clarified their career options. Students also spoke about the informational interviews in their second reflective letters and their interview with me, demonstrating how memorable it was. Though students did not explicitly connect this to the career development content integrated into the course, these informational interviews would not have happened without the career content, since this was a specific course assignment.

Peer relationships were also valued by students and influenced their understanding of themselves and biosystems engineering. When positioning themselves within biosystems, students often found commonalities with their peers in terms of interests and values. Specifically, an interest in helping others and helping the environment. For students who did not share this interest, there appeared to be less belonging in their recollections. Students also relied on their peers for support through the challenges presented by their demanding academic program, appreciating the tight-knit community which emerged from having similar timetables.

Coursework influenced students' development. It was through coursework in high school that students identified interests in subjects which they used to decide on engineering. In university, coursework also provided clues to students in terms of what their occupational interests might be. When a student enjoyed a class, they tended to consider how this could relate to the world of work.

Students were also influenced by problems in society which they sought to remedy through engineering. The major issues students cared deeply about were healthcare and the climate crisis. Student's interviews and reflections suggested that their careers were a direct response to medical issues or climate change. They saw themselves as helpers called to respond to these large issues using the knowledge they would acquire through engineering education.

As students developed vocationally, career information was a critical factor in exposing them to the career options available to them. They accessed career information through multiple avenues, including through their career mentor and through the career curriculum itself. To identify their mentor, they were taught to identify relevant job titles, employers, industries, and directories using multiple online tools. They were also taught to use their network to access labour market information, then practiced this skill by conducting an informational interview. Students were also taught how to use job postings, LinkedIn, professional associations, sector councils, and relevant databases to learn more about occupations of interest. In turn, students progressed in their vocational identity development, progressing towards more career clarity or identifying options they had not known about previously. This career information fueled decision-making, allowing students to increase their career options and refine their existing career ideas.

This exposure to information also increased students' awareness of what it means to be a biosystems engineer: what jobs they can do, who they are, what skills are required, and the tasks accomplished by these professionals in the workforce. They developed as biosystems engineering students, better understanding the professional applications of their education. This awareness is a distinct progression, considering so many students could be said to have "stumbled" into biosystems engineering, meaning they did not access career information as part of their decision-making process to enter this program. Biosystems engineering does not have a clear, prescribed employment outcome that students can easily identify and strive for. Instead, biosystems career options are broad and varied. Employers do not always understand what biosystems engineers are capable of or think to explicitly name this program in job postings. This makes career planning more challenging for students, whose words demonstrated their lack of understanding of what their program offers, particularly when they used deficit language to describe biosystems or were unable to identify employment options. The biosystems identity is not obvious – it is evasive and illusive. It takes time and exposure to cultivate. With the career interventions, students were encouraged to do this cultivation sooner – right at the start of the program. Their reflections and interviews provide examples of how the curriculum facilitated their growth as biosystems engineering students, as they gradually began to more specifically explain their program and their own identity as professionals.

With all of this in mind, it is clear that the career development content itself was influential in supporting student vocational identity development. It was through the course that students were taught how to access career information and were encouraged to connect with their career mentor. They were also given space to reflect on this learning at multiple points. Though the impact of reflection is not measured in this study, it is worth considering how the very data this study is analysing might have impacted students' vocational identity development. By writing their reflections and engaging in the interview process, students were forced to engage in reflective thinking, which could have allowed students to improve their self-awareness and further their career development.

Secondary: How do students experience their identity development over time in the course? A major identity progression experienced by students in the course, as represented by the emergent theoretical model, is towards biosystems engineering student. As time passed in the course, students advanced across multiple domains as they began to better understand themselves and their career options. Students who stumbled into biosystems had a slightly different experience to those who purposefully selected biosystems with a particular career goal in mind.

For students who stumbled into biosystems, with little information about their options or because they did not get into their first-choice program, there was an increase in awareness of options, access to career information, and for students who had a rejection before entering biosystems as a second choice, more hope attached to their career options. Some students remained unsure about their career goals, but felt more comfortable in this uncertainty. Other students heard about the open-endedness of their mentors' career paths and internalized this message in their own careers.

Other students, who came to biosystems with existing career plans, often to be biomedical or environmental engineers, increased their awareness of other options and also refined their existing career goals. Students began to better understand their career options as well as the skills and experiences required to reach specific occupational goals. This is evidenced by students' reflection on the importance of getting relevant experience after meeting with their career mentor for an informational interview.

Secondary: How do students perceive supports and barriers over time in the course? Students identified multiple supports and barriers during their time in the course. The local labour market was perceived as a barrier, while schoolwork acted as both a support and barrier. Other supports included the career curriculum and people in students' lives.

The local biomedical labour market was a barrier identified by some students in their interviews. As they learned more about the labour market, they became aware of the high level of competition for local biomedical jobs. Students reacted to this in varying ways, considering other options or feeling motivated to work harder to acquire an edge as an applicant.

Interestingly, schoolwork was both a support and barrier. It was a driving factor in terms of self-understanding and conceptualization of career interests for students, providing a vehicle for students to explore options and understand their skills. It was also a barrier to career development. Students mentioned that school stress and competing academic priorities often got in the way of them investing the time required for career development.

The career curriculum itself was a support, counteracting the barrier school enacted for student career development. By investing class time in career development and incentivizing activities through course credit, students were encouraged to include their career development as part of their academic priorities, as opposed to seeing it as something that would prevent them from investing the required time into their studies.

A further support were the people in students' lives. Students identified peers, family members, and their career mentor as supports in their career journeys. Peers provided academic guidance, career advice, and support during difficult times. Family, friends, and significant others provided support and motivation to students. Students were also supported by their career mentor, who provided advice and inspiration to students. Ultimately, the people in students' lives tended to be important as they progressed in the course.

Emergent Theoretical Model and Systems Theory Framework

Systems theory framework of career development (Patton & McMahon, 2014) is the theoretical framework of this study, informing the development of the emergent theoretical model. In STF, acausality is a key tenet, suggesting career development is not a linear process. While the model does have directional arrows, this should not be taken literally. Careers are not straight lines, and the students did not have orderly progressions in this course. Along this same line is the notion of discontinuous change, which posits that change can occur in multiple ways: gradually, in sudden bursts, or in sudden regressions.

Recursiveness is present in the model, with all factors influencing all other parts of the system. This is illustrated using a dashed line, similar to that of the visual representation of STF in figure 1 of this study. This demonstrates the ways in which the pieces of this model are influencing all other parts.

The emergent theory also represents an open system, in which the student cannot be separated from their context. All factors represented in the model are overlapping and influenced by factors not depicted in the model, such as the media, the government, and geographic location. Students' progression towards identifying more deeply as biosystems engineering students is occurring within a complex system, with multiple interrelated influences. This is all happening with the influence of time. As students progress in the course and in their career development, time is passing.

A particularly interesting component of the findings of this study is the ways student perception of the contextual system changed. Awareness of the labour market was more important to their development than the labour market itself. While the labour market did not necessarily change, the students' awareness of it did change. They were unaware of their occupational options or the specific labour market demand for jobs until the course. Upon accessing this information, the labour market was suddenly brought into focus, therefore becoming a major influence on the individual. Though this might not be considered a chance event by some, it might have felt like an unexpected or chance event to the students discovering this reality, and their perspective as individuals is a critical feature of both STF and this emergent theory.

Emergent Theoretical Model and the Current Literature

The emergent model characterizes the progression over time of participants from student towards engineer as they experience the career curriculum, as well as change in the domains of career development, knowledge of biosystems, connection to labour market, connection to profession, connection to peers, and descriptions of biosystems. This model can be aligned with existing literature already presented in Chapter 2 on the topics of career development of post-secondary students, emerging adulthood, and reflection in experiential learning. The following section will compare these findings with the relevant literature of these three cognate areas.

Career development of post-secondary students. The current study aligns with existing research on the career development of post-secondary students and career development curricula and extends beyond the existing information on this topic. Chapter 2's overview of existing literature on career development curriculum presented anecdotal evidence from practitioners on the value and impact of career development supports in post-secondary classrooms. The majority of studies showcased the power of career development courses, while four provided preliminary information on the integration of career development topics into other courses.

Career development courses. As already presented in Chapter 2, career courses are linked to increases in beneficial domains, such as career maturity (Ganster & Lovell, 1978; Smith, 1981; Ware, 1981; Carver & Smith, 1985), student retention (Folsom, 2000; French, 2013), career decision-making (Roberts, 2004; Reese & Miller, 2006; Scott & Ciani, 2008; Fouad, Cotter, & Kantamneni, 2009; Gallo & Roberts, 2019), career self-efficacy (Roberts, 2004; Fouad, Cotter, & Kantamneni; Gallo & Roberts, 2019), vocational identity (Scott & Ciani, 2008), and academic performance (Folsom, Peterson, Reardon, & Mann, 2005). At the same time, more negative domains decreased, such as dysfunctional career thoughts (Reed, Reardon, Lenz, & Leierer, 2001; Osborn, Howard, & Leierer, 2007; Taylor, 2009) and psychological distress (Belisle, 2005). This study is congruent with this information, aligning with information on student retention, career decision-making, career self-efficacy, and vocational identity. The study did not provide further information on dysfunctional career thoughts, psychological distress, career maturity or academic performance.

While the present study does not provide explicit data on student retention, this domain can be connected to emerging themes. Students expressed feeling more connected to their profession and those considering leaving biosystems ultimately decided to remain in the program. Students spoke about better understanding how their field of study connects to the labour market and the options available to them. Students who had “stumbled” into biosystems increased their connection to the program. At the time of interview one year after completing the course, none of the participants appeared to have dropped out of the program. This highlights the connection between career curriculum and positive academic outcomes for students, although it does not provide explicit detail on student retention.

Progress in career decision-making was an important finding of this study, as students progressed in their career development: refining existing ideas, discovering further options, and making career decisions. This is similar to the findings in research on career courses, where multiple studies indicated students became more career decided after taking the class (Roberts, 2004; Reese & Miller, 2006; Scott & Ciani, 2008; Fouad, Cotter, & Kantamneni, 2009; Gallo & Roberts, 2019). Integrating career development activities into a course appears to maintain the effectiveness of the support in terms of helping students progress in their career decisions.

Career self-efficacy refers to the belief that an individual can have career success and make career choices (Roberts, 2004; Fouad, Cotter, & Kantamneni; Gallo & Roberts, 2019). The findings of this study are congruent with previous research, as emerging themes indicated students appeared to increase their career self-efficacy. While this was not measured quantitatively, as in the previously cited studies, the findings did align with progress related to self-efficacy. In the interviews, themes emerged around making a career plan and making career decisions based on the course. In the reflective letters, the most relevant theme is *refining existing career ideas and discovering more career options*. This ability to envision the future and discuss their decision-making process, indicates a level of career self-efficacy amongst participants.

Progress in terms of vocational identity (the development of an understanding of the self in a career context; Brown & Hirschi, 2013) was also evident amongst participants, through their coursework and interviews. Relevant themes from the reflective letters included *refining existing career ideas and discovering more career options, movement from an academic description of biosystems to an industry description, helpers and "green people,"* and *increasing labour market awareness*. In the informational interview reflections, themes connected to vocational identity development were *becoming more connected to Biosystems Engineering, connecting schoolwork to industry,* and *refining existing career ideas and discovering more options*. Finally, interview themes that are relevant include *connecting with others in biosystems engineering* and *a call to action against the climate crisis*. Through these themes and the model they informed, there is a description of students progressing in terms of their understanding of themselves as engineers and workers, their understanding of career options, and ultimately, their ability to put themselves in the context of career. I will expand further on vocational and engineering identity development in the next section.

This study did not explicitly measure or ask about dysfunctional career thoughts and psychological distress, and no explicit themes about these topics emerged during analysis. Still, some participants did speak or write about experiencing more positive feelings about their career options and their career plans in the stumbling into biosystems theme. It is too much of a stretch to link this to the quantitative concepts of decreased dysfunctional career thoughts or decreased psychological distress, but these findings do provide a clue that further research on these specific topics in relation to integrated career development courses is warranted.

The study did not provide further information on career maturity or academic performance. These topics were not explicitly inquired about in the reflection prompts or interview questions, and they did not emerge during analysis. While some students did speak about improving academically during their interviews, they did not speak about this being connected or disconnected from the career content in the course. This could be a topic for further study. Overall, the present study provided qualitative information on the integration of career curricula in existing classes.

Integration of career development into post-secondary classrooms. As detailed in the literature review, existing information on career development integrated into post-secondary classrooms comes from word of mouth amongst career practitioners, formally through conferences and informally through career centre websites. There are also a limited number of studies on this topic. This project confirms anecdotal and initial findings, and provides much more information on the impact of this type of curriculum in classrooms. Further, while the courses in these studies in the literature did integrate career development into the classroom, the content was not as extensive as in this study.

This study confirms anecdotal knowledge amongst career development practitioners, who have been providing these supports in classrooms. This study showcases the impact of this programming, providing insight into the ways students grow and progress during their time in a course infused with career content.

The study provides further insight into additional realms of student career development, suggesting a starting point for additional research and program development. It is the first study to provide a detailed grounded theory analysis of integration of career development into a post-secondary course. This is also the first study to explore this topic for engineering and more specifically, within biosystems engineering.

Emerging adulthood with a focus on vocational and engineering identity

development. The current study provides further detail about emerging adults as they develop their vocational and engineering identities. The entire study explores emerging adults as they determine who they are as workers and engineers, with the entire model linking directly to identity development, as students progress from student to engineer along the domains of career development, knowledge of biosystems, connection to labour market, connection to professions, connection to peers, and descriptions of biosystems (academic to industry).

Vocational identity development. Vocational identity is defined as “the development of a coherent view of oneself as a worker” (Brown & Hirschi, 2013, p. 309). Previous research has linked strong vocational identity with the ability to better select a more congruent post-secondary major (Leung, 1998). While this study did not specifically measure the “match” between students and biosystems engineering, in their reflections, students did write and speak about becoming more connected to their major and the options available to them.

Within a STF context, the present study aligns with previous vocational identity research, which conceptualized vocational identity development as everchanging, fluid, and influenced by the many systems and contexts surrounding the individual as the individual crafts their understanding of the past and their future (LaPointe, 2010; McMahon & Patton, 2018; McMahon & Watson, 2013). The findings of this thesis aligns with this previous research, as participants conceptualized the complexities of their understandings of themselves and their profession over time in the course.

The comparison view of biosystems engineering shared by participants adds to the STF model. Students spoke of their understanding of biosystems engineering within the broader context of the academic and engineering community – how they fit within the broader system of biology, medical science, environment, and other engineering disciplines.

Engineering identity. Engineering identity development is a major component of the emerging theoretical model, providing the overarching progression from student to engineer, as students develop along multiple domains. Just as in Murphy and colleagues (2015), students built commonality with their peers. Students identified technical skills as important components, as they discussed their academic abilities, just as in Marjoram & Murphy (2015). What differs in this study is the unique perspective of biosystems engineering students, who are studying a small discipline of engineering with specific skills and occupational outcomes. In this way, the findings of this study provide a unique perspective on the progression of engineering identity within biosystems engineering, which is unique from other engineering specializations. Students identified this uniqueness, noting the unique occupational outcomes, specializations within their academic program, and their unique perspective as *helpers and "green people."*

Reflection in experiential learning. The present study provided students the opportunity to reflect on their career development via three written reflections and an interview. There was also an experiential learning component, as students went and interviewed a career mentor then wrote a reflection on this topic. This informational interview assignment was particularly impactful, with students referring to it not just in the reflection directly connected to the assignment, but also in their second reflective letter and their interviews with the researcher. This experiential component allowed students to access the benefits of experiential learning in the labour market, without needing to sign up for and be admitted to the co-op program offered in the faculty. This networking activity provided students with increased connection to their profession, more clear career plans, and allowed them to make informed career decisions. The present study details students progression in their career as they experience and then reflect on that experience.

Strengths and Limitations

This study provided an in-depth depiction of the experiences of biosystems engineering students who took a course which included career development supports. No studies have investigated this process before, and it provides valuable insight into this experience for career development practitioners and engineering educators. At the same time, because there is no research on this topic, there is no way to confirm the accuracy of this model in the context of other research.

This study had a fairly large sample size for a qualitative study, with about half of eligible students agreeing to donate their coursework. This large amount of data, which came from multiple sources for each student, provided a robust and detailed starting point for analysis, which can increase confidence in the findings. Further, the use of reflexivity and memoing throughout analysis, while not eliminating bias, mitigated it. Still, the findings should not be generalized beyond the specific population and experience of biosystems engineering students. It does provide insight, though, which will likely be thought-provoking and inform the practice of both engineering educators and career development practitioners.

It is also important to note that the interviews were conducted about one year after the course was completed. While this provided an interesting, longer-range perspective as students looked back on their time in the course, highlighting what was most impactful and memorable, it also means they did not remember everything clearly. During the interviews students sometimes said they did not remember, particularly when trying to answer the question about chance events which happened during the course or when asked about what supports and barriers they experienced. This issue is mitigated by the fact that the coursework was completed at the time of the course when the experience was fresh in students' minds.

The diversity of the part icipant is both a strength and limitation of this study in different domains. The participants were representative of biosystems engineering students in terms of their gender identity. A limitation is that no international students volunteered to be interviewed, meaning this aspect of the student experience is unrepresented in the interview data. Fortunately, international students were amongst the participants who donated their coursework to the study.

Implications of Findings

The findings of this study offer implications worth considering for both career development practitioners and engineering educators.

Career development practitioners (CDP). This study provides insight into the experiences of biosystems engineering students who have had career development curriculum integrated into their required university coursework. While this cannot be explicitly used to predict the experiences of students in other classroom settings, it can provide insight for the work of career development practitioners, both at University of Manitoba Career Services and more broadly throughout the profession.

First, students particularly internalized information they received directly from other engineers. Though they hear similar messages from me during the class, they did not attribute any of these messages to me or the career curriculum. Instead, they wrote and spoke about the impact of the stories and advise they heard from professionals working in relevant jobs. For example, though they were encouraged to acquire relevant experience and told that careers were open-ended by me in class, they attributed these concepts to their mentors only in their reflections and interviews. This suggests that getting information directly from industry professionals, not just career development professionals, is a particularly powerful method of delivering career information. CDPs often work to encourage their clients to get relevant experience, and this suggests that the best medium for this message is respected professionals in a relevant occupation to the audience.

Second, students internalized labour market and career information and used it to make decisions about their careers. This was an important factor for students who initially considered biomedical engineering. Some of these students decided to consider other options upon discovering the tight local labour market, while others decided to work more diligently to improve their employment potential. Students also spoke about being hopeful and having more career ideas or confirming their initial ideas by gathering more career information. This highlights the importance of incorporating career information and labour market information into career programming. Students require this information to make informed choices and demonstrated their willingness to incorporate this information in their career planning.

Further, this study highlights the importance of research into the work of career development practitioners. This is the first study of its kind at University of Manitoba, despite the fact these types of interventions are commonplace. No other studies have looked at the impact of integrating career programming into classes, so this study also shines a light on the need for further research on the innovative work happening at other post-secondary career centres.

Finally, thinking of University of Manitoba Career Services more specifically, this study reiterates the power of in class career interventions, encouraging the department to continue this work. At the same time, providing this type of tailored service to more programs takes time in an already busy department, which means additional funding for staff would be necessary to expand these sorts of offerings. Further, it is worth noting that Career Consultants are within the union job classification “Administrative Assistant 2.” The competency and education required to do the sorts of interventions described in this study goes beyond an administrative job category. Course-based interventions require labour which is more similar to that of a university instructor, which at University of Manitoba sits within a separate union and is paid twice as much at the top of the pay scale. Career consultants should be compensated fairly if they are expected to be developing lessons, lecturing in university classrooms, creating rubrics, developing assignments, and maintaining expert level knowledge of career theory and occupational information. Further, more competitive compensation would allow Career Services to attract and retain professionals who are capable of providing these services. Funding would need to be provided for these specialized positions, perhaps coming directly from faculties who would like to see these tailored interventions integrated into their programs. A shortage of time and funding is likely a factor that would also need to be considered at other post-secondary institutions who are interested in prioritizing in-class career supports.

This study affirms what may post-secondary career development already know from their practice: integrating career development into classrooms is impactful. For biosystems students, who are extremely busy, it can be challenging to make time for career development. Students expressed their appreciation for “enforced” career planning in their classes. This finding highlights the importance of post-secondary career-development practitioners finding ways to collaborate with faculty.

Engineering educators. Engineering educators can gather valuable information from this study, specifically at Price Faculty of Engineering at University of Manitoba, and more broadly across engineering schools. At Price Faculty of Engineering, it is clear that students struggle to define biosystems engineering. The faculty should consider ways to educate students about the expertise and options for biosystems engineers, perhaps through videos on their website highlighting the career paths of alumni or through panel discussions about the field. Participants did speak of the power of events highlighting engineering majors, so it is clear there is value to this and that it should be continued and even expanded. Only a one student mentioned attending these events, so finding ways to bring this information directly to more students is worth considering. Participants pointed out that biosystems does not have its own first-year engineering course and that they did not feel there was a lot of exposure to this field until they were in the biosystems program. Price Faculty of Engineering might consider ways to give biosystems more space in the first-year curriculum so students can make more informed choices about their majors. This could also include incorporating career supports into one of the required first year engineering courses so all engineering students can make more informed career decisions.

Students struggle to understand what biosystems engineering is, but through career interventions, this understanding increased as their identity as biosystems engineering students developed. Other programs that are more challenging to define (essentially any beyond the core historical disciplines of engineering such as civil, electrical, mechanical, and geological engineering) might benefit from integrated career interventions to support their students down a murkier career path. More research is required to determine the benefits of career supports in more established engineering disciplines, but noting how much biosystems engineering students appeared to benefit from these interventions, it is possible all engineering students could benefit from early career supports in their classrooms. While this study did not explicitly study retention, it is worth considering how career programming might be impactful in both attracting and retaining students, who might be more likely to select and stay in a program if they understand how it fits into their broader life and career.

A strong theme which emerged from this study was that students found that the intense workload in engineering was a barrier to them making time for career planning. By making space for career development in the classroom, students are incentivized to prioritize career planning amidst their busy lives.

As has already been mentioned in the previous section, integrating the voice of professionals into the classroom is particularly powerful. This could be through an informational interview assignment, like in this study. Other options might be through guest lectures, panels, site visits, or videos. Engineering educators might also note the value of collaboration with career development practitioners in the development of curriculum. By bringing in the expertise of a CDP, the educational experience of students can be enriched. Students can be supported in better understanding themselves, their career options, and how their education is connected to their future. This increased student awareness of the relevance of their coursework to their future might be particularly interesting to educators wanting to create engaging, relevant curriculum for their students.

As a profession guided by strict educational expectations and graduate attributes, there might be room for educators to consider how career development can have a higher profile in the CEAB graduate attributes. Engineering educators are ultimately preparing their students to be professional engineers, trained to work effectively upon graduation. By considering how career development can support students while they attend university, they can be better prepared to succeed in the profession once their post-secondary education is complete, thereby training more capable and well-adjusted engineers, working in jobs that are meaningful and fulfilling to them.

Implications of Findings for Future Research

Quantitative research into the impact of career development curriculum integrated into post-secondary coursework is warranted. While this study provided extensive detail into the experience of Biosystems Engineering who had career development activities included in their coursework, there is a need for further research to determine the quantitative impact of this sort of intervention. Further, additional qualitative or quantitative research on other faculties and student populations would provide a more in-depth understanding of the impact of this type of intervention in other fields.

This study did not provide information on reduction of negative quantitative concepts which were identified in previous studies on career courses. Future research could measure the impact of integrated career curriculum on dysfunctional career thoughts and psychological distress. Further, there is room to explore the ways this curriculum influenced career maturity and academic performance, which was influenced in studies on career courses.

Another finding of this study worth exploring further is the focused code *comparing biosystems engineering using deficit language.* As students compared themselves to their peers in other engineering disciplines, I wondered if other engineering students use comparative language when describing their program, or if they see their specialization in different terms. A study looking at engineering identity across departments would be interesting. The present study has provided detail on the specific experience of biosystems engineering students engaging in a required career curriculum in Design 1, while also illuminating space for further research on adjacent topics.

Conclusion

This study shines light on the value of integrating career development into a biosystems engineering classroom, showcasing the ways in-class career interventions support informed career planning, thoughtful career decision-making, comfort in an uncertain labour market, and the development of the identity of biosystems engineering students. This study provides a grounded theory examination of students' experiences of career supports in the first year of the Biosystems Engineering Program at the University of Manitoba, addressing a gap in the literature and proposing a low-level theoretical model of how students progress in their identity as biosystems engineering students.

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Appendix A

Memoing

A.1: Memo Structure Example

Guiding ideas to reflect on after memoing:

- o Personal and professional meanings of the topic to the researcher
- o Preliminary ideas and expectations of findings
- o New emerging ideas
- o Perspectives and experiences of engineering students
- o Perspectives and experiences of career counsellors, and
- o Perspectives and experiences of researchers in the field
- o My multifaceted roles: what do I notice as a career consultant, research assistant, and master's student

<u>Date memo was written</u>

Title of memo

The body of the memo will go here and will include relevant contextual information (such as what prompted the memo to be written, like a recent interview), related quotes, reflections, and analysis.

A.3: "Cross-a of my Career Narrative to SFT"

- o Personal and professional meanings of the topic to the researcher

Various components of my career narrative can be connected to STF.

- **Chance**: This narrative includes a lot of planning for the future, but that planning is influenced by chance, and those plans do not necessarily come to fruition (i.e., the first journey to university, plans to be a clinical psychologist, and my written career plan). Chance events changed the course of the story, such as joining Peers and volunteering at Career Services, which changed my career trajectory without me understanding at the time how influential they would be.
- **Individual:** This story comes from my perspective as an individual. Notions of who I am as an individual are apparent throughout the story, from my values, my skills, my self-concept, and my knowledge about the world of work.
- **Employment market / Workplace**: Various systems influenced me. From the workplaces I entered and what they were like, to the ways the labour market influenced the opportunities I could access while looking for work.

- **Social system:** Key actors played a critical role in my career. From the friends I made by volunteering, the coworkers I learned from, and the teachers who shared their knowledge with me throughout my career.
- **Time:** Finally, time influences the story. My understanding of who I was at different times in my life is reconstructed and reimagined as I moved forward in my career. Who I was in high school, influenced the way I experienced my first attempt at university. My conception of the future also constantly changed as I moved forward and new experiences influenced my understanding of myself and the world around me.

Appendix B

Field Note Structure

Date of field note

Title if applicable

Observation of event: (State and describe the event)

Body of field note will include:

- Subjective experience
- Social/Cultural influences
- Interpersonal relationships for participant
- Intrapersonal dynamics for participant
- Linkages to systems theory framework
- Possible hunches for ideas pertaining to research questions
    - Central Question: Through exposure to in-class career development supports in a biosystems engineering course, what influences students vocational identity development?
    - Secondary: How do students experience their identity development over time in the course?
    - Secondary: How do students perceive supports and barriers overtime in the course?

Appendix C

C.1: Interview Protocol

2. Tell me how you came to be in biosystems engineering.

3. During Design 1 this year, you met with a professional to talk about their career. Tell me about that experience.

4. What did you understand about biosystems engineering when you came into this class? What do you understand now?

5. How do you imagine your career after graduation when you came into this class? How do you imagine your career after graduation now?

6. What are you doing to prepare for your career future?

7. What was the biggest thing you learned about your career during Fall 2019?

14. What people influenced your career in Fall 2019?

    Follow up: How did they influence you?

15. Walk me through the peaks and troughs of Fall 2019 and Design 1.

    Follow up: What, if anything, got in your way in terms of your career development? What, if anything, helped you be successful?

16. Tell me about your skill development.

17. Tell me about the ways the world around you has influenced your career. You might think about things like the labour market, where you live, or global events.

18. How have events in Design 1 and/or outside of this class impacted your career development?

19. Did any chance events happen to you during Fall 2019? Tell me about that.

20. Is there anything else you'd like to share/you'd like me to know?

C.2: Interview Protocol Aligned with Research Questions

Research Questions	Interview Protocol
Central Question: Through exposure to in-class career development supports in a biosystems engineering course, what influences students vocational identity development?	1. Tell me how you came to be in biosystems engineering. 2. During Design 1 this year, you met with a professional to talk about their career. Tell me about that experience. 3. What did you understand about biosystems engineering when you came into this class? What do you understand now? 4. How do you imagine your career after graduation when you came into this class? How do you imagine your career after graduation now? 5. What are you doing to prepare for your career future? 9. Tell me about your skill development. 12. How have events in Design 1 and/or outside of this class impacted your career development?
Secondary: How do students experience their identity development over time in the course?	2. During Design 1, you met with a professional to talk about their career. Tell me about that experience. 3. What did you understand about biosystems engineering when you came into this class? What do you understand now? 4. How do you imagine your career after graduation when you came into this class? How do you imagine your career after graduation now? 6. What was the biggest thing you learned about your career during Fall 2019? Follow up: How did this influence your understanding of yourself and/or your career? 8. Tell me about your professional development. 9. Tell me about your skill development.
Secondary: How do students perceive supports and barriers overtime in the course?	7. What people influenced your career in Fall 2019? Follow up: How did they influence you?

	8. Walk me through the peaks and troughs of Fall 2019 and Design 1. Follow up: What, if anything, got in your way in terms of your career development? What, if anything, helped you be successful? 10. Tell me about the ways the world around you has influenced your career, if at all. You might think about things like the labour market, where you live, or global events. 13. Did any chance events happen to you during Fall 2019? Tell me about that. Note: this has the potential to emerge from any question.

C.3: Interview Protocol Aligned with STF

Interview Protocol	Connections to STF
1. Tell me how you came to be in biosystems engineering.	This question asks for a career story, which is connected to the narrative components of STF (McMahon et al., 2012).
2. During Design 1 this year, you met with a professional to talk about their career. Tell me about that experience.	This question is asking the participant to reflect on an experience with related to their career development. This reflection is associated with experiential learning theory (Kolb, 2015). Further, this questions asks about the influence of a member of the professional community and therefore the social context described in STF (Patton & McMahon, 2014).
3. What did you understand about biosystems engineering when you came into this class? What do you understand now?	This question connects to the notion of learning changing over time, as is the assumption of STF (Patton & McMahon, 2014). Though the question does not explicitly ask about contextual or systemic factors, the open-ended nature of this question could illicit answers about context and the engineering community. Biosystems engineers themselves could be understood as a community within the social system.
4. How do you imagine your career after graduation when you came into this class? How do you	This speaks to the concept of career development learning as lifelong, recursive, ever-changing process, with

imagine your career after graduation now? 5. What are you doing to prepare for your career future?	perceptions of future in constant flux (Patton & McMahon, 2014)
6. What was the biggest thing you learned about your career during Fall 2019? Follow up: How did this influence your understanding of yourself and/or your career?	Again, this situates career development as a learning process (Kolb, 2015). By following up about influences, it brings the question back to the self as central to career development (Patton & McMahon, 1999).
7. What people influenced your career in Fall 2019? Follow up: How did they influence you?	This question speaks to the social influences on career development, and could illicit responses related to peers, educators, professionals, and other people who have influenced the participants. The use of the word “influence” mirrors language in STF (Patton & McMahon, 2014).
8. Walk me through the peaks and troughs of Fall 2019 and Design 1. Follow up: What, if anything, got in your way in terms of your career development? What, if anything, helped you be successful?	This question asks for a story of highs and lows of the term, which can be understood as barriers and opportunities surrounding the individual (Patton & McMahon, 2019).
9. Tell me about your skill development.	This seeks information about skill, which is a component of the individual in STF (Patton & McMahon, 2014). Further, the notion of “development” eludes to change over time, which is inherent in STF (Patton & McMahon, 2014). This is important to inquire about due to the skills which underpin the concept of engineering identity.
10. Tell me about the ways the world around you has influenced your career, if at all. You might think about things like the labour market, where you live, or global events.	This question is asking about the environmental-societal system (Patton & McMahon, 2014).

11. How have events in Design 1 and/or outside of this class impacted your career development?	Again, this looks at the system of the school and the broader context, inquiring about the ways these systems influenced the individual (Patton & McMahon, 2014).
12. Did any chance events happen to you during Fall 2019? Tell me about that.	This question is linked to the notion of chance in STF (Patton & McMahon, 2014).
13. Is there anything else you'd like to share/you'd like me to know?	This is an open-ended question that could prompt participants to share a variety of stories or details with the interviewer.

C.4: Demographic Information

Age: ___________________

Gender: _________________

Are you an international or domestic student? *Domestic students are a Canadian citizen or permanent resident, or have Refugee/Protected Persons Status.*

International student ❐

Domestic student ❐

Please briefly outline your work and volunteer history:

Appendix D

Recruitment Scripts

H.1 *The following script will be used by the Research Assistant (e.g. Rebecca Balakrishnan) in the biosystems classes to invite students to participate in the research study and share the letter of informed consent. The PI, Dr. Jillian Seniuk Cicek, all instructors for the courses, and all teaching assistants will be asked to leave the room before the announcement.*

Hi everyone. My name is Rebecca Balakrishnan and I am Dr. Seniuk Cicek's/Jill's research assistant. I am working on my Master of Education in counselling psychology. As you have probably already noticed on the syllabus, career development is being integrated into this class. We are working on a longitudinal study to understand how biosystems students experience in-class career development in their curricula in the Biosystems Design Spine to improve career and engineering education. Specifically, we want to better understand how your career development life stories evolve, how you develop professionally, and how your personal development as a student impacts your professional/vocational development over the course of your biosystems program (approximately 3 – 4 years), and one year after you graduate. To understand this, after your course is complete, your grades are entered, and the appeal period is over, I would like to look at your coursework from this course (Design 1), (and eventually Design 2, 3 and 4!) and conduct an individual interview with you, where I would ask you questions about your career development over the term. Participating in this study is not a requirement of this course.

Since Dr. Seniuk Cicek/Jill has a conflict of interest as your professor, I will be doing the analyses of your coursework and conducting all the interviews throughout your program. Dr. Seniuk Cicek/Jill – and Dr. Mann – will not know whether or not you decided to share your coursework or who participates in the individual interviews until after you graduate from the Biosystems program.

I am handing out the informed consent letter, which has more detail about what the study is about. I would love it if you take some time to read it over and consider participating.

I am going to give you a few minutes to read this over.

Do you have any questions?

I will be here at your next class to answer any questions you may have about the study (if you prefer to contact me individually, my phone number and email are on the letter) and to collect the forms. If you are interested in letting me analyze your coursework for this class and/or participating in an interview, please sign your agreement to participate on the last page. To keep who does and does not participate in the study more private, I will collect the forms from everybody when I return the next class, whether you have signed it or not.

Thanks for your time, everyone! I hope that you'll seriously consider participating.

H.2 *The following script will be used by the Research Assistant (e.g. Rebecca Balakrishnan) as a follow-up to the above script in the following class. Again, the PI, Dr. Jillian Seniuk Cicek, all instructors for the courses, and all teaching assistants will be asked to leave the room before the announcement.*

Hi everyone. I hope everyone took the time to consider if you would like to participate in this study. Does anyone need another copy of the informed consent? Does anyone have any questions?

I am going to collect the forms. Please do not hesitate to contact me if you have any further questions.

I will sort through these forms when I get back to my office. I will scan the forms of those of you who agreed to participate in this study, and will email you a copy of your Informed Consent.

Thank you so much for your interest in this study!

H.3 *The following email script will be used by the Research Assistant (e.g. Rebecca Balakrishnan) as a follow-up to the above script. It will be sent to all consenting participants. A scanned copy of their signed informed consent will be attached to the email.*

Dear [student's name],

Thank you so much for agreeing to participate in this study! Please find a scanned copy of your signed Informed Consent, and a copy of the Interview protocol. I will be in touch in the Winter/Summer 2020/2021/2022 term to arrange an interview with you.

Please don't hesitate to email or phone me if you have any questions.

All the best,

Rebecca Balakrishnan

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Appendix E

Letter of Informed Consent

C.1 Letter of Informed Consent for Coursework Analysis and Individual Interviews with BIOE 2900/BIOE 3900/BIOE 4900/BIOE 4950 students

[original on U of M Price Faculty of Engineering letterhead]

Informed Consent for Coursework Analysis and Individual Interviews

Research Project Title: "Assessing the Integration of Career Development into Biosystems Engineering"

Principal Investigator and contact information: Jillian Seniuk Cicek
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[Date]

Dear Biosystems Student:

You are being invited to participate in a research study investigating student experiences in your Biosystems Design courses, which will include career development components. You are being asked to participate because you are currently enrolled in BIOE 2900/BIOE 3900/BIOE 4900/BIOE 4950.

I am the Principle Investigator for this study, but to ensure your participation does not conflict with your position as my student, my Research Assistant, Rebecca Balakrishnan, a Master of Education student in Counselling Psychology, is carrying out the data collection and analysis. Dr. Priya Mani, Associate Professor in the Faculty of Education, and Rebecca's thesis co-advisor, is also consulting on this phase of the study (2019–2020).

The study seeks to understand how you experience your career development as a Biosystems engineering student in BIOE 2900/BIOE 3900/BIOE 4900/BIOE 4950. Your participation includes a review of your coursework by Rebecca, and/or an individual interview with you, conducted by Rebecca. This letter, a copy of which will be left with you, will explain the study and invite you to give your written informed consent to participate.

If you have any questions or would like more detail, please feel free to ask.

The purpose of this study is to understand the experiences of students taking a required Biosystems engineering course with integrated career development activities. Specifically, the study is designed to examine how students' career development life stories evolve, how students develop professionally, and how students' personal development impacts their professional/vocational development throughout the course. The findings will inform the design and improvement of career and engineering education.

Should you agree to participate, your participation will involve one or both of the following:

1. **Granting permission to the researchers to assess your coursework, and use the work as a source of data for this study.** The coursework will be used to understand your perspectives, your career story, and your experiences in the BIOE 2900/BIOE 3900/BIOE 4900/BIOE 4950 course.

2. **One individual interview of approximately one hour with Rebecca.** The interview will be scheduled for winter 2020 with details on date/time/location to follow. The conversation during the interview will focus on your career development journey, your evolving identity as a biosystems engineering student, and your skill development.

Conflict of Interest

Dr. Jillian Seniuk and Dr. Danny Mann, or any other Biosystems engineering professor will not know whose coursework will be reviewed as part of this study until you have graduated from the Biosystems engineering program. The teaching assistant will sign an Oath of Confidentiality, and provide the coursework to Rebecca for analysis once final grades have been entered and the appeal period is over.

Dr. Jillian Seniuk Cicek and Dr. Danny Mann or any other Biosystems engineering professor will not know who participates or does not participate in the individual interviews and who said what in the individual interviews.

Student Work

If you consent to let Rebecca review your coursework, Rebecca will photocopy your work and black-out all personal identifying information, including your name. You will be assigned a number or a pseudonym for the duration of the study. Only this new copy will be analyzed by the research team.

There is no compensation for sharing your coursework with the researchers.

Individual Interview

Interviews are discussions designed to gather perceptions on the experiences of individuals who are able to share insight about a topic of interest. The purpose of the individual interview is to better understand the story of your career journey as a Biosystems engineering student.

If you consent to an individual interview, it would be conducted at the University of Manitoba campus at a time suitable for you. Rebecca Balakrishnan would interview you, following a semi-structured interview style typical of qualitative research. A prepared list of open-ended questions, which you will be given prior to the interview, will be used to guide the conversation.

The interview will be audiotaped and later transcribed by a member of the research team, who will also remove any information that could identify you, replacing your name with a letter or number or pseudonym. Once the interview is transcribed, the audiotape will be securely destroyed. Your identity as a participant in the interview will be kept confidential. You will be invited to review the transcript and correct, clarify, or add to the story within the transcript. Rebecca will make revisions to the transcript based on your comments. Only members of the research team will have access to the de-identified data.

Participants who attend the individual interviews will receive a $25 gift card. If you withdraw your consent at the beginning or during the interview, you are still encouraged to keep the gift card.

Ideally, we would like 5 - 8 students agree to participate in an individual interview.

Dissemination

Direct quotes from your coursework and/or your interview may be included in the findings that could be shared in Rebecca's Master/PhD thesis, in published journal articles, or at conference presentations. Data from the study may also be presented to the Biosystems Department during Department council or retreats, and will be used for accreditation documentation. Your name will not be included in the results; only a number or pseudonym will be used. The quote would be attached to a pseudonym or a general descriptor such as "one student" or "student 3." The data will be cleaned of all identifying information.

Confidentiality

A letter, number or pseudonym, and not your name, will be used to identify you within the study to ensure your confidentiality. In all findings based on this study, information that could identify you will be removed from all quotations and paraphrases. The master list that links your name to your letter, number or pseudonym will be kept in a locked file in a locked office, stored separately from the rest of the data from the study, so your confidentiality will be protected, and will be destroyed within 2 years of this study completion.

All the data, including the master list, and the coursework, audiotapes of the individual interviews and the interview transcripts will be kept by the research team in two separate locked, secure locations that meet University of Manitoba's Education/Nursing Research Ethics Board standards.

Withdrawal

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in this research study and agree to participate in the study for this year. You will be asked each year, for the next 3 years, for your consent to participate in order that your potential continued participation is informed. In no way does your consent to participate waive your legal rights nor release the researcher, sponsors, or involved institutions from their legal and professional responsibilities. You are free to refrain from answering any questions during the interview you prefer to omit, and/or to withdraw from the study at any time, without penalty, prejudice or consequences by contacting Rebecca or me via email, mail or phone. If you choose to withdraw, all of your data, including coursework, your interview transcripts, your contact information and your letter of consent will be removed from the study and destroyed. If your data has already been analyzed or disseminated, your individual data and contact information will still be destroyed, but we will not be able to remove your contribution to the study up to the date of your withdrawal.

Your continued participation should be as informed as your initial consent, so feel free to ask for clarification or new information throughout your participation. Our contact information is as follows:

Jillian Seniuk Cicek
333 SPEB, 97 Dafoe Road
University of Manitoba, Winnipeg, Manitoba, Canada R3T 5V6
Tel 204-474-9698 Email Jillian.SeniukCicek@umanitoba.ca

Rebecca Balakrishnan
474 University Centre
University of Manitoba, Winnipeg, Manitoba R3T 2N2
Tel 204 474 8970 E-mail Rebecca.Balakrishnan@umanitoba.ca

This research has been approved by the Education/Nursing Research Ethics Board. If you have any concerns or complaints about this project, you may contact the above-named persons or the Human Ethics Coordinator at 474-7122, or e-mail humanethics@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

Sincerely,

Jillian Seniuk Cicek

Please sign below to indicate your informed written consent to participate in this study.

Please sign ALL the options that you agree to participate in.

Option #1: I consent to allowing the co-investigator to **assess my coursework** from BIOE 2900/BIOE 3900/BIOE 4900/BIOE 4950.

____

Participant's Full Name

____

Participant's signature Date

____

Researcher's signature Date

Option #2: I consent to participate in the **individual interview**.

Contact Information to arrange Interview: ___________________________________

____

Participant's Name Phone Number

____

Email

____

Participant's signature Date

____

Researcher's signature Date

To receive a summary of the results of this study, please fill out this section:

I would like to receive the summary as an

E-mail attachment to the following e-mail address: ___________________________________

The summary of the results will be provided by August 2020, approximately.

Appendix F

Oaths of Confidentiality

F.1 Oath of Confidentiality for Research Assistant(s)

I agree to hold the privacy and identity of all participants in this study, **"Assessing the Integration of Career Development Activities in Biosystems Engineering,"** in confidence, and will not discuss identity details with anyone for the duration of this study. I agree to return and/or securely destroy any identifiable data that have been kept by/sent to me for checking and/or analyses as soon as these data are no longer needed by me, at the end of my time as a research assistant, or at the end of the study, whichever comes first.

Date: ____

Name of **Research Assistant** (Print):

____

Signature of **Research Assistant**:

____

F.2 Oath of Confidentiality for Teaching Assistant(s)

I agree to hold the privacy and identity of all participants in this study, **"Assessing the Integration of Career Development Activities in Biosystems Engineering,"** in confidence, and will not discuss these details with anyone but the Research Assistant, (i.e., Rebecca Balakrishnan). I agree to return and/or securely destroy any identifiable data that have been sent to/kept by me as soon as these data are no longer needed by the Research Assistant(s).

Date: ____

Name of **Teaching Assistant** (Print):

____

Signature of **Teaching Assistant**:

____

F.3 Assurance of Confidentiality to Interview Participants

This standard text will be used for all interviews. The Research Assistant will read or paraphrase the following:

Thank you for agreeing to participate in this study. Everything you say will be held in confidence. The purpose of this interview is to understand how you experienced your career development as a Biosystems engineering student in BIOE 2900. The conversation during the interview will focus on your career development journey, your evolving identity as a Biosystems engineering student, and your skill development. The questions have been designed to explore these areas. The goal is to see our time together as a relaxed conversation and not a structured question-and-answer period. You are free to withdraw any of your comments or withdraw completely from this study at any time without penalty, prejudice or consequences, and you are under no obligation to answer any of the questions. The interview will be audiotaped using a Sony recorder. The audiotape will be transcribed by me, or by a transcriber. We have both signed a Pledge of Confidentiality. When I summarize the audiotape and report the results of the study, I will use a letter, number, or pseudonym to identify you, and will not use any quotations that would identify you specifically. After I have transcribed the audiotape, the transcript will be returned to you for your review, and the audiotape will be securely destroyed. As mentioned earlier, all comments you provide during the interview will be held in confidence. Dr. Seniuk Cicek, [name of Design instructors], and all Biosystems/U of M Faculty and staff will not know your identity. As well, I ask that you agree to also hold what is said during this interview by you in confidence, and that you do not discuss this interview outside of this session, and that any transcripts that have been sent to you for member checking are returned to me and/or securely destroyed once you have reviewed them. Do you have any questions about these procedures?

Appendix G

Letter seeking approval of the Dean of Engineering to approach students and recruit them for this study

Date of Email: October 14, 2019

Email Sent to:
Dr. Jonathan Beddoes
Professor and Dean
Price Faculty of Engineering
E2-290 Engineering & Information Technology Complex
University of Manitoba, Winnipeg, MB R3T 5V6 Canada
Phone: 204-474-9809 Fax: 204-275-3773
dean_engineering@umanitoba.ca

Cc'ed: Dr. Jillian Seniuk Cicek & Dr. Danny Mann

Subject of Email: Request for approval for a longitudinal study in Biosystems Engineering

Dear Dr. Beddoes,

I am writing to request your approval for a longitudinal study I would like to conduct within the Biosystems Design courses, which is a step required for ethics approval by the Education / Nursing Research Ethics Board (ENREB). I am the Research Assistant supporting this study. I have cc'ed my Principle Investigator and one of the professors of the course, Dr. Jillian Seniuk Cicek, as well as the other professor for the course, Dr. Danny Mann, who have already given their approval for the study.

The purpose of this study is to explore the experiences of Biosystems engineering students taking required design courses integrated with career development activities to improve career education and engineering education. Specifically, the study's objectives are to understand students' experience of the career planning process as they clarify who they are as professionals, understand their skills, understand what a Biosystems engineer is, and understand their possible career futures, and to assess the impact of career development activities/interventions within the Biosystems Design courses.

This will be longitudinal study that will take place over a 4 year period, where one cohort of students will be followed through the following courses: BIOE Design 1 (first year of Biosystems program); BIOE Design 2 (second year of Biosystems program); BIOE Design 3 and 4 (third year/last year of Biosystems program); and 1 year after graduation.

Research questions:

> Central Question: How does students' career development evolve through exposure to in-class career development interventions?
>
> Secondary: What changes do students experience in their career development over time in the course?
>
> Secondary: What changes do students experience in their identity development over time in the course?
>
> Secondary: What strategies do students use to develop their engineering identity?
>
> Secondary: What strategies do students use to develop their broader identity?
>
> Secondary: What challenges did students experience in relation to their career development within the course?

Please find attached the copy of the ethics application, which details the project as well as ethical considerations and precautions.

Please let me know if you have any questions. Thank you for your time and attention.

Sincerely,

Rebecca Balakrishnan
Research Assistant, Price Faculty of Engineering
Master of Education Student, Counselling Psychology, Faculty of Education
Career Consultant, Career Services
474 University Centre
University of Manitoba
Winnipeg, MB R3T 2N2
Tel: 204.474.8970
rebecca.balakrishnan@umanitoba.ca

Pronouns: she / her

The University of Manitoba campuses are located on original lands of the Anishinaabeg, Cree, Oji-Cree, Dakota, and Dene peoples, and on the homeland of the Métis Nation.

H.2 Approval from Dean of Engineering to approach students and recruit them for this study

Date of Email: October 15, 2019

Email from:
Dr. Jonathan Beddoes

Professor and Dean
Price Faculty of Engineering
E2-290 Engineering & Information Technology Complex
University of Manitoba, Winnipeg, MB R3T 5V6 Canada
Phone: 204-474-9809 Fax: 204-275-3773
dean_engineering@umanitoba.ca

To: Rebecca Balakrishnan

Cc'ed: Dr. Jillian Seniuk Cicek & Dr. Danny Mann

Subject of Email: Request for approval for a longitudinal study in Biosystems Engineering

Rebecca,

I approve of this study. Please proceed with the ENREB approval.
If you need anything further from me, just let me know.

Regards,
Jonathan Beddoes

Appendix H

TCPS 2: CORE Certificate

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

Rebecca Balakrishnan

has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)

Date of Issue: **16 April, 2018**

Appendix I

Ethics Approval and Amendments

UNIVERSITY OF MANITOBA | Research Ethics and Compliance

Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Email: humanethics@umanitoba.ca

PROTOCOL APPROVAL

TO: **Jillian Seniuk Cicek**
Principal Investigator

FROM: **Zana Lutfiyya, Chair**
Education/Nursing Research Ethics Board (ENREB)

[redacted]

Re: **Protocol #E2019:064 (HS23057)**
Assessing the Integration of Career Development Activities in Biosystems Engineering

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Effective: October 21, 2019 **Expiry:** October 21, 2020

Education/Nursing Research Ethics Board (ENREB) has reviewed and approved the above research. ENREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.*

This approval is subject to the following conditions:

1. Approval is granted for the research and purposes described in the application only.
2. Any modification to the research or research materials must be submitted to ENREB for approval before implementation.
3. Any deviations to the research or adverse events must be submitted to ENREB as soon as possible.
4. This approval is valid for one year only and a Renewal Request must be submitted and approved by the above expiry date.
5. A Study Closure form must be submitted to ENREB when the research is complete or terminated.
6. The University of Manitoba may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans*.

Funded Protocols:

- **Please e-mail a copy of this Approval, identifying the related UM Project Number, to the Research Grants Officer at researchgrants@umanitoba.ca**

Research Ethics and Compliance is a part of the Office of the Vice-President (Research and International)
umanitoba.ca/research

UNIVERSITY OF MANITOBA | Research Ethics and Compliance

Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Email: humanethics@umanitoba.ca

AMENDMENT APPROVAL

December 2, 2019

TO: **Jillian Seniuk Cicek**
Principal Investigator

FROM: **Zana Lutfiyya, Chair**
Education/Nursing Research Ethics Board (ENREB)

[redacted]

Re: **Protocol #E2019:064 (HS23057)**
Assessing the Integration of Career Development Activities in Biosystems Engineering

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Education/Nursing Research Ethics Board (ENREB) has reviewed and approved your Amendment Request received on **November 07, 2019** to the above-noted protocol. ENREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.*

This approval is subject to the following conditions:

1. Approval is given for this amendment only. Any further changes to the protocol must be reported to the Human Ethics Coordinator in advance of implementation.
2. Any deviations to the research or adverse events must be submitted to ENREB as soon as possible.
3. Amendment Approvals do not change the protocol expiry date. Please refer to the original Protocol Approval or subsequent Renewal Approvals for the protocol expiry date.

Appendix J

Overview and Critique of the Literature

Identity

Category	Author, year, and title	Country of the study	Purpose of the study	Sample size	Gender	Age of participants	Critique of the methodology used	Key study results
Identity	Marcia, J.E. (1966). Development and validation of ego-identity status. Journal of Personality and Social Psychology, 3, 551–558. http://dx.doi.org/10.1037/h0023281.	USA	to define and validate ego-identity	86	male	unknown - college students	no gender diversity (and likely there are other diversity issues since this was published in 1966)	Identified people as high or low in crisis and commitment, generating 4 statuses: achievement, foreclosrure, moratorium, diffusion. Created a model for identity formation, expanding on Erikson.
Identity	Crocetti, E., Rubini, M., & Meeus, W. (2008). Capturing the dynamics of identity formation in various ethnic groups: Development and validation of a three-dimensional model. Journal of Adolescence, 31, 207–222. http://dx.doi.org/10.1016/j.adolescence.2007.09.002.	Italy	add a third dimension to identity	1952	diverse	early & middle adoles	does not account for the impact of relational factors, it only demonstrates a point in time and not longitudinal information	added to Marcia's model, depicting a model of continuous, cyclical revision as required: individuals undergo identity formation and maintenance (they explore and make choices based on knowledge of self) and also engage in reconsideration of commitment (engaging in further consideration and choice if the current choice is not fitting).This model keeps the exploration and commitment aspects of the four identity statuses and adds reconsideration.

Identity	Crocetti, E., Scrignaro, M., Sica, L., & Magrin, M. (2012). Correlates of Identity Configurations: Three Studies with Adolescent and Emerging Adult Cohorts. Journal of Youth and Adolescence, 41(6), 732–748. https://doi.org/10.1007/s10964-011-9702-2	Italy	examine the correlates of identity instability / stability in adolescents and emerging adults	1000 + Per study	boys & girls (more girls)	43798	self-report limitations, looked at current point in time not longitudinal	"participants experiencing a condition of identity stability in both domains reported a better profile than their peers displaying a condition of instability in both realms. Further, individuals with identity stability only in one domain reported intermediate scores"
Career Identity	Laughland-Booÿ, J., Newcombe, P., & Skrbiš, Z. (2017). Looking forward: Career identity formation and the temporal orientations of young Australians. Journal of Vocational Behavior, 101, 43–56. https://doi.org/10.1016/j.jvb.2017.04.005	Australia	"to undertake a qualitative exploration of the associations between young people's career identity development, their time perspective, and their expectations for the future."	28		16 & 22		
Vocational Identity	Leung, A. (1998). Vocational identity and career choice congruence of gifted and talented high school students. Counselling Psychology Quarterly, 11(3), 325–335. https://doi.org/10.1080/09515079808254064	USA	to determine the relationship between vocational identity and congruent career choices	136 male and 230 female	male & female	juniors in high school	They only looked at congruence in terms of Holland's model - did not include other factors such as values	"Vocational identity was related to college major choice congruence, but not to career choice congruence"
Vocational Identity	Hirschi, A. (2011). Vocational identity as a mediator of the relationship between core self-evaluations and life and job satisfaction. Applied Psychology, 60(4), 622–644. https://doi.org/10.1111/j.1464-0597.2011.00450.x	Germany	to determine whethere vocational identity is related to self evaluations, career, well-being, job satisfaction	310	male & female	13 to 17	self-report, convenience samples	"vocational identity related positively to lifesatisfaction but that this relationship disappeared once core self-evaluationswere controlled"

Identity	Johnson, J., Smither, R., Holland, J., & Osipow, S. (1981). Evaluating Vocational Interventions: A Tale of Two Career Development Seminars. Journal of Counseling Psychology, 28(2), 180–183. https://doi.org/10.1037/h0077971	USA	to determine if a career development seminar impacted vocational identity	29	mostly males		no validity or reliability mentioned for the assessments used to quantify the results, not all students took all seminars, interviewed students who were not impacted by the seminar but did not interview students who were impacted	Students' vocational identity increased significantly overall. No interactions were found between student characterisitcs and vocational identity changes.
Emerging Adulthood	Keniston, K. (1971). Youth and dissent: The rise of a new opposition. New York: Harcourt Brace Jovanovich		Outline a theory for youth culture in relation to social movements and dissent in the mid 20th century				Arnett argues that the term "youth" is confusing to refer to young adults	
Emerging Adulthood	Levinson, D. J. (1978). The seasons of a man's life. New York: Ballantine.	USA	To examine the development of men across the lifespan	40	male only	35-45	Only men were interviewed	Daniel Levinson's (1978) book examines development in adulthood based on the life stories of 40 adult men, suggesting distinct stages of life spanning from early adulthood to the settling down period to mid-life and the start of middle adulthood.
Engineering identity	e, N., Martins, L., Borrego, M., & Kendall, M. (2019). Professional Aspects of Engineering: Improving Prediction of Undergraduates' Engineering Identity. Journal of Professional Issues in Engineering Education and Practice, 145(3). https://doi.org/10.1061/(ASCE)EI.1943-5541.0000413	USA	Find predictors of engineering identity beyond academic factors	1536	male and female	undergraduate students	Survey, pearson correlation, and linear regression - only looked at 2 universities	Engineering competence, interest, and recognition, as well as tinkering, analysis, and design can also predict engineering identity development (Choe et al., 2019).

Engineering identity	Danielak, B., Gupta, A., & Elby, A. (2014). Marginalized identities of sense-makers: Reframing engineering student retention. Journal of Engineering Education, 103(1), 8–44. https://doi.org/10.1002/jee.20035	USA	To understand why a student stays in or leaves engineering	1	male	undergraduate student	Case study - gives a very vivid story of only one student	Identity was an important factor in determining if he stay or leave engineering
Engineering identity	Morelock, J. (2017). A systematic literature review of engineering identity: definitions, factors, and interventions affecting development, and means of measurement. European Journal of Engineering Education, 42(6), 1240–1262. https://doi.org/10.1080/03043797.2017.1287664	USA, UK, Australia, Sweden, Greece, Denmark, Netherlands	To understand and organize studies on engineering identity based on definitions, factors influencing development, interventions, and measures	46 studies	male & female		Screening led to more conference papers than journal papers	1. Engineering identity develops based factors such as group membership, gender, academics, and occupational identities; 2. Engineering identity can be framed as a personal perception of oneself as an engineer; 3. Engineering identity can be understood as a personal perception of oneself as an engineer; 4. Engineering identity stems from one's responsibilities and actions (Morelock, 2017).
Engineering identity	Murphy, M. Chance, S. & Conlon, E. (2015). Designing the identities of engineers. In Christensen, S., Didier, C., Jamison, A., Meganck, M., Mitcham, C., & Newberry, B. (2015). Engineering identities, epistemologies and values engineering education and practice in context (Volume 2). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-16172-3	Ireland	To compare and uncover the identities of engineering and engineering technology students	interviews: 7, survey: 153			No mention of the type of thematic analysis followed for any of the qualitative analysis, only faculty were interviewed not students (imposing opinions of faculty on the student identities)	The findings suggest that engineering identities are design-oriented, career-oriented, and there is a sense of commonality of identity among the engineering students. Tehcnologists had less defined identities.

Experiential Learning

Category	Author, year, and title (APA format)	Country of the study	Purpose of the study	Sample size	Gender	Age	Critique of the methodology used	Key study results
Experiential Learning	Tiessen, R., Grantham, K., Cameron, J., Cowley, S., & Sá, C. (2017). The Relationship Between Experiential Learning and Career Outcomes for Alumni of International Development Studies Programs in Canada. Canadian Journal of Higher Education, 48(3), 23–42. https://doi.org/10.7202/1057127ar	Canada	" (1) What do IDS alumni consider important experiential learning opportunities? and (2) What is the perceived relationship between experiential learning and career outcomes? "	1901			survey	"Overwhelmingly, IDS graduates perceive experiential learning as beneficial for furthering their knowledge learned in the classroom, developing new skillsets, and networking with potential employers."
Eng ed - employability	Winberg, C., Bramhall, M., Greenfield, D., Johnson, P., Rowlett, P., Lewis, O., … Wolff, K. (2018). Developing employability in engineering education: a systematic review of the literature. European Journal of Engineering Education, 1–16. https://doi.org/10.1080/03043797.2018.1534086	International	A systematic review of the literature to determine "Which curricular and pedagogical arrangements promote engineering students' employability"					
Co-op	Ferguson, S., & Wang, S. (2014). Graduating in Canada: Profile, labour market outcomes, and student debt of the class of 2009-2010 - revised, Section 3 Co-operative education. Statistics Canada. Retrieved from https://www150-statcan-gc-ca.uml.idm.oclc.org/n1/pub/81-595-m/2014101/section03-eng.htm	Canada	Determine outcomes of Canadian college and university graduates, including those who did co-op	59467	representative		This is a huge Statisitics Canada study, though it would run into self-report limitations	co-op was correlated with more related employment, higher pay, and more fulltime work
Experiential learning - eng	Gadola, M., & Chindamo, D. (2017). Experiential learning in engineering education: The role of student design competitions and a case study. International Journal of Mechanical Engineering	Italy	Case study looking at experiential learning of an	20			case study - only surveyed students and told own personal	Students described their experience using words like passion,

	Education, 47(1), 3–22. https://doi.org/10.1177/0306419017749580		engineering design team				experience of the team as opposed to hearing it from the students. Analysis was a simple word count.	collaboration, and learning
Experiential learning - higher ed	Astin, A., Vogelgesang, L., Ikeda, E., Yee, J. (2000). How service learning affects students. Higher Education Research Institute, UCLA. Retrieved from https://heri.ucla.edu/PDFs/HSLAS/HSLAS.PDF	USA	To determine how service learning in and outside the classroom impacts students academically and personally	22236			Dependant measure was standardized test score - these types of assessments have been criticized	Service learning linked to higher academic performance and transferable skills
Experiential learning - eng	Abdulwahed, M., & Nagy, Z. (2009). Applying Kolb's Experiential Learning Cycle for Laboratory Education. Journal of Engineering Education, 98(3), 283–294. https://doi.org/10.1002/j.2168-9830.2009.tb01025.x	UK	To apply experiential learning cycle to an enginineering lab and to find ways to improve learning	70			Students not in the experimental group had access to the training materials, so more high achieving students were self-selected out of the control group	
Experiential learning - eng	Li, H., Öchsner, A., & Hall, W. (2019). Application of experiential learning to improve student engagement and experience in a mechanical engineering course. European Journal of Engineering Education, 44(3), 1–11. https://doi.org/10.1080/03043797.2017.1402864			unstated - one class	unstated	unstated	This study is practitioner research on a course as opposed to a specific, rigorous study with controls	
Experiential learning - eng	Chen, W., Shah, U., & Brechtelsbauer, C. (2016). The discovery laboratory - A student-centred experiential learning practical: Part 1 - Overview. Education for Chemical Engineers, 17, 44–53. https://doi.org/10.1016/j.ece.2016.07.005	UK	To explain how experiential learning was implemented in a course and how it was perceived by				This study is practitioner research on a course as opposed to a specific,	

			students and teachers				rigorous study with controls	
Experiential learning - eng	Giridharan, K., & Raju, R. (2016). The Impact of Experiential Learning Methodology on Student Achievement in Mechanical Automotive Engineering Education. International Journal Of Engineering Education, 32(6), 2531–2542.	India	Experiment on how experiential learning methods impact grades, attendance, and employability	144	12 women	20-22	Different instructor for traditional vs. experiencial class	

Career Course

Category	Author, year, and title (APA format)	Country of the study	Purpose of the study	Sample size	Gender	Age	Critique of the methodology used
Career course	Reese, R., & Miller, C. (2006). Effects of a University Career Development Course on Career Decision-Making Self-Efficacy. Journal of Career Assessment, 14(2), 252–266. https://doi.org/10.1177/1069072705274985	USA	"The purpose of this study was to assess the efficacy of a career development course for students who were undecided on a major or wanted to change or confirm their major"	96	male & female	median age 19.5	participants self-selected into the two courses being compared, which could impact the findings (no random assignment), small sample size
Career course	Scott, A., & Ciani, K. (2008). Effects of an Undergraduate Career Class on Men’s and Women’s Career Decision-Making Self-Efficacy and Vocational Identity. Journal of Career Development, 34(3), 263–285. https://doi.org/10.1177/0894845307311248	USA	to determine if a career development course was an effective in improving	88	men & women	M = 19.18	95% of participants were caucasian, no control group, hard to say if vocational

			student vocational identity and career decision-making				identity changes were due to maturation or course
Career course	Joy, R., Shea, R., & Youden-Walsh, K. (2015). Meeting the challenge of work and life using a career integrated learning approach. Proceedings of the 2015 Atlantic Universities' Teaching Showcase, 19, 76-79.	Canada	to determine if integrated employability language into a course was beneficial to students	450	not reported	not reported	Not a scholarly study - only a report and survey of an experience
Career course	Tuffley, D., & Antonio, A. (2013). First year engagement & retention: A goal-setting approach. Journal of Information Technology Education: Innovations in Practice, 12, 239-251. Retrieved from http://www.jite.org/documents/Vol12/JITEv12IIPp239-251Tuffley0362.pdf	Australia	to determine if the integration of career development into a course was benefitial to students	258	90% male		no baseline to compare progress against, interventions not based in broader career development context
Career course	Thomson, A. (2010). Embedding an online career development program into student learning. Australian Journal of Career Development, 19(3), 6–14. https://doi.org/10.1177/103841621001900303	Australia	to explain the process of developing a career development course for use in post-secondary classrooms	n/a			This is not a scholarly study, but a description of how a program was developed and used in a university
Career course	Folsom, B., & Reardon, R. (2003). College Career Courses: Design and Accountability. Journal of Career Assessment, 11(4), 421–450. https://doi.org/10.1177/1069072703255875	USA	To locate existing career courses in				

			American universities				
Career course	Osborn, D., Howard, D., & Leierer, S. (2007). The effect of a career development course on the dysfunctional career thoughts of racially and ethnically diverse college freshmen.(Effective Techniques). Career Development Quarterly, 55(4), 365–377. https://doi.org/10.1002/j.2161-0045.2007.tb00091.x	USA	To explore the impact of a career development course in dysfunctional beliefs and to examine relationships with gender and race/ethnicity	158	117 women , 41 men	17-20	no control group
Career course	Taylor, L. D. (2009). Undecided students and career exploration courses. Studia Universitatis Babes-Bolyai - Psychologia-Paedagogia, 54(20), 29-40.	USA	impact of career course on dysfunctional career thoughts				no control group
Career course	Belisle, R. H. (2005). Student psychological distress in a career exploration course (Published doctoral dissertation). Brigham Young University-Provo, USA. Retrieved from https://scholarsarchive.byu.edu/cgi/viewcontent.cgi?article=1572&context=etd	USA	dissertation - to see if a career course reduced psychological distress	127	male & female	18-27	small size of clinical group, not much diversity
Career course	Roberts, P. K. (2004). Perceived changes in career decidedness following completion of a for-credit career class (Published doctoral dissertation). University of Northern Colorado, USA.	USA	dissertation - to see if a career course increased career decidedness	796	male & female	majority 18-19	no control group
Career course	Gallo, J., & Roberts, T. (2019). College Students’ Career Decision-making and Career Decision-making Self-efficacy: a Case Study in Formative Assessment and Course Design. Journal of Formative	USA	impact of career course on self-	64	male & female	unknown	no control group, convenience sample

	Design in Learning, 3(1), 88–95. https://doi.org/10.1007/s41686-019-00032-3		efficiacy / decision-making				
Career course	Folsom, B., Peterson, G., Reardon, R., & Mann, B. (2005). Impact of a Career Planning Course on Academic Performance and Graduation Rate. Journal of College Student Retention, 6(4), 461–473. https://doi.org/10.2190/4WJ2-CJL1-V9DP-HBMF	USA	impact of career course on time to graduate, credit hours taken, withdrawls from courses, GPA	544	male & female		couldn't control for some possible issues because it was archival data