Self Authorship and Reflective Practice in an Innovation Minor

Chris Gewirtz, Virginia Polytechnic Institute and State University

Chris Gewirtz is PhD student in Engineering Education at Virginia Tech. His research interests start with how culture, history and identity influence assumptions made by engineers in their practice, and how to change assumptions to form innovative and socially conscious engineers. He is particularly interested in humanitarian engineering, where American engineering assumptions tend to fall apart or reproduce injustice.

Dr. Lisa D. McNair, Virginia Polytechnic Institute and State University

Lisa D. McNair is an Associate Professor of Engineering Education at Virginia Tech, where she also serves as co-Director of the VT Engineering Communication Center (VTECC) and CATALYST Fellow at the Institute for Creativity, Arts, and Technology (ICAT). Her research interests include interdisciplinary collaboration, design education, communication studies, identity theory and reflective practice. Projects supported by the National Science Foundation include exploring disciplines as cultures, liberatory maker spaces, and a RED grant to increase pathways in ECE for the professional formation of engineers.

Kirsten A. Davis, Virginia Polytechnic Institute and State University

Kirsten is a PhD student in Engineering Education at Virginia Tech, where she also completed her master's degree in Higher Education. She has previously worked in industry in the field of IT analytics and has experience with corporate recruiting. Her primary research interests are engineering study abroad, developing intercultural competency in engineering students, and international higher education.

Mr. Ramon Benitez, Virginia Polytechnic Institute and State University

Ramon Benitez is interested in how engineering identity and animal participatory design can be used to recruit Chicano K-12 students to engineering professions. Benitez completed his BS in Metallurgical and Materials Engineering at the University of Texas at El Paso (UTEP), and is now a Ph.D. student in Engineering Education at Virginia Tech (VT). Benitez seeks to understand how to best instruct and assess ethical reasoning of engineering practices and engineering responsibilities, including wildlife and humanity, in our definitions of public good.

Self-Authorship and Reflective Practice in an Innovation Minor

Abstract

This project describes a minor in Innovation that is being introduced in an engineering department as a part of a new general education curriculum initiative. The minor connects three existing courses from different colleges to form the core course sequence. The theories of self-authorship[1] and reflective practice[2] served as guiding principles for an ethnography of each of the classes. These theories are meaningful to students of many disciplines, are relevant to the development of innovators, and have implications for the future design and effectiveness of the minor. Furthermore, the structure of the minor will be situated in a framework of "academic plans in sociocultural context," as described by Lattuca and Stark[3]. This framework models the interactions between faculty, learners, instructional resources, assessments and other factors relevant to the "shape of the curriculum" within an educational environment. We chose this framework to situate the findings from an ethnographic study of the three core courses.

A protocol that references reflective practice and Baxter Magolda's Learning Partnerships Model, which is based on self-authorship, was developed for ethnographic classroom observation. The collected data will help us better understand the educational environment and educational processes[3], as well as the actors situated within them. In this paper, we offer an analysis of pilot data to better understand how the classes might align with desired outcomes - such as student development of self-authorship, reflective practice, and capacity for innovation. Using this analysis, we identify possible implications for (a) adjustment of academic plans, and (b) evaluating and adjusting the educational environment, both described by Lattuca & Stark's model.

Introduction / Purpose Statement

General education is a core component of developing well-rounded students[4], but it can be challenging to figure out how to make these classes meaningful for students. In recent years, Virginia Tech recognized that many students viewed their general education requirements as a checklist to complete, picking classes that fit in their schedule or were known to be easy. Students did not seem to connect their general education courses with their major or future career, they were just requirements to meet along the way to their goals. To address these challenges, Virginia Tech is implementing a new general education curriculum called *Pathways to General Education*. In the new format, students will have multiple options, or *Pathways*, to choose from to fulfill their general education requirements. One of these options is to complete a *Pathways Minor*: an interdisciplinary minor that covers several general education learning outcomes that is centered around a common theme. The goal of pathways minors is to help students 1) develop their general education skills through classes that are related to and build on each other in an intentional way and 2) reflect meaningfully on how these classes connect to their majors and future careers.

This paper will explore the educational environment demonstrated in a three course sequence that makes up the core of a *Pathways Minor* in Innovation. The Learning Partnerships Model, based on self-authorship theory, will be our primary guide for understanding this environment, and will be used to inform an ethnographic protocol. In addition to using the ethnography results to further develop the minor, we will present the results to contribute to the understanding of innovation as well as curriculum development.

Background

As the *Pathways to General Education* program was introduced, faculty members were invited to propose pathways minors. Faculty in multiple disciplines were already collaborating in developing classes on the topic of innovation, and took the *Pathways* initiative as an opportunity to turn three existing courses into a pathways minor. Faculty in the departments of Engineering Education, Science and Technology in Society, Management, and Industrial Design have since worked through the minor development process and submitted the minor to governance for approval. This development process included identifying which general education learning outcomes (provided by the Pathways team) would be met in each of the three core courses, selecting electives, creating an assessment plan, and developing the capstone experience for the minor. This process represented cross-disciplinary work far beyond that required for the traditional general education model, which resulted in both benefits and challenges. We believe that the resulting minor will benefit students through the interdisciplinary perspectives and experiences that if offers. On the other hand, developing and getting such a minor approved in a system built for disciplinary work was challenging, particularly in engineering departments where general education courses have never been offered. The process of developing the minor and assessing its core courses is described more fully in another research project presented at ASEE 2017[5].

The Innovation Pathways Minor (IPM) is for students who want to develop as innovators in an interdisciplinary context. This minor provides a core sequence of classes with opportunities to practice these skills, as well as elective credits for students to pursue their personal interests. This minor also fills a unique niche by helping students expand their entrepreneurial ideas through customer discovery and business model activities. At the end of the minor, students will have a capstone opportunity to unite their skills in innovation with what they have learned in their major. The minor requires students to complete 18 credits of coursework, the majority of which will count towards their general education requirements. The 12 credit hours of required courses for the minor are:

- STS 2254: *Innovation in Context*
- ENG 2094: *Create!* Ideation for Innovation
- MGT/ENG/IDS 4094: *Startup*: Commercialization of Innovation
- ENG 4104: Innovation Capstone

Innovation in Context uses readings, discussion and course projects to help students explore critical perspectives of innovation and what it means to be an innovator. In *Create!*, students engage in process of ideation, customer discovery, and critique to explore opportunity spaces and user experiences and to design their own innovations. The *Startup* class gives students the opportunity to work on innovative, real world commercialization projects. The *Innovation in Context* course was recently developed for the IPM and had only been taught once before. The *Create!* and *Startup* courses, on the other hand, had been taught "under the radar" by various faculty for the past five years[6]. The university-level support for a "pathway" program catalyzed the effort to bring the courses together in a cohesive minor. Thus the design and assessment of the courses occurred at different stages, and faculty collaborated across current and past instructors to capture the strengths of various instructional theories and practices.

In addition to these core classes, students must also complete a minimum of 6 credits from a list of approved elective courses. At the end of the minor, students will take either the *Innovation Interdisciplinary Capstone* or an in-major capstone course within their major. As a part of the *Pathways to General Education*, the IPM will help students make progress towards their general education requirements for the following learning outcome areas:

- Critical Thinking in the Humanities (3 CR – 50% of required credits)
- Critique and Practice in Design (6 CR – 100% of required credits)
- Reasoning in the Social Sciences (3 CR – 50% of required credits)
- Quantitative and Computational Thinking (3 CR – 33% of required credits)
- Other outcomes based on student selection of electives

Literature review

Educational environments

Educational environments are important because they greatly influence the learning that happens in the classroom, even outside of explicitly defined educational structures. Moreover, the educational environment has a significant role in determining how those structures are defined. In his mixed methods study, Strayer found that there were statistically significant differences in students' perceptions and preferences for the environment of a mathematics classroom, based on whether the class was traditional or inverted[7]. The educational outcomes of their academic achievement and persistence may be negatively affected by student's perceptions of the educational environment as ostracizing or "chilly"[8–10]. In their study of science faculty implementing new practices, Henderson and Dancy identify many situational barriers to changing instruction practices, including departmental norms, and lack of instructor time[11].

We turn to Lattuca and Stark's model of Academic Plans in Sociocultural Context in order to better understand the relationships between educational environment and the features of curricula[3]. A diagram of the framework is shown in Figure 1.

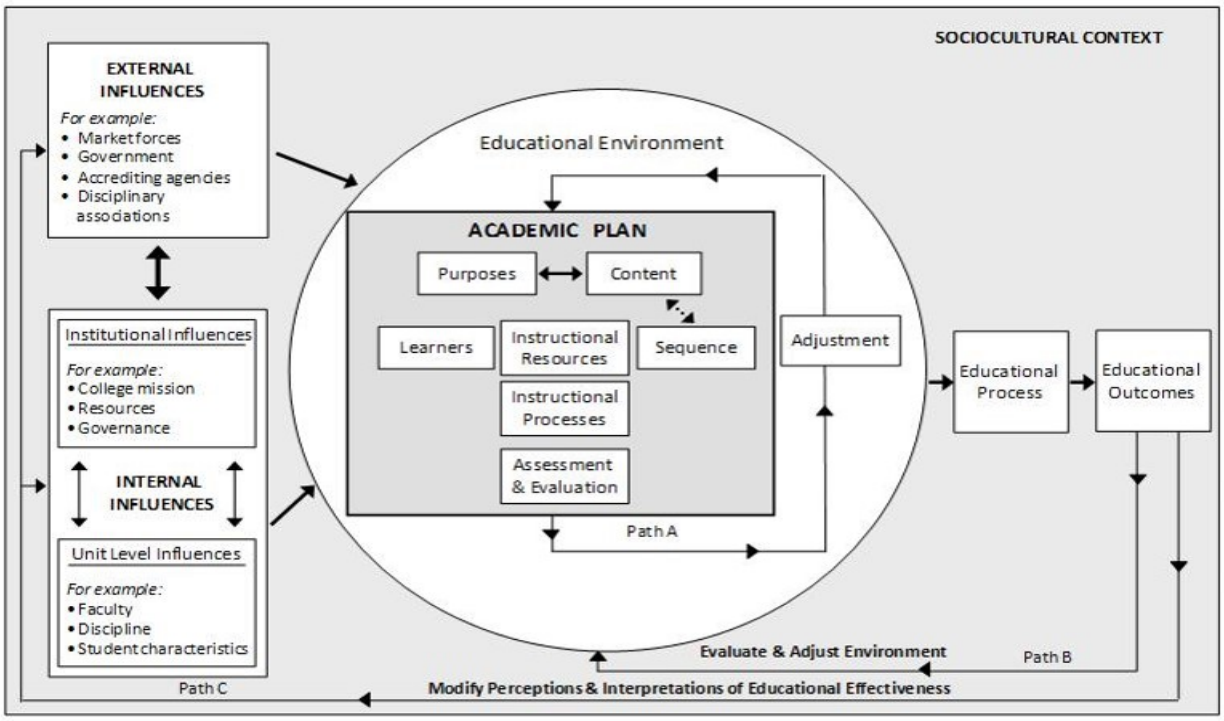

Figure 1: Academic Plans in Sociocultural Context[3]

Lattuca and Stark's framework foregrounds the fact that *academic plans* are implemented within a sociocultural context[3]. The *academic plan* is created, and sometimes designed, to meet the needs of multiple stakeholders. Traditionally, measurement of educational outcomes has the primary purpose of demonstrating these educational outcomes to external stakeholders, like accrediting agencies. However this measurement is also part of the process of meeting those goals. Lattuca and Stark's model includes three assessment cycles, paths A, B and C, shown in Figure 1[3]. These three pathways function very similarly to "control loops", as they use outcomes to adjust academic plans to provide new outcomes.

Path A adjusts the academic plan without changing the educational environment. Assessment can point to where students are not meeting educational objectives, and adjustments to the curriculum will result. Path B is the adjustment of the surrounding educational environment, without which there are limits to the degree to which academic plans can be effective. Path C describes how educational outcomes can be used to affect the internal and external factors outside of the immediate educational environment. For current work describing the process of using assessment to make adjustments following these paths, see the paper by Davis et al[5].

This paper focuses on the educational environment that surrounds the Innovation Pathways minor. Our intent is to understand that environment using classroom research, and use insights from that research to inform future adjustments to the minor and the environment (path A and path B).

Defining Innovation

It is important to define innovation if we are to investigate the ways in which an educational environment affects innovation and if we are to design an academic plan to inspire innovators. However, there is no single accepted definition of innovation. Some define innovation as a personal characteristic of individuals within organizations, diametrically opposed to "adaption"[14]. Others define innovation as the capacity for students to demonstrate particular skills, and they become innovators as they develop self-efficacy in those skills[12] Still others define innovation as a necessary trait for an organization to produce new and impactful goods and services[13].

In our definition we accept that innovation is closely related to creativity. Innovation and creativity can be grouped together as goals for general education [15], and, often, creativity is defined as a necessary precursor for innovation. Insights into creativity can also provide insight into innovation as an individual trait.

One aspect of creativity that influences our definition of innovation is the notion that there are multiple (plural) creativities[16]. Another way of putting it is that "there is no single recipe for making [creativity] happen"[17]. Craft asserts that our efforts to educate creative individuals are limited by failing to recognize that creativity and its significance is context specific, rather than having an absolute definition[18]. However, though creativity may be context bound and plural, it's origins can partially be accounted for in cultural and environmental factors [15,17]. Along this line, Rank, Pace and Frese discuss how Hofstede's dimensions of culture may have a demonstrable effect on creativity and innovation as a psychological process [19]. The importance of culture and context in the development of creativity is what directs our attention to educational environments.

We recognize the ability to solve complex, unique, and relevant problems from unconventional perspectives as a significant aspect of innovation – and we find that self-authorship and reflective practice provide key insights into the development of students who can innovate.

Self-Authorship, reflective practice, and innovation

In our ethnography and resulting design of the IPM, we use Baxter-Magolda's Learning Partnerships Model (LPM), as well as Schön's theories of Reflective Practice to guide our understanding of innovation, as well as general education. Self-Authorship, which informs the LPM, has been used as a lens to understand creative ways of knowing in engineering [20] and is also considered an important goal for liberal education[21]. Reflective Practice describes how a departure from narrow, well-established, so-called "rigorous" approaches to learning and action allows for complex problem solving[22]. Interestingly, these two theories overlap significantly when describing the learning necessary for developing the kind of problem solving necessary for innovation. They prompt us to be concerned with "how people think, rather than what they think"[23]. We adopt these approaches to shape the learning objectives of the courses, and ultimately the educational environment we construct for the IPM, while still allowing for plural "creativities".

Self-Authorship is a framework explaining the intersection of multiple dimensions of development (cognitive, intrapersonal, and interpersonal), which reinforce each other. The framework describes multiple stages of meaning making based on one's development. In the

stage of *external formulas*, the individual relies on others for determining their identities, the nature of their relationships, and even what counts as valid knowledge. In the stage of *self-authorship*, one's identity is negotiated from multiple intersecting identities and one's own set of core values. Self-Authors, when presented with claims about what is true, compare those claims to what they already know. In general, *self-authorship* describes the potential for individuals to be aware of, and committed to acting upon, their internally defined values rather than externally defined formulas[21]. The third stage, *crossroads,* lies in between these two stages, when an individual begins to discover their own internal values and challenge external formulas.

Self-Authors have the capacity to think critically, analyze data beyond the surface level, situate their knowledge and work in context and "negotiate competing interests to make wise decisions"[1]. Self-Authorship also provides necessary support for integrative thinking, because accepting responsibility for constructing knowledge allows individuals to negotiate mismatches between paradigms of thinking in order to integrate them (as opposed to relying on external guides for integration)[24].

Reflective practice is a process by which professionals understand and solve problems without constantly adhering to a body of established knowledge. Reflective practitioners perform *reflection-in-action*, engaging in problem solving not just with the intent of exercising their established disciplinary knowledge, but also with an openness to learning new things about their problem. About the value of reflection-in-action, Schön had this to say:

> "Reflection-in-action has a critical function, questioning the assumptional structure of knowing-in-action. We think critically about the thinking that got us into this fix or opportunity; and we may, in the process, restructure strategies of action, understandings of phenomena, or ways of framing problems." [22] P.28

Without reflective practice, the individual practices "technical rationality", where they are intent on falling on the "rigor" side of a false dichotomy between "rigor" and "relevance".

While innovation can be defined as a set of skills[12], by focusing on self-authorship and reflective practice, we are attempting to account, in part, for the mindsets, identity, and more generally, meaning making, that may be responsible for innovation. Self-Authorship - the ability to integrate and express internal values instead of conforming to externally imposed formulas, and reflective practice - the orientation to problem solving that can question the assumptions of a discipline, both result in the ability to look beyond formulas and solve complex problems without precedent solutions.

The relationship between these theories and innovation are not new. Self-Authoring engineers construct new definitions of what it means to be an engineer, which opens up creativity in their work[20]. Taking the stories in *A Whole New Engineer* as an example: when students are able to develop and trust internal criteria for what is important to them, and are able to tolerate the uncertainty inherent in challenging models of authoritative knowledge, students can engage in innovative activity[25]. Schön gives many examples of professionals being able to approach new and complex problems because of their ability to depart from established knowledge, and their ability to redefine problems[22]. Also, the plural nature of creativity may result from its partial grounding in an individual's subjective meaning making and set of values. In her critique of the conceptualization of creativity in education, Saunders argues that "creativity…is stimulated by the encouragement of vivid inner lifeworlds, a sense of imaginative interiority and a sensuously-felt subjectivity" [26], calling self-authorship to mind.

Baxter-Magolda explains that the movement to self-authorship depends both on personal characteristics as well as environmental context[1,21]. She summarizes the connection between these two factors with the LPM, meant to develop the self-authorship of students. In order to develop students self-authorship, one must create educational experiences that:

a) validate students' ability to know,

b) situate learning in students' experience, and

c) define learning as a mutual process.

The model challenges learners to construct their own meaning of situations. In action, the LPM is meant to "propel students toward self-authorship by creating contexts whereby formulas for success are not readily available"[27]. These environments usher students into self-authorship by disrupting their reliance on external formulas. Schön echoes this claim in his recommendation for centering learning on student's construction of knowledge by *coaching*, rather than *teaching*.

Both Baxter-Magolda[23] and Schön[22] discuss the need for working with and developing a student's existing meaning making, instead of imposing meaning making onto them. In our conception of innovation, students become innovators when they are freed from thinking with stereotypes and freed from unilaterally seeking approval from their relationships with others, and instead can develop the capacity to construct their own knowledge, identities and relationships.

Methods

For our research in understanding and reporting on the educational environment in which the IPM classes were situated, we relied on ethnographic observation. Ethnography provides researchers with the opportunity to understand and develop their own naturalistic interpretations of cultural groups and social systems[28], and has been used to understand important constructs such as engineering identity [29], engineering design[30] as well as curriculum innovation[31]. In addition to developing understanding of self-authorship and reflective practice in the educational environment, classroom research using ethnographic methods also plays a role in the scholarship of teaching in learning[3]. It allows researchers to connect theory to experience, and share the discoveries within classrooms to reach larger audiences to improve practice.

Participants

The participants in this study were students in the Fall 2016 offerings of the core courses of the minor. All courses included students across the freshman to senior levels. The student population in the *Innovation in Context* class included 6 women, 22 men, with the majority of students (16) in engineering majors, and the rest distributed across business, science and humanities majors. The student population in the *Create!* class included 4 women, 5 men, across engineering (5), science (2), and industrial design (2) majors. The student population in the *Startup* class included 22 women, 28 men, with the majority of students (30) in architecture or industrial design, 10 in engineering, 7 in business, and others in science or journalism majors.

Data Collection

Our research protocols and data management plan were approved by the Institutional Review Board of Virginia Tech. A research protocol was developed to focus the attention of the ethnographer on topics of interest, shown in appendix A. To achieve this goal, one researcher was assigned to collect data in all of the three core classes for a semester as a participant observer. The researcher writing the literature review did not collect observational data, in order

to maintain a quality of cognitive distance between the theory and data collection (called *bracketing*) that improves trustworthiness[32].

Once the class was informed of the observations, and consent was obtained from students, the observer began attending classes, collecting observational data in the form of notes typed on a laptop and digital photographs. The observing researcher would also write reflective memos after each observed class. The observer held short conversations with students during the class, and developed rapport with the students. Photographs were collected inconspicuously, through a webcam on the back face of an open laptop. All observational data was anonymized, and students that did not give consent were not photographed. Of note, the observing researcher was a teaching assistant in the *Create!* class.

Data Analysis

The data was primarily coded by two researchers through multiple rounds of coding, with regular deliberation during the process of coding to improve trustworthiness. The coding process was similar to that described by Goetz and LeCompte for "reducing" ethnographic data[33], starting with open coding and then proceeding to constant comparative coding. The first round of coding was *provisional*, in part guided by the observational protocol, but with openness to the emergence of new codes[34]. The second round was informed by the researchers' experiences in the classes and compared to the themes drawn from the educational literature review. After coding, all three researchers met to discuss the interpretations and conclusions drawn from the coded data.

Results

Themes identified through the data collection and coding process were organized into narrative threads that describe several central concepts in the Learning Partnerships model as observed in each of the three courses. While the ethnographic protocol focused the attention of the observer on 5 main themes (*Exchange of Experiences, Learning Innovation, Sharing the Floor, Use of Space, Conflicts and Harmony*), the analysis grouped the results of the observation somewhat differently. *Exchange of Experiences* and *Learning Innovation* are generally summarized by themes of *co-learning,* and the *Use of Space* in the classroom was subsumed into the theme of *sharing the floor. Conflicts and Harmony* shifted to the theme *conflict,* which allowed for a discussion more closely aligned with Baxter-Magolda's work. Themes discussed in this narrative of learning in a curricular design process include *co-learning, conflict*, and *sharing the floor,* and were common in each of the courses.

Innovation in Context

In the first introductory class, instructors encouraged *co-learning* through a Socratic style of questioning that challenged students to engage in critical inquiry. Reframed, this approach is known as "critical participation" and encourages students "to explore the values and consequences of the innovation alongside the practitioners they study"[35]. *Conflict* was a productive mode of meaning-making in the course, since it became a norm of in-class debates in which the instructors guided students to resist the temptation to embrace a single, immediately apparent "right" answer. In other words, the answers for individuals and teams did not rely on external formulas. However, this style was at times competitive and debate was often cut off. Everyone, including the instructors, was competing for time, and *sharing the floor* was especially critical in these classes. The instructors challenged students to use tools of inquiry to construct

their own definitions of innovation by using readings that introduced students to different ways of thinking about concepts, and then using these tools to examine examples of innovation and reflect on how they might fit into pre-established categories. Within and across teams, students used the same tools to arrive at different answers, and learned further through comparing these answers. In this context, debate and more specifically dialectical argument as a pedagogical tool appeared to support a learning partnership approach in which both student and instructor views were used to construct a definition of innovation that the class converged on.

In all three courses, the ways that instructors and GTAs shared *the floor* served as potential models for collaborative behaviors, for example, in terms of who can navigate *the floor* and how. In the first introductory class, the instructor and GTA were co-instructors who frequently engaged in cross-talk that at times was tense, though in a way that reflected the high value of critical inquiry in their home discipline in the humanities. The navigation of *the floor* in this class was challenging not only because of inquiry and debate being modeled by instructors as the norm for communication, but also by physical manipulation of space. The instructor and GTA continually rearranged the tables and chairs so that each class meeting rearranged *the floor* and literally introduced a different perspective of the course for each meeting of the class.

Create!

Co-learning in the second introductory course offered students minimal structure, and extremely few instances of knowledge delivered as "facts". In terms of sharing *the floor*, the class was run in more of a Platonic fashion; although *the floor* was often opened up with questions, the students were urged to traverse an ambiguous space between the ideal and the pragmatic. For example, in the first week of class a guest instructor encouraged students to be creative in a reflexive fashion of being both "aspirational" (idealistic) in their ideas but also grounded (rationalistic) by seeking knowledge from different environments. The class would regularly feature guests that would bring new perspectives, and serve as co-creators, consultants and occasionally as facilitators. Guests would return for multiple classes and had a significant impact on student projects in that way. As opposed to the other two courses, the students were not required to read rigorous texts.

When offered *the floor* in this unstructured space, students often didn't take it. In this loosely structured introductory course, at a point when students were accustomed to structured classes, they were reluctant to take *the floor*, especially when asked to do so according to their internal values. Without practice in this kind of interaction, and without a well-defined path to success, a perceptible level of discomfort existed. Instead, the activities served to push students to engage in divergent thinking, with a focus on generating multiple perspectives on a problem/opportunity space. This type of learning environment resulted in a *crossroads* between external and internal values that promoted a *conflict* for most students. The *conflict* may have been so great that it overshadowed learning in the class. Although students chose their projects related to their internal values, they struggled to invest fully and bring their embedded, discipline-related internal values to their team project. In terms of professional identity, students take this course at the point when they are starting to negotiate between their professional and personal selves, and the uncertainty embedded in the pedagogy during this semester resulted in an atmosphere of sustained tension and hesitation throughout much of the course.

The floor modeled by the instructor and GTAs was less hierarchical than the other two courses. The GTAs participated both as instructors and as students in many of the in-class

activities. The GTAs also *coached* students. They would circulate between teams during activities providing their insight while encouraging students to set their own goals and develop their own understandings of material. The instructor worked mainly as a facilitator, introducing but not marshalling activities, including critiques and guest instructor visits. The critiques were modeled on a method that prioritizes respect for the artist who is sharing their work, and emphasizes non-confrontational feedback processes in which the presenter chooses what kind of critique they would like to hear[36]. In terms of physical space, the chairs and tables would be set up by instructor and GTAs when students arrived, then students would be able to restructure space according to the activity planned for the day. As in the first introductory course, students often worked with their groups using supplies from the art cabinet at their tables and on the whiteboards. Although we did not employ Gerber's survey to measure Innovation Self-Efficacy (ISE)[12], in many ways the students dispositions reflect signs of low self-efficacy. However, the ISE indicators reflect the types of activities taught in the class, and students slowly acclimated throughout the semester in an arc that could be further explored through the lens of self-efficacy.

Startup

If the first two introductory courses straddled the line between Socratic and Platonic approaches, the advanced course might be characterized as Aristotelian. As a *co-learning* environment, the advanced class instantiated the other end of the pedagogical spectrum: the students were treated as professionals, were given responsibility for a real-world technology transfer project, and were expected to collaborate with faculty and participants from the non-academic community. *Co-learning* was not as evident in the lecture-structure of the class, in which the instructors consistently delivered knowledge as established facts. Like *Create!*, the class featured guests, but generally those guests wouldn't keep up with the state of student projects, their role usually being defined as lecturer for a single class. However, throughout the course, the instructors did encourage peer-like relationships with local entrepreneurs and university-faculty inventors. Although *co-learning* between the students and the instructors was not foregrounded, the central team-based projects did promote *co-learning* between students in their teams and with experts and mentors outside of the class. In terms of *conflict*, this course may have helped students the most in navigating crossroads of following internal values over external models, as well as persevering in the face of uncertainty--they learned to continue on a project without a clear plan, and they learned to resist outside structures to get to their goals.

In terms of *sharing the floor* and use of space, the instructors in the advanced course were the gatekeepers of *the floor* in this class. All of the student's questions, for example, had to go through the instructors, and this was reinforced through the use of physical space. Although students sat around tables with their team, the overall structure of the classroom was always set up lecture-style, with the speaker and podium at the front. When student teams presented, the instructors and GTAs sat in the front row, where they had to turn around in order to see the audience. From this position they commanded *the floor*. Even in the team presentations, the instructors controlled the Q&A sessions. Since they were in the front and facing the front, they often did not notice when people in the audience had their hands raised, which resulted in either the question being ignored or forcing the presenting team to be brave enough to override the instructors and call on audience members to ask their questions. This act, through a learning partnership lens, is tantamount to *taking the floor* from an authority figure. In the course this hierarchical structure may have led to tighter teams in which students learned to self-author and

independently collaborate. However, this hierarchical obstacle also may have restricted the amount of *co-learning* that can happen between the different teams in the class.

Discussion

The results from this study may inspire "more" learning partnerships, but are primarily meant to discover how learning partnerships may already be formed in the environments that faculty are creating and enacting in their classes, and enhance those existing partnerships. We found that learning partnerships and contexts for the development of self-authorship were present in all of the classes, though each with their own mode. In addition to different learning partnerships in each class, the classes also framed innovation with multiple definitions, sometimes shifting definitions within classes. In particular, the *Innovation in Context* class framed innovation from multiple perspectives in order to compare and analyze the definitions and their origins in cultural, economic and historical context.

In framing the course narratives in terms of three great early philosophical traditions, we have indulged in a potentially useful metaphor of how learning could progress in our curricular design. Through challenging Socratic inquiry, the first introductory course immerses students in a critical mode of inquiry to doubt and question as one investigates the world and one's place in it, with a goal of doggedly pursuing an elusive and form-changing truth. The second introductory course, on the other hand, dares students to have enough faith in the ideal to be aspirational but also to use strategies for mapping back to rational, pragmatic activities. Finally, the advanced class situates this awareness of one's agency within the social realm, in projects that require critical inquiry, creative thinking, and, ultimately, innovative practice.

Adjustment

Even though learning partnerships were present in each class, there is room for improvement and adjustment of these core classes, as well as room for development of the rest of the minor. We turn to Lattuca and Stark's model of *academic plans in socio-cultural context* to guide our insights to action, using the ethnography results to adjust the academic plan and the educational environment along the pathways described by the model [3].

Following path A, adjusting the academic plan, we will use the insights from the ethnography to develop a set of ePortfolio assignments that run through the core classes of the minor. The ethnography points to the need for integrative learning, given that multiple definitions of innovation and the multiple modes of learning are present throughout the classes, and ePortfolio can provide that integrative learning[3,37]. The ethnography also helps us decide which assignments to encourage students to include in their construction of the ePortfolio, because observation gives us insight into which parts of the class need to be integrated. The ethnography serves as a basic research platform for designing ePortfolio pedagogies, while factors like limits on instructor time and the course learning objectives serve as design constraints.

More directly, results from the ethnography provide insight into sites in the educational environment that need to be adjusted (path B). Influenced by the writings of Schein, following Lewin, we can plan for a process of "unfreezing", "changing" and "refreezing" cultural fixtures[38]. Our ethnography is part of "unfreezing", as we provide our reasoning in determining what needs to change. We have held and will continue to hold debriefings with the faculty teaching the core courses in order to open lines of communication about our understanding of the

minor and to discuss course-level and program-level assessment outcomes. The general areas of discussion based on this study are

- Allowing for more debate in the *Innovation in Context* class, given that the primary learning partnership was comparison of interpretations between students.
- More structure and scaffolding for the realistic pathways through the *Create!* class, given that the lack of external formulas may have promoted *conflict* that was received with resistance, though *conflict* is appreciated to a degree.
- More scaffolding of teamwork in *Startup*, given that the primary learning partnership was within teams working on projects and interpreting the lessons of the class.

Kerns and Watson discuss the process of change within the context of engineering education organizations, and describe many kinds of resistance that highlight how difficult change can be[39]. Though we can attempt to wield our understanding in order to overcome resistance and accomplish change, Lewin also asserts that we cannot fully understand an organization until we have tried to change it[38]. Shifts in the culture of the minor that create an innovation supporting context will require multiple iterations – with each attempt at change meeting resistance and providing more insight into that context.

Future Work

As Abes et al. discuss, self-authorship a does not provide an entire description of an individual's meaning making[24]. It is important to note that, while we do use these theoretical lenses to understand how each class may inspire innovation, we do not presume all self-authors or reflective practitioners to be innovators, nor vice versa. This is especially the case when acknowledging the potential for multiple pathways towards innovation. There are other frameworks that can aid in understanding how students develop as innovators. Self-efficacy of innovative skills may influence the development of student capacity for innovation by mediating engagement with class activities[12], as is suspected to be the case in *Create!*. The theory of the *Zone of Proximal Development* (ZPD) frames how students are granted learning opportunities through social factors in a given environment, and this may be a pathway to becoming an innovator[40]. The ZPD may be particularly important in *Create!*, where students struggled with the lack of external formulas that can function as scaffolding.

While performing this ethnography, we also collected quantitative assessment data, reported in another conference paper[5]. Future work will draw new and deeper conclusions from combining of these two sources of data. As Lattuca and Stark describe, the process of program assessment will require more iterations of classroom assessment, more discussions with faculty, and possibly more studies of the educational environment in order to drive the observed outcomes of the class closer to the desired outcomes of the class. Future published works will describe the process of designing a coherent ePortfolio sequence that encourages integrated learning, development of self-authorship and reflective practice, and the building of student capacity for innovation. The results of these classroom studies will also be leveraged in our design of the capstone course for the IPM, helping us make decisions to nurture learning partnerships and perform authentic, useful and flexible assessments of students and faculty.

References

1. Baxter Magolda MB. Three elements of self-authorship. *J Coll Stud Dev*. 2008;49(4):269–284. doi:10.1353/csd.0.0016.
2. Schön D. *The Reflective Practitioner*. Basic Books; 1983.
3. Lattuca LR, Stark JS. *Shaping the College Curriculum: Academic Plans in Context*. San Francisco, CA: Jossey-Bass; 2011.
4. AAC&U. What is a 21st Century Liberal Education? About LEAP. https://www.aacu.org/leap/what-is-a-liberal-education. Published 2016.
5. Davis, K., Gewirtz, C., Mcnair, L. D., & Ramon, B. (2017). Assessment and Implementation of an Interdisciplinary General Education Minor. In *ASEE Annual Conference and Exposition*. Columbus, Ohio.
6. Martin T, Kim K, Forsyth J, Mcnair LD, Coupey E, Dorsa E. Discipline-based instruction to promote interdisciplinary design of wearable and pervasive computing products. *Pers Ubiquitous Comput*. 2013;13(3):465-478.
7. Strayer JF. How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learn Environ Res*. 2012;15(2):171-193. doi:10.1007/s10984-012-9108-4.
8. Cech E a., Waidzunas TJ. Navigating the heteronormativity of engineering: the experiences of lesbian, gay, and bisexual students. *Eng Stud*. 2011;3(933165213):1-24. doi:10.1080/19378629.2010.545065.
9. McLoughlin L a. Spotlighting: Emergent Gender Bias in Undergraduate Engineering Education. *J Eng Educ*. 2005;94(4):373-381. doi:10.1002/j.2168-9830.2005.tb00865.x.
10. Strayhorn TL. Fittin' In: Do Diverse Interactions with Peers Affect Sense of Belonging for Black Men at Predominantly White Institutions? *J Stud Aff Res Pract*. 2009;45(4):501-528. doi:10.2202/1949-6605.2009.
11. Henderson C, Dancy MH. Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics. *Phys Rev Spec Top - Phys Educ Res*. 2007;3(2):1-14. doi:10.1103/PhysRevSTPER.3.020102.
12. Gerber E, Martin C, Kramer E, Braunstein J, Carberry AR. Developing an Innovation Self-Efficacy Survey. In: *Frontiers in Education*. Seattle, WA; 2012.
13. Morris MH, Avila RA, Allen J. Individualism and the modern corporation: Implications for innovation and entrepreneurship. *J Manage*. 1993;19(3):595-612. doi:10.1016/0149-2063(93)90006-9.
14. Kirton M. Adaptors and innovators: A description and measure. *J Appl Psychol*. 1976;61(5):622-629. doi:10.1037/0021-9010.61.5.622.
15. Lozano F, Sabicer A. Creativity and Innovation: Building Ecosystems to Support Risk Taking, Resiliency, and Collaboration. *Lib Educ*. 2016;102(2).
16. Ferguson D, Ohland M. What is Engineering Innovativeness? *Eng K-12 Educ*. 2009;28(January):1-35.
17. Edmonds EA, Weakley A, Candy L, Fell M, Knott R, Pauletto S. The Studio as Laboratory: Combining Creative Practice and Digital Technology Research. *Int J Hum Comput Stud*. 2005;63(4-5).
18. Craft A. The limits to creativity in education: dilemmas for the educator. *Br J Educ Stud*. 2003;51(2):113-127. doi:10.1111/j.1467-8527.2003.00229.x.
19. Rank J, Pace VL, Frese M. Three avenues for future research on creativity, innovation, and initiative. *Appl Psychol*. 2004;53(4):518-528. doi:10.1111/j.1464-0597.2004.00185.x.
20. Paretti MC, Mcnair LD, Gewirtz C. Creativity and Identity in the Construction of Professional Portfolios. In: Bairaktorova D, Eodice M, eds. *Creative Ways of Knowing in Engineering*. Springer International Publishing; 2017:151-172. doi:10.1007/978-3-319-49352-7.
21. Baxter Magolda MB, King PM. Self Authorship as the Common Goal of 21st Century Education. In: *Learning Partnerships*. Sterling, VA: Stylus Publishing, LLC; 2004:1-35.

22. Schön D. *Educating the Reflective Practitioner*. Jossey-Bass; 1987. doi:10.1086/602063.

23. Baxter Magolda MB. The Activity of Meaning Making: A Holistic Perspective on College Student Development. *J Coll Stud Dev*. 2009;50(6):621-639. doi:10.1353/csd.0.0106.

24. Abes ES, Jones SR, McEwen MK. Reconceptualizing the model of multiple dimensions of identity: The role of meaning-making capacity in the construction of multiple identities. *J Coll Stud Dev*. 2007;48(1):1-22. doi:10.1353/csd.2007.0000.

25. Goldberg D, Somerville M. *A Whole New Engineer*. ThreeJoy Associates, Inc; 2014.

26. Saunders L. Silences and Silence in "Creativity." *London Rev Educ*. 2012;12(2):215-225.

27. Pizzolato JE, Ozaki CC. Moving Toward Self-Authorship : Investigating Outcomes of Learning Partnerships. 2016.

28. Creswell J. Chapter 4 - Five Qualitative Traditions of Inquiry. In: *Qualitative Inquiry and Research Design: Choosing among Five Traditions*. ; 1998.

29. Tonso KL. *Student Engineers and Engineer Identity: Campus Engineer Identities as Figured World*. Vol 1.; 2006. doi:10.1007/s11422-005-9009-2.

30. Goncher A, Johri A. Contextual Constraining of Student Design Practices. *J Eng Educ*. 2015;104(3):252-278. doi:10.1002/jee.20079.

31. Caracelli VJ, Greene JC. Data Analysis Strategies for Mixed-Method Evaluation Designs. *Educ Eval Policy Anal*. 1993;15(2):195-207. doi:10.3102/01623737015002195.

32. Walther J, Sochacka NW, Kellam NN. Quality in interpretive engineering education research: Reflections on an example study. *J Eng Educ*. 2013;102(4):626-659. doi:10.1002/jee.20029.

33. Goetz J, LeCompte M. Ethnographic Research and the Problem of Data Reduction. 1981;12(1):51-70.

34. Matthew B. Miles, A. Michael Huberman, Saldana J. Fundamentals of Qualitative Data Analysis. *Qual Data Anal A Methods Sourceb*. 2014:Chapter 4.

35. Wisnioski M. The Innovation Imperative. *Illumination*. 2016;1.

36. Lerman L. *Critical Response Process*. 1st ed. Liz Lerman Dance Exchange; 2003.

37. Peet M, Lonn S, Gurin P, et al. Fostering integrative knowledge through eportfolios. *Int J ePortfolio*. 2011;1(1):11-31. http://www.theijep.com/pdf/IJEP39.pdf.

38. Schein EH. Kurt Lewin's Change Theory in the Field and in the Classroom : Notes Toward a Model of Managed Learning. *Syst Pract*. 1996:1-17.

39. Kerns S, Watson K. Overcoming Resistance to Change. In: *Designing Better Engineering Education Through Assessment*. Stylus Publishing, LLC; 2008.

40. Fila ND, Fernandez T, Purzer S, Bohlin AS. Innovation and the Zone of Proximal Development in Engineering Education Innovation and the Zone of Proximal Development in Engineering Education. In: *ASEE Annual Conference and Exposition. ; 2016.*

Exchange of Experiences	Sharing The Floor	Conflicts and Harmony
• What skills are emerging from student teams? How are they communicated / do they emerge? • Where have students developed those skills? • Do students share experiences? Is there a certain time when it's okay to share experiences? • Do instructors share experiences? How do students react to those experiences? • How does the leadership in the class respond to student skills and experiences? (Delegation?) • How do the learning activities respond to student skills and experiences? (Do they give certain students an edge? can students demonstrate experiences with the activities or not?) • How do students engage with the skills, experiences and perspectives of other disciplines, how do they demonstrate their own?	• Who talks? • Who interrupts? • How is the floor opened up? (Gestures, verbal cues, physical touch) • Who agrees / disagrees? • How does floor sharing interact with the exchange of experiences? (Do students who dominate the floor talk about their own experience, or others experiences; can floor sharing prevent or inspire the exchange of experiences?) • What do students and instructors do with the floor besides talk? (Draw?) What other kinds of discourse is expressed besides verbal?	• When do students feel they have succeeded? • Why are students in the class? • Is there anything that frustrates students? • Do students voice frustrations to each other and/or to the instructor? • How do students handle not knowing what to do? (Uncertainty) How do they handle poor or good grades? • Are there things that the whole class, or the majority, agree on? • What advice / support is given by the instructors (or by students to other students), what identifies someone as needing advice or support? • How does the class match up with students prior experiences? Is their prior experience an obstacle, or is the class an obstacle, or neither?
Learning Innovation	**Use of Space**	**Miscellaneous**
• Do students refer to the material of the class? (Either as flawed or as a source of knowledge, or something else) • What changes do you notice in the students, something that they might have done differently at the start of the semester? • Do students refer to having an understanding of innovation or what it means to be an innovator? (I expect this would be occasionally be in the form of jokes) • What does it mean to be an innovator? Who defines it? Who bids for it? Who is ascribed the identity of innovator? (either by students or by the instructor) • What experiences are considered valid innovation experiences? • What advice / support is given by the instructors (or by students to other students)?	• What objects do students and instructors use and for what? (Drawings, markers, laptops, paper) • Who uses the objects? • Does the space ever serve as an obstacle? (IE not enough whiteboard markers) • What do students and instructors draw? Who interprets the drawings? • Does the use of space reflect floor sharing? (Is there a podium for the instructor?) • Does the use of space reflect bids for innovation? Does the use of an object represent a certain identity? • Do students demonstrate experiences using certain objects?	• What other trends do you notice? • Some discourse may not fall into other categories, or the meaning might not be so obvious even if it is interesting • Important quotes can also go here, even if they don't fit anywhere else