

**NETWORKS OF AMBIGUITY IN PROJECT-BASED LEARNING:  
UNDERSTANDING HOW STUDENTS EXPERIENCE AND MANAGE  
AMBIGUITY IN WPI'S IQP EXPERIENCE**

by

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## **Abstract**

WPI's global and off-campus IQPs, rich with real-world sponsors/projects and increasingly diverse teams, require that both faculty and students navigate a network of ambiguous situations and relationships. Despite the increasing adoption of project-based learning as a preferred educational model across higher education, and the prevalence of project-based work in STEM careers, research on how to best prepare students and faculty to identify and navigate ambiguity inherent to project-based learning is limited. Seeking to fill this important gap, this graduate thesis advances a pilot qualitative study focused on how students in domestic and off campus IQPs experience and navigate ambiguity in their IQPs. The thesis presents preliminary grounded theory regarding the types of ambiguity experienced by students, how students navigate through the ambiguity, and elements that appear to impact a student's success in that navigation.

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## Introduction

Project-based learning is a proven teaching method with positive outcomes. In a review of the project-based learning literature, the Buck Institute for Education found that project-based learning increases academic achievement and helps students build skills needed to be successful in college and careers (21<sup>st</sup> century competencies) compared to traditional teaching methods and helps to close the achievement gap and reach diverse learners (“Research Summary on the Benefits of PBL,” 2013). A study done by Hart Research Associates on behalf of the Association of American Colleges and Universities found that employers saw graduates’ abilities to demonstrate proficiency in skills such as communication and critical thinking that are cross-cutting across majors as a high priority when considering if they should hire a recent college graduate (*Fulfilling the American Dream*, 2018). Along similar lines, some employers felt that undergraduates who participated in “applied and project-based learning experiences” were more valuable and had a hiring edge (*Fulfilling the American Dream*, 2018, p.16) . This research indicates that using project-based learning in higher education is essential not just for strong student learning outcomes but also for the success of their future careers.

Real-world, project-based learning, such as that which happens at Worcester Polytechnic Institute (WPI) in the Interactive Qualifying Project (IQP), allows students to “work in a team environment and apply theoretical and evidence-based knowledge and methods to the solution of practical problems...” (Elmes & Loiacono, 2009, p.23). While these real-world projects enable students to apply abstract theory to concrete situations while working in teams, I would argue that ambiguity is also inherently part of these real-world projects and that practice navigating ambiguity in real-world contexts is a central premise of why project-based learning is so valuable.

I define ambiguity as situations that support several different meanings at the same time – where multiple explanations, interpretations, and perceptions are plausible. Unlike uncertainty, ambiguity is not resolved by more information as it may not be clear what questions to ask or what problems to solve. Instead, navigating ambiguous situations requires faculty and students to engage in sensemaking, interpretation, empathic inquiry, and negotiation, especially as they work across cultural and disciplinary boundaries (Elizabeth Long Lingo, 2019; Lingo & O’Mahony, 2010).

Research on ambiguity of any kind is limited. Many studies have focused heavily on ambiguity in specific fields, such as within management education (Banning, 2003; Huber, 2003). Current research also tends to examine individuals’ tolerances for ambiguity instead of examining it as a dynamic, multifaceted concept (Furnham & Marks, 2013; Huber, 2003; Tallent, 2016). The major gaps in research on ambiguity relevant to this study are understanding types of ambiguity undergraduates experience in project-based learning settings and how students experience and navigate this ambiguity. My research seeks to explore these questions.

My goal for this research is not to minimize nor eliminate ambiguity in any real-world, project-based learning experience such as the IQP but instead to help students learn to identify and successfully traverse this ambiguity. It is likely that in their careers, they will encounter significant ambiguity and should be prepared to be successful in navigating those experiences (Dubrin, 2018). I conducted this research as an initial study and have preliminary insights that will be further tested in future research with the goal of eventually developing tools and strategies for faculty and students who face ambiguity in their project-based learning experiences. On the basis of in-depth, retrospective interviews with nine WPI students who have completed their projects at a domestic project location, my work builds preliminary grounded

theory about the types of ambiguity encountered by students and how students experience and respond to ambiguity during their IQPs.

In this thesis, I first look at the literature that informs my research questions and discuss my methods. I then turn to my findings and discuss conclusions and recommendations for further research.



## **Literature Review**

Particularly in education, research on how people identify and experience ambiguity is limited in breadth. The majority of these studies look at one's tolerance for ambiguity within various settings such as organizations (Huber, 2003; Kajs & McCollum, 2009; Shyti & Paraschiv, 2015). The research that examines ambiguity as a more dynamic process does not do so within an educational setting. When examined within educational settings, ambiguity still focuses primarily on tolerance at an individual level. As a result we know very little about types of ambiguity students experiences when working in project-based learning, how they deal with this ambiguity in settings such as with diverse teams or professional partners, and what elements help them learn the skills necessary to successfully navigate through ambiguity without getting stuck in the process.

### **Ambiguity**

Much of the existing research that looks to understand how people interact with ambiguity focuses at the individual level, seeking to understand individuals' tolerances for ambiguity and/or level of ambiguity aversion measured by various scales. Budner created one of the original scales (1962), which requires subjects to self-report answers on the scale and includes poorly worded statements such as "an expert who doesn't come up with a definite answer probably doesn't know too much" and "I would like to live in a foreign country for a while" (1962). Other scales have been created over time by researchers such as MacDonald (1970) and McLain (2009) asking individual to self-report on similar categories. McLain, for example, asks people to report on items such as "I don't tolerate ambiguous situations well" and "I am tolerant of ambiguous situations" (2009). A new publication by DuBrin provides an overview of tolerance for ambiguity and discusses where people encounter ambiguity as leaders and how to improve their overall tolerance to become stronger leaders (2018). This research is

problematic in understanding how people can learn to navigate ambiguity as the scales treat ambiguity as a static concept that one can handle or not. Durrheim and Foster begin to change the conversation by developing a scale to measure tolerance of ambiguity within specific settings instead of as a personality trait (1997). While their research moves from looking at tolerance for ambiguity as a general personality trait to looking at tolerance as something that can shift depending on the situation, it still treats ambiguity as a static concept that someone tolerates instead of a dynamic concept that someone can learn to navigate.

Additional research uses a variety of scales to examine how people in various contexts tolerate ambiguity and what shapes one's tolerance for ambiguity. Shyti and Paraschiv, for example, studied connections between entrepreneurial experiences and the effect they have on ambiguity attitudes (2015). Buckert et al. studied the impact of stress on ambiguity aversion (2014). Other researchers have looked at how one's tolerance of ambiguity might impact other factors. Friedland, Keinan, and Tytiun, for example, looked at how stress and tolerance for ambiguity impacted how frequently one participates in stereotyping behavior (1999). However, the static problem remains in this research; it continues to treat ambiguity as a state of being and not as an ever-evolving, multifaceted concept that needs to account for the dynamics of student-context interactions over time. This type of research leaves large holes in our understanding of ambiguity as it focuses on ambiguity at an individual, static level, considering only an individual's tolerance of ambiguity and factors that might impact that tolerance. It does not study ambiguity as a vibrant network, where multiple types of ambiguity and multiple people may be engaged in working through ambiguity to explore the complex nature and potential solutions of problems.

There is limited research that starts to build a new foundation for our understanding of ambiguity and how it is an integral part of project-based learning which requires intentional skill

building. The current research is especially limited in educational settings. Lingo and O'Mahoney shed new light on the study of ambiguity (2010) in their research on project-based careers among music producers. They looked at the types of ambiguity that producers encountered and the phases in which these types of ambiguity tended to be present. Their research begins to shift the conversation away from one's ability to tolerate ambiguity to an understanding of types of ambiguity experienced within a single project and how music producers experience ambiguity over time. Lastly, their research highlights how an individual, in their case the music producer, may experience ambiguity that they must navigate through a network of people and not simply as a static, individual experience. Lingo and O'Mahoney's research, however, does not examine ambiguity within an educational context and thus the generalizability of their findings to project-based learning may be limited.

### **Ambiguity in Education**

There is limited research on ambiguity within an education context. It too primarily focuses on understanding students' tolerances for ambiguity and elements that impact a student's tolerance, keeping ambiguity as a static notion (Banning, 2003; Huber, 2003). Additionally, many of the educational settings pertain to examining tolerance for ambiguity within specific disciplines, such as management education (Banning, 2003; Huber, 2003). Huber is well known for her work on teaching tolerance for ambiguity to leadership students using a project-based approach (2003). Her approach is to have students experience ambiguity by completing the project-based work, examining how participating in project-based work increases their tolerance for ambiguity. Banning takes a similar approach in his research, using case studies to try to improve management students' tolerances for ambiguity (2003). These studies see student engagement with ambiguity as an individual tolerance and perpetuate the gap in understanding

around types of ambiguity in project-based learning and how students experiences these types within a network of people and not simply at the individual level.

Tallent (2016) took a similar approach to Huber and Banning, although her research examines a situation where instructors intentionally spoke to students about the presence of ambiguity within project-based learning. She studied the experience of two faculty members who wanted to increase tolerance for ambiguity through a project-based experience. These two faculty members embedded discussing ambiguity into the project experience as a way to help students improve their tolerance of the situation. Tallent says that while there appeared to be some positive learning outcomes such as increased creativity, the faculty “were shocked at not only the lack of students’ abilities to deal with ambiguity, but also at the anger students displayed when challenged to analyze ‘messy’ problems.” Tallent concludes saying, “Dealing with ambiguity is critical in the IMC/Strategic Communications profession and it is essential students learn how to deal with the process before becoming professionals. This means it is incumbent on professors to give students the tools necessary so students can learn to adapt with changing situations as they grow in their careers” (2016, p.17). This recommendation speaks to what is missing from research that looks at students’ tolerance for ambiguity. Simply examining their tolerance or hoping their tolerance increases by being thrown into project-based learning opportunities is not enough. Research needs to understand the types of ambiguity students encounter and how they encounter and navigate through them so that faculty can provide research-based tools to support not only students but also themselves when leading project-based learning experiences in the classroom or the field.

Overall, there are many gaps within the research on ambiguity, especially around understanding ambiguity as a dynamic component of projects and how students can learn to experience and navigate the challenges that ambiguity poses. My study seeks to build on the

research done by Lingo and O'Mahoney (2010) which tackles ambiguity not as a tolerance but as a dynamic concept, bringing this approach to an educational, project-based context. My work not only seeks to understand the types of ambiguity that students face and how they navigate these experiences, but also looks to explore ambiguity as an experience that students have within a broader network of teams, advisors, and professionals, rather than as a static, individual trait. The ultimate goal of this work is to understand enough about student experiences with ambiguity to be able to develop intentional, meaningful instruction and tools for students in project-based learning experiences. Developing skills to successfully navigate ambiguity in their projects will provide students with a foundation for responding effectively to the ambiguous situations they are likely to face in their futures.

## Methods

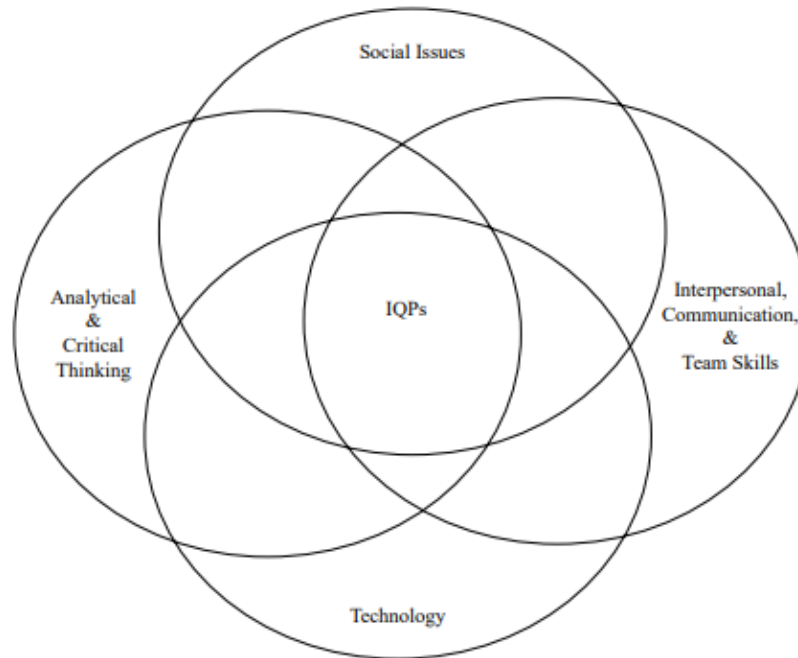
Given the limited existing research on types of ambiguity in project-based learning opportunities and how students experience and navigate this ambiguity, I used a grounded-theory approach to lay the foundations of theory for future work in this area (Creswell & Poth, 2017). As this thesis is a pilot study on the topic, I examined the data to understand emerging concepts and trends. My analysis used constructivist grounded theory which puts the ideas within a context, acknowledging the influence of the researcher and “treating research as a construction but acknowledg[ing] that it occurs under specific conditions” (Charmaz, 2014, p.13). The study received IRB approval on September 20, 2018.

### Sample

The sample includes nine current WPI students who previously completed their IQP at an off-campus, domestic project center. These are projects that take place in a single term away from the WPI campus but within the United States. I intentionally chose not to include students from international project centers nor on-campus projects in this study for two primary reasons. First, on campus IQPs are typically completed over multiple terms (versus one term for off-campus projects) and I did not want the difference in time over which the project is completed to confound the findings. Secondly, I chose to focus on domestic versus international project centers to so that I could focus on ambiguity within the project-based learning context, apart from any ambiguity a student might feel living in a new culture for seven weeks.

I deliberately chose to conduct this study with WPI undergraduates because of WPI’s years of experience involved with project-based learning. In 1970 WPI created an educational plan that required all students to do project work focused on real-world problems (van Alstyne et al., 1970). Today this occurs in multiple ways, including the IQP. “The IQP at WPI teaches students how to develop practical solutions to complex problems in real-world settings while

enhancing their critical thinking and interpersonal skills” as displayed in Figure 1 (Elmes & Loiacono, 2009, p.29). Given the established nature of the real-world project experience at WPI, it was the perfect place to find participants for this study.



**Figure 1:** IQPs in the context of service-learning and skill development (Elmes & Loiacono, 2009, p.29)

I contacted interviewees in two ways. First, I looked up publicly available IQP final reports on the WPI website and contacted members of teams who had completed their IQP in one term at a project center in the United States. I then contacted students by emailing the domestic project center email aliases for projects completed within the 2017-2018 and beginning of 2018-2019 academic years. Students were offered a \$5 Dunkin Donuts gift card if they participated in the study.

### **Data Collection**

I collected data through retrospective, inductive interviews of participating students. I engaged in an ethnographic approach to interviewing (Spradley, 1979), using a grand-tour interview technique where I started interviews by asking participants to describe their IQP

experiences from beginning to end (see interview protocol in Appendix 1) and then asked more specific follow-up questions about various components. Because ambiguity is in itself an ambiguous word which people struggle to define, I was intentional in not specifically using the word ambiguity in interview questions, instead crafting questions that let students describe how they experienced the IQP and related components. For example, I asked participants questions such as “what kind of questions did you bring or NOT bring to your advisor(s) and why?” and “what open-endedness did you experience in your project and how did you handle it?” Both of these questions provided students with the space to discuss how they maneuvered through various project pieces, painting a picture for me of what happened, allowing me to code moments as ambiguous or not. Since I used a grounded-theory approach for this study, questions were adjusted to understand new themes as they emerged (Creswell & Poth, 2017).

### **Limitations**

The main limitations of this study are related to sample size. Given that this was a pilot study, the sample size for this research was only 9 interviews. This small size limited the amount of theoretical sampling and saturation that could occur.

### **Impact of Researcher**

It is important to acknowledge the impact of researcher identity in this process. Charmaz states “every researcher holds preconceptions that influence, but may not determine, what we attend to and how we make sense of it” (2014, p.156). My previous experience working on topics of access and equity in education over the past decade comes with me as I interpret the data. Additionally, preconceptions formed prior to conducting interviews impacted the questions asked and consequentially responses received. For example, because this research focuses on an academic experience, interview questions tended to focus on project-related topics. I discovered, however, that multiple students struggled with personal ambiguity, such as struggling to handle



negative feelings about the project or dealing with individual mental health issues, which impacted their projects. While this topic came up in interviews due to the open-ended nature of the questions, future interviews should include questions about students' personal spheres to more intentionally examine this theme. My inescapable personal perspective influences not only how I ask the questions but also how I examine the responses. As Charmaz states, “we *construct* our codes because we are actively naming data – even when we believe our codes form a perfect fit with actions and events in the studied world. We may think our codes capture the empirical reality. Yet it is *our* view: we choose the words that constitute our codes” (2014, p.115).

### **Analysis**

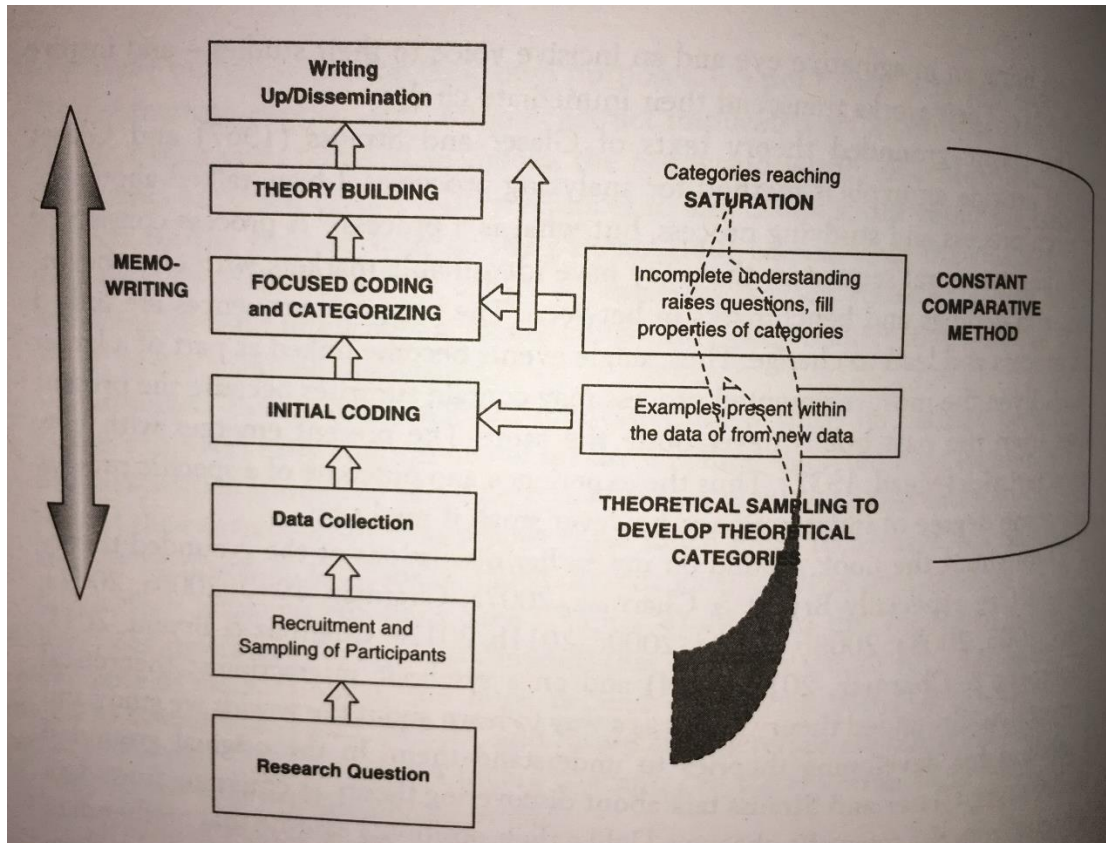
To understand my analysis, it is important to understand the ways in which I have used two concepts. First, I operationalized ambiguity to include situations where seeking more information might actually solve the problem if the student did not realize that useful resources were available and therefore did not attempt to find the information. In my introduction, I defined ambiguity as times when additional information would not be helpful in resolving situations. Because this research is grounded in the actual experiences of the students, as I considered what to code as ambiguous, it was important that I met participants where they were in terms of awareness of what information existed. If students did not know there was additional information that would have helped them answer questions in their projects, I considered ambiguity to be present. For example, one participant discussed struggling to know how to plan an event and the ways the team tried to figure out this process. While more information would have helped this team resolve the situation of not knowing what one should consider when event planning, such as contacting an event planner and asking questions, for this team, the situation was considered ambiguous because they did not know that interviewing an event planner was even a possibility to consider. Second, I considered a student blocked or stuck in ambiguity when

they were not able to process through what was happening and move to a new understanding of the situation. This analysis was based on their description of what happened in various moments of their IQP experience. For example, if a participant said that over the course of the IQP, their team never figured out how to handle role divisions with a difficult teammate, I considered them blocked by ambiguity because they never were able to fully solve the question of roles in the team to a level that left everyone feeling positive.

I analyzed the data in three phases using constructivist grounded theory approaches and the Gioia methodology of presenting data, both of which analyze data in an iterative, holistic way (Charmaz, 2014; Creswell & Poth, 2017; Gioia, Corley, & Hamilton, 2013).

### **Phase 1: Open Coding**

I created an extensive list of concepts through initial coding using handwritten notes and memos, a process I began when I had collected half of my data. This process was highly iterative as I worked to determine how I would make meaning of the information. As would be expected in a pilot study, I was able to do limited theoretical sampling at this emergent level of grounded theory research; as concepts arose in interviews, I noted potential codes and asked about these concepts in future interviews. While the data is not yet fully saturated and requires future theoretical sampling, a solid foundation has been created. Figure 2 shows a piece of my sensemaking process, and the process I would encourage future research to incorporate into the analysis.



**Figure 2:** Constructing Grounded Theory Process (Charmaz, 2014, p.18)

As part of this initial coding, I found it important to analyze the data through two lenses: (1) ambiguity as experienced by the student and (2) elements that appeared to impact ambiguity. This helped me to begin to make sense of the many categories I had within each of these sections. Within the interviews, because participants were sharing their experiences of engaging with both their IQP project and various project-related stakeholders and networks, moments that I classified as ambiguous in the students' eyes and moments or situations that impacted ambiguity were often intertwined within their stories.

### **Phase 2: Creating Codes & Theory**

Using handwritten notes and Dedoose (a qualitative and mixed methods research tool), I then analyzed concepts within each bucket, looking to see which of the concepts were most regularly used and which felt particularly salient and meaningful. Through this process of

focused coding, I determined my final codes. I examined these codes by creating a conditional relationship guide (Scott & Howell, 2008). While Scott and Howell encourage examining the information, given that the scope of this research covers only the early stages of creating grounded theory, I focused on three (see Table 1): the what, why, and how (Scott & Howell, 2008).

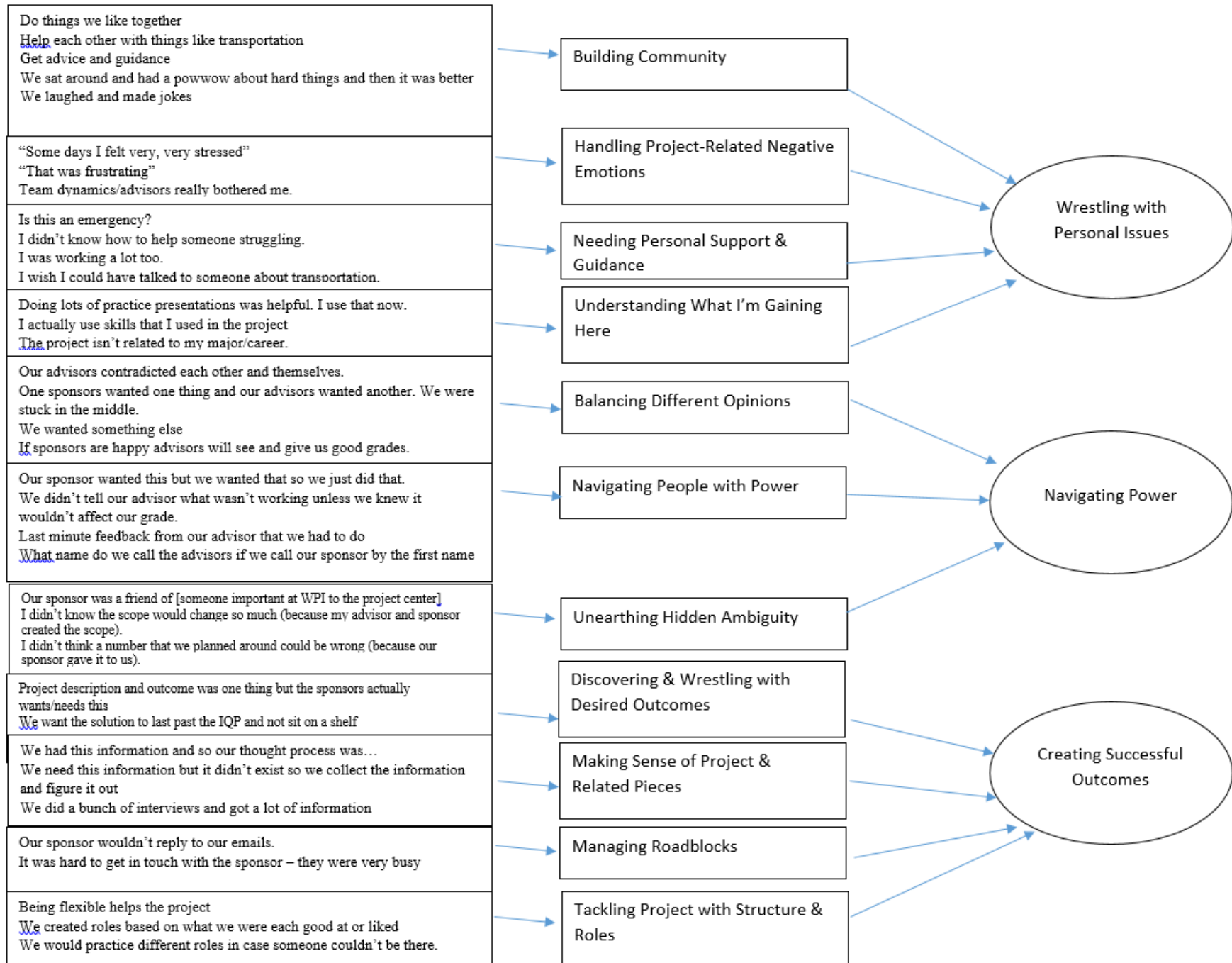
Still informed by constructivist grounded theory, I developed three aggregate dimensions from my second-order themes (Gioia et al., 2013), examining ambiguity as dynamic dimensions and not as a static concept. As shown in Figure 3, the aggregate dimensions make sense of the second-order themes at a more abstract, theoretical level. “In this 2<sup>nd</sup>-order analysis, we are now firmly in the theoretical realm, asking whether the emerging themes suggest concepts that might help us describe and explain the phenomena we are observing” (Gioia et al., 2013, p.20). I grounded both the second-order themes and aggregate dimensions in the words of the people I interviewed, working to ensure I remained close to the lived experiences of participants.

The first aggregate dimension I categorized, *wrestling with personal issues*, brought together codes that looked at ambiguity students faced that were connected with the person I was interviewing: their emotions, concerns, struggles, and well-being. While I did not initially ask questions about personal struggles during the IQP experience, the topic kept emerging in various ways and could not be ignored as a piece of this developing theory. The second aggregate dimension, called *navigating power*, developed from themes related to ambiguity students faced related to power, often reflective of hierarchical dynamics. The third and final aggregate dimension, *creating successful outcomes*, was the broadest of the processes in terms of the number of situations coded as part of this dimension; in part because of the focus of the interview questions asked, much of the data was centered on sensemaking at every level of topics connected to the IQP.

### **Phase 3: Understanding Relationships**

Lastly, I brought my analysis from a two dimensional data structure to a dynamic, emerging system by creating a preliminary data analysis model designed to show possible relationships among the three aggregate dimensions (Gioia et al., 2013). To create this model, I examined which dimensions participants spoke about discussing regularly with others and which ones they mentioned being able to resolve or work through. I also noted how elements impacting ambiguity were or were not present when students were blocked. Through this iterative process of reexamining the data, I developed a preliminary model that focuses on making sense of how students experience ambiguity and attempt to work through it.

**Figure 3: Data Structure**



## Findings

In my findings I share my results and preliminary grounded theory, bringing them to life with quotes and stories from the interviews. I start by discussing the types of ambiguity I identified from my data. Next, I share the theory I build for each of the three aggregate dimensions and how the three dimensions intersect with each other. Lastly, I share my findings around contextual variables and strategies that impacted how students experienced ambiguity.

### Types of Ambiguity

I created eleven second-order themes in my data analysis which I also determined to be the main types of ambiguity participants encountered throughout their IQP experience. These types, displayed in the conditional relationship guide in Table 1, are categories I determined that best make sense of the issues that I heard students wrestle with respect to ambiguity. It’s important to note that not everyone experienced all types of ambiguity nor various types of ambiguity in the same ways or same places during their projects.

**Table 1. Ambiguity Types Conditional Relationship Guide**

Category	My Definition	What <i>(1<sup>st</sup>-Order Themes)</i>	Why	Quotes
Building Community <i>(Wrestling with Personal Issues)</i>	How students figured out forming non-project related relationships.  Could be with teammates.  While some individuals are successful in this, often they don’t know why or those who aren’t successful don’t know why	Do things we like together  Help each other with things like transportation  Get advice and guidance  We sat around and had a powwow about hard things and then it was better  We laughed and made jokes	Living near new people.  New professional experiences  Working and liking/not liking people	‘I want a community of people like that...helpful and collaborative’  ‘It’s important to have bonding time with your team rather than it all just be professional’  ‘If everyone hadn’t been so positive and receptive and understanding of what it’s like to be a WPI student, it would have been completely different.’

<p>Handling Project-Related Negative Emotions</p> <p><i>(Wrestling with Personal Issues)</i></p>	<p>How students handled negative project-related emotions.</p>	<p>“Some days I felt very, very stressed”</p> <p>“That was frustrating”</p> <p>Team dynamics/advisors really bothered me.</p>	<p>Negative feelings are coming up but students are not at school – they are in a more professional setting</p>	<p>“We were low-key suffering.”</p> <p>“It’s a little stressful at first because you don’t know what to do, kind of.”</p>
<p>Needing Personal Support &amp; Guidance</p> <p><i>(Wrestling with Personal Issues)</i></p>	<p>How students managed non-project related personal struggles.</p>	<p>Is this an emergency?</p> <p>I didn’t know how to help someone struggling.</p> <p>I was working a lot too.</p> <p>I wish I could have talked to someone about transportation.</p>	<p>While students do the IQP, their lives carry on and personal stresses and situations occur that are ambiguous.</p> <p>At times these needs interest with IQP needs (such as shelter or transportation)</p>	<p>“I didn’t know who else to reach out to.”</p> <p>“A stable living environment is important”</p> <p>“Being able to talk to someone or have someone check in on us like mental health wise would have been better because we were all struggling.”</p>
<p>Understanding What I’m Gaining Here*</p> <p><i>(Wrestling with Personal Issues)</i></p>	<p>How students made sense of what they were learning in the IQP experience and how it would serve them outside of the IQP.</p>	<p>Doing lots of practice presentations was helpful. I use that now.</p> <p>I actually use skills that I used in the project</p> <p>The project isn’t related to my major/career.</p>	<p>Students often see the IQP as unrelated to their majors and careers and don’t seem to know what to take away as transferable skills/unsure what could help them outside the project.</p>	<p>“The most unexpected part was that it [the IQP] would have an impact on my career.”</p>
<p>Balancing Different Opinions</p> <p><i>(Navigating Power)</i></p>	<p>Navigating different opinions about their work from their network of stakeholders, often who had more power than they did.</p>	<p>Our advisors contradicted each other and themselves.</p> <p>One sponsors wanted one thing and our advisors wanted another. We were stuck in the middle.</p> <p>We wanted something else</p> <p>If sponsors are happy advisors will see and give us good grades.</p> <p>Communication within our sponsor wasn’t good and they had different internal opinions.</p>	<p>Unlike the classroom, there is not one leader with answers (faculty) and learners (students).</p> <p>In IQP there are multiple people with power (sponsor, informal sponsor, advisor, multiple advisors) who have different backgrounds and ideas.</p>	<p>“You had to please two different people because one was grading you and one you were there to help.”</p> <p>“We always saw it like the sponsor was the most important thing. And even though we were being graded by our advisor, we always knew that if the sponsors were super impressed then the advisor would realize this was good for them.”</p> <p>“You think the advisors and sponsors talk more but they don’t”</p> <p>“Our sponsor had the more technical perspective and our advisors were always trying to push the humanities side of things”</p>



				<p>“One week our advisors’ feedback would be this and then the next it would be ‘oh change it back”</p> <p>“I mean [our sponsor] said it was fine as long as we were keeping whatever we had discussed with him previously and like just take what the advisors were saying as an additional.”</p> <p>“The worst part was when we butted heads with our sponsor”</p> <p>“[Our primary sponsor] would say yes, I agree with you. And then [her boss] would say I think you should do this.”</p>
<p>Navigating People with Power <i>(Navigating Power)</i></p>	<p>Navigating situations heavily impacted simply because a member of their network had power of some kind.</p>	<p>Our sponsor wanted this but we wanted that so we just did that.</p> <p>We didn’t tell our advisor what wasn’t working unless we knew it wouldn’t affect our grade.</p> <p>Last minute feedback from our advisor that we had to do</p> <p>What name do we call the advisors if we call our sponsor by the first name</p>	<p>The hierarchical role of students’ in the IQP experience is often blurry and students are often working with people who have greater power and influence than they do. These people at times make decisions or do things that to which students then have to figure out how to respond</p>	<p>“By the end we had a much better idea of what we wanted in the project so we would go back [to our advisors] and have conversations with them about where we disagreed and I would say about 50/50 we listened”</p> <p>“We kind of completely ignored our advisor” when we disagreed on our scope.”</p> <p>“It was just way too much work so we had to tell [the sponsor] we couldn’t do it. That was hard.”</p>
<p>Unearthing Hidden Ambiguity <i>(Navigating Power)</i></p>	<p>Assuming or not assuming information based on someone’s positional power and then struggling to know how to adjust to this hidden surprise.</p>	<p>Our sponsor was a friend of [someone important at WPI to the project center]</p> <p>I didn’t know the scope would change so much (because my advisor and sponsor created the scope).</p>	<p>Students have assumptions about what could be ambiguous and often these assumptions revolve around if the person who told them the information has authority/power. They also often wait to ask questions to experts</p>	<p>“We would have thought [our sponsor] would give us contacts...but they were like you guys can try to get in touch”</p> <p>“I know from other teams, the team has a set proposal and then they meet with their sponsor and sponsor wants something completely different and I don’t know how this miscommunication happens.”</p>

		<p>I didn't think a number that we planned around could be wrong (because our sponsor gave it to us).</p> <p>We didn't know our sponsors and advisors didn't talk.</p>	<p>until they are told to do so by their sponsors or advisors.</p> <p>Sometimes the power someone carries is hidden.</p>	<p>"We were thinking it was one problem [based on the sponsor] and then found it was another...you don't think that somebody sees their problems the wrong way."</p>
<p>Discovering &amp; Wrestling with Desired Outcomes</p> <p><i>(Creating Successful Outcomes)</i></p>	<p>Making sense of what would be successful outcomes (may be personal, advisor, and/or sponsor outcomes).</p>	<p>Project description and outcome was one thing but the sponsors actually wants/needs this</p> <p>We want the solution to last past the IQP and not sit on a shelf</p> <p>I personally wanted this outcome to happen even though that wasn't the goal of our project.</p>	<p>The need or desire for what the final product will be can change over time.</p> <p>There may be different outcomes that different stakeholders hope for.</p> <p>Some outcomes may be personal to the students and not related to the project scope.</p>	<p>"We didn't know where to start"</p> <p>"My sponsor was very smart and knew the topic...sometimes in the beginning of the project it was like this is really cool but it was kind of like okay what are we actually contributing to advancing this product?"</p> <p>"The solutions we proposed [were the most open ended part of the project] because through our research we found...tens of different solutions that were possible"</p> <p>"The most important part [for us] was the usability of these materials for them [after the IQP]"</p> <p>"We had to gauge the interest of what this company was looking for"</p>
<p>Making Sense of Project &amp; Related Pieces</p> <p><i>(Creating Successful Outcomes)</i></p>	<p>Making sense of new information, especially information that requires some sort of expertise and knowledge.</p>	<p>We had this information and so our thought process was...</p> <p>We need this information but it didn't exist so we collect the information and figure it out</p> <p>We weren't sure what the words meant</p> <p>We did a bunch of interviews and got a lot of information</p>	<p>New information is constantly coming up.</p>	<p>"We didn't know where to start"</p> <p>"We had to gauge the interest of what this company was looking for"</p> <p>"It's important to be ready for anything"</p> <p>"Just being able to be there all the time, like actually work in the same building as them, where you can go down the hall and it'd be like 'oh, we have a draft.'"</p>

		What do you think about this		
Managing Roadblocks* <i>(Creating Successful Outcomes)</i>	Navigating roadblocks, such as no response to communication.	Our sponsor wouldn't reply to our emails. It was hard to get in touch with the sponsor – they were very busy	Students are often inexperienced at knowing what to do when someone goes wrong. They are used to looking to a faculty member to tell them in school related situations.	"I wish the sponsor was around more. Not that we needed him but I think it would have felt different if he was more present." "If we couldn't contact someone [we would ask our advisors what to do]. Should we give up?"
Tackling Project with Structures & Roles <i>(Creating Successful Outcomes)</i>	Determining what structures and roles they wanted to use to best work through the IQP	Being flexible helps the project We created roles based on what we were each good at or liked We would practice different roles in case someone couldn't be there.	They are working with people they don't know (teammates, sponsors, advisors) and on topics they are not familiar with so have to figure out (or no) how they want to create roles and working structures.	"It was also good to give flexibility to the first weeks because you're adapting to a whole new place." "They had prior experience in that and I don't really know much about it..." "We had differences but we would just present advantages and disadvantages"

Figure 4 shows if participants (called media in the figure) were coded as experiencing one of the eleven types of ambiguity. A 1 indicates they experienced that type of ambiguity at some point in the IQP experience and a blank box indicates they did not experience it. Figure 5 shows the frequency with which codes were applied to the same pieces of the transcript and thus are co-occurring. The red indicates high numbers of overlapping codes while the blue indicates lower numbers.

Not unsurprisingly, in talking about their IQP experiences, students spoke most frequently about experiencing ambiguity around determining project outcomes, making sense of information, and figuring out team roles and processes. As can be seen in Figure 4, *discovering and wrestling with desired outcomes, making sense of the project and project-related pieces, and*

tackling the project with appropriate structures and roles were the three types of ambiguity experienced by all participants.

Media	Codes													
	Wrestling with Personal Issues	Building Community	Handling Project-Related	Needing Personal Support	Understanding What I'm	Navigating Power	Balancing Different	Navigating People with	Unearthing Hidden	Creating Successful Outcomes	Dis covering & Wrestling w/	Making Sense of Project &	Managing Roadblocks	Tackling Project w/
91		1		1	1		1	1	1		1	1	1	1
81		1					1	1	1		1	1	1	1
71		1	1		1		1	1	1		1	1	1	1
61		1	1	1	1		1	1	1		1	1	1	1
51		1	1	1					1		1	1		1
41		1	1	1			1	1	1		1	1	1	1
31			1				1	1	1		1	1	1	1
21			1				1	1	1		1	1		1
11		1	1	1	1		1	1	1		1	1	1	1

**Figure 4.** Code Presence across Participants

Not only did those three type of ambiguity appear regularly in their IQP stories, but these three types frequently occurred at the same times as one another (see Figure 5). For example, one participant had a sponsor who was an expert in the technical side of their project. Their team had to figure out what their roles were on the project if they didn't need to be the technical experts (*tackling project with structures and roles*). They had to make sense of a highly technical scope that did not always make sense (*making sense of project and related pieces*), and they had to

figure out what their outcomes were supposed to be when the scope of the project kept changing (*discovering and wrestling with desired outcomes*).

Codes	Wrestling with Personal Issues	Building Community	Handling Project-Related	Needing Personal Support	Understanding What I'm	Navigating Power	Balancing Different	Navigating People with	Unearthing Hidden	Creating Successful Outcomes	Discovering & Wrestling w/	Making Sense of Project &	Managing Roadblocks	Tackling Project w/
Wrestling with Personal Issues														
Building Community			8	2	1		3	4				2		8
Handling Project-Related		8		2			7	11	2		5	11	2	10
Needing Personal Support		2	2					1	1			2		1
Understanding What I'm		1									1	1		1
Navigating Power														
Balancing Different		3	7					16	5		11	20		2
Navigating People with		4	11	1			16		2		8	12	3	3
Unearthing Hidden			2	1			5	2			4	8		
Creating Successful Outcomes														
Discovering & Wrestling w/			5		1		11	8	4			30		6
Making Sense of Project &		2	11	2	1		20	12	8		30		1	21
Managing Roadblocks			2					3				1		
Tackling Project w/		8	10	1	1		2	3			6	21		

**Figure 5:** Code Co-Occurrences

Other types of ambiguity were not noted frequently but seem to be areas that are noticeable and that may emerge later when additional research is conducted. *Understanding what I'm gaining* and *managing roadblocks* are the two primary types to which this applies. While

students encountered limited ambiguity that would fit into the *understanding what I'm gaining* category, I chose to keep this in the data analysis due to the fact that in interviews, I started to wonder if there is confusion about the IQP project and what one is supposed to gain from the experience. Multiple people commented on choosing their IQP intentionally so that it would relate to their major and future careers. For example, one student said, "I chose a project that was kind of major related. That's what I was looking into, something that would be helpful not only on the humanities aspect but probably something more in my major too." Multiple people referenced the IQP as either a humanities, humanitarian, or social science project even though all projects are also related to a science, technology, engineering, or math (STEM) field. This flagged for me that there might be more under the surface around students facing ambiguity understanding the true breadth of ways they will gain transferable skills for both their major and careers by participating in the IQP. *Managing roadblocks* was the second theme that I chose to leave in the data analysis. While infrequently identified as a type of ambiguity, I noticed that when students did encounter roadblocks, they often gave up or looked to someone with more power to navigate the ambiguity for them. For example, one student talked about not getting an email back from their sponsor and deciding not to put further effort into contacting them, assuming the lack of response was an indication of how important the sponsor felt the project was to them. Another participant stated, "If we couldn't contact someone [we would ask our advisors what to do]...Should we give up?" While the student had tried multiple times to get in touch with the contact, it was not an essential contact to the project but yet still did not feel comfortable on their own determining if they wanted to continue reaching out. Because this theme seems to have a connection with other themes related to people with power, I determined it was best to include it in the data analysis.

## **Aggregate Dimensions and Theory**

I developed three aggregate dimensions: *creating successful outcomes*, *navigating power*, and *wrestling with personal issues*. I define aggregate dimensions that connect related second order themes that emerge from the research. The dimensions are abstract constructs that are rooted in the raw data and can be discussed in the context of new and existing theory.

### **Aggregate Dimension: Creating Successful Outcomes**

This aggregate dimension is the most predictable in terms of where I assumed we would see ambiguity. As mentioned previously, project-based learning is inherently ambiguous as students must wrestle with processes and content applied to a real-world problem for which there has not been determined a defined solution. This aggregate dimension is also the most openly discussed of the three within the project network of student, advisor, sponsor, and others supporting the project. Students expect to get feedback here from their advisors and/or sponsors. For example, when discussing their team in the pre-project work, one student, “Our communication was not the best but we had a lot of feedback from our advisors so we kind of fixed that. We worked on that.” Students also talked about these dimensions among their peers. One participant said, “Every day for a solid five hours at the beginning of the day we would just start with [discussing] what we wanted to see and so that’s how we started designing stuff.” Students also were comfortable with asking their network questions about this dimension. When asked about advice for future IQP students, one participant said “...and if you have questions...just go. Don’t be afraid to ask [your sponsor] because you’re investing all this time into this project and you want to make sure that you’re going in the right direction.”

In our current preparation at WPI, we do extensive work on teams, roles, dynamics, making sense of information, and structures. Advisors in the pre-project work often brainstorm with students how to start their projects and make sense of the scope. One participant reflected

about the usefulness of pre-project work making sense of their project saying, “there were five 5-minute presentations which was good because you were forced to keep it short but get a lot of information in.” In many ways, this is the most understandable ambiguity as we tell our students to expect it without using the world ambiguity, pushing them into sensemaking. Rarely did I find students completely blocked by the patterns within this dimension. One participant said the most frustrating part of the project was the beginning stating, “We didn’t really know where to start,” but yet the team moved through that ambiguity and had a successful project. Another said “...our meetings were like end of the week. We’re like okay we did this but what are we getting into? And then like a couple weeks in we’re like, okay, like let’s just do this. It was like a good ‘this is what we’re doing moment.’” While students typically moved through these moments, they were not always able to reflect on how they did so as they were using skills that they don’t fully know how to articulate but could be truly helpful (if articulated) when applied to future work situations.

It was interesting to find that while outcomes (such as the final deliverable for the sponsor) comprised much of what was discussed, some students and/or teams had personal outcomes they hoped to achieve that were separate from the final product. For example, two people interviewed talked about the importance of not only delivering a final product that satisfied the sponsor, but also ensuring that the product would be useful for a long time. One participant talked about how they made their final product editable so it could be adapted for future years; they said, “I knew in order for it to be relevant for every year that it had to be editable.” Another participant said that the most successful and most consistent part of their project was the idea to find a way to make the project usable in the future. They said, “We had a conversation early on...on whatever tools we use for this project we might as well save and pitch to them later and give to them as a package.”



### **Aggregate Dimension: Navigating Power**

*Navigating power* as a dimension of ambiguity was comprised of three themes that, at times, proved to be challenging for students to navigate. While not as challenging as the dimension of *wrestling with personal issues*, *navigating power* had the second highest rate among students who felt blocked when trying to move through the ambiguity. All students experienced this dimension at some point in their project experience.

In making sense of *navigating power*, not only did students have to make sense of various types and levels of power to determine how to move forward, they also had to examine their own selves as professionals – or not – within the project context. Some students struggled to do this, often feeling like they had to always do what their advisors or sponsors wanted. One student said, “It was like you had to please two people because one was grading you and one you were actually there to help. So it’s like trying to meet in the middle.” Within this quote, the participant discussed the situation almost as if they were only implementers of work instead of the creators of work. Other students felt more comfortable disregarding power and continuously choosing their own path saying, “We politely ignored [our advisor]...that was my leadership.” While the sample size is too small to determine a relationship, it is interesting to note that this participant mentioned more often than others moments of getting blocked by ambiguity.

For this aggregate dimension, it is interesting to note that the ambiguity themes within this dimension often coexisted with project related ambiguity such as making sense (see Figure 5). This is not surprising as many of the examples that participants gave were related to having multiple opinions from advisors and sponsors on the direction the project should go and the way to make sense of their work. One student had a situation where the advisor wanted them to use one approach, the sponsor wanted another, and the students wanted a third. Part of why the students wanted the third option was because they didn’t think the other two approaches made

sense for the goal of their project. In that moment, the students chose to handle the ambiguity by moving in the direction that made the most sense to them but in doing so, disappointing their advisor (according to the student).

Additionally, within this dimension, students sometimes talked about ways that they were struggling with these ambiguities, but not always and certainly not as often as they discussed ambiguity related to *creating successful outcomes*. Some students acknowledged to those in power when the person with the power was creating ambiguity and utilized communication as a tool to make sense of it. One student said, “We ask both sides, like in front of each other because I think a lot of information kind of gets lost between the students and the advisors and sponsors.” Another said they would “talk to our advisors and be like this is what the sponsor wants and this is what you want. What do we do?” Other students didn’t speak up about the power dynamics and ambiguity and instead chose to comply or outright ignore whatever was asked of them. One student, previously quoted, said they would “keep whatever we had discussed [with the sponsor] previously and like just take like what the advisors were saying as like an additional.” Others felt concern with speaking up for reasons that included being graded on the project. For example, a participant described a conflict with their advisor and said they made the decision not to speak with the advisor until the very end so that their grade would not be impacted (among other reasons). The fact that communication strategies around ambiguity within this dimension were intermittently used could be in part why there were a good number of times where students were blocked.

### **Aggregate Dimension: Wrestling with Personal Issues**

This dimension was the most surprising finding of my research. Given that I had specifically chosen domestic, off-campus project centers for this research to intentionally cut out personal ambiguity that comes from living in new cultures, I did not anticipate the emergence of

such a theme. While not everyone experienced all types of ambiguity associated with this dimension, everyone experienced at least one type. With four themes in the dimension, seven out of nine students experienced two or more at various points in the IQP experience. Five out of nine participants experienced personal ambiguity completely unrelated to the project itself.

It is important to note the number of accounts that students gave related to trying to solve emotional and personal ambiguity during their project. While some students struggled with topics like transportation, knowing how to navigate their living situation, and dealing with negative emotions related to their projects, others talked about struggling with mental health or struggling to be a support person for a peer who was struggling with mental health concerns. Multiple students commented on the support they wished they could find. One student said, “[My advisor] had no idea my whole team was going through what they were going through” and then later “I think [the support person] needs to be like an intermediate, like someone who is not responsible for you and your project and who isn’t grading you...so they’re not like judging you on your performance.”

Students were least likely to get unstuck when they were struggling with ambiguity related to *needing personal support and guidance* followed closely by *handling project-related negative emotions*. Project-related emotions arose regularly and while some students were able to experience frustration or stress and move through it, many struggled to do. I considered students ignoring their emotions as being blocked by that ambiguity dimension; even though they appeared to move on and discuss other topics, similar themes of stress and frustration continued to emerge in their comments. For example, one participant struggled with project-related negative emotions throughout their project experience, commenting repeatedly on how annoyed they had been or how frustrating and upset something was; “a teammate would be [frustrating]...it was really annoying...it really bothered me and we were also frustrated with our

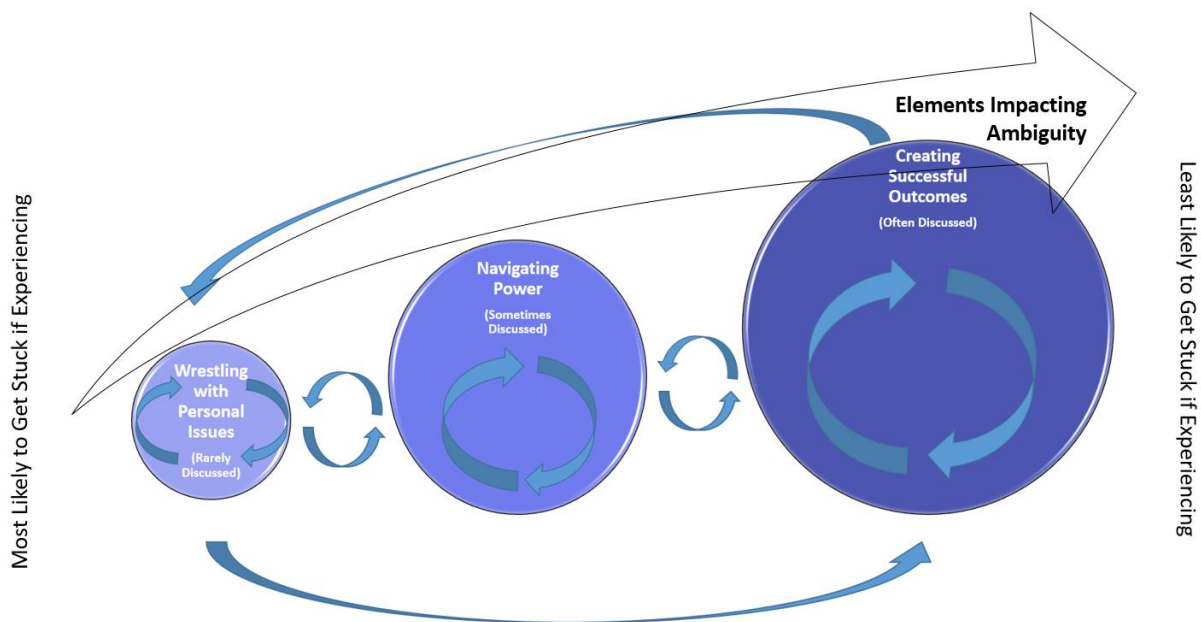
advisors many times...I think it was just, we would get frustrated with people mostly and with each other.” While they did feel they knew how to get support for their frustrating teammate, they did not know how to get support for the conflict with the advisors.

*Wrestling with personal issues* was the least discussed dimension within the project network of students, advisors, and sponsors. When it was discussed, it was often only discussed about team issues or at a very superficial level. When asked if the participants received help or sought out help, the response was often that they had not or had only done the minimum. For example, one student described a difficult personal situation that was impacting their ability to focus on the project. While they told their advisor about the situation, there was no further discussion or follow up discussions and the student just tried to get through the project without ever figuring out how to deal with the personal situation. Some participants described personal struggles that impacted the work that they never shared with their advisors or sponsors. As indicated in a previous quote, some of them felt that their advisors had no idea that they were struggling or that they were frustrated with them. It is possible that there is a relationship between the number of times the students seemed blocked by ambiguity on this dimension and the lack of communication with their advisor, teammates, or other support systems.

### **Aggregate Dimensions Intersection and Success**

After analyzing the data, through the iterative process of creating second-order themes (types of ambiguity) and then aggregate dimensions, it was clear to me that these three aggregate dimensions are constantly engaging with each other as shown in Figure 6. The size of the aggregate dimension in Figure 6 correlates to the frequency with which the dimension was discussed within the project network of student, advisor, and sponsor. It is impossible at this point in the research to analyze exactly when and how they connect, but per Figure 5, it is clear that there are significant co-occurrences of both the aggregate dimensions and the themes that

exist within them. Next, I determined that, based on student stories, the less students either felt comfortable or knew how to talk about what they were facing, the less likely they would be able to successfully engage in meaningful sensemaking or move through the ambiguity. Finally, while at a very preliminary level, I noted that students were also less likely to look for and/or find strategies that could impact their ability to move through the ambiguity in *wrestling with personal issues*, and more so likely to find strategies in the dimension of *creating successful outcomes*.



**Figure 6.** Encountering and Moving Through Multiple Types of Ambiguity

**Elements Impacting Ambiguity**

Throughout the stories of IQP experiences, embedded in the types of ambiguity, I often heard of contextual variables and strategies that appear to impact and/or influence students’ abilities to break through ambiguous situations and not remain stuck. While the data is too limited to say definitively what the appropriate theory for these elements is, it is worth telling the stories that illustrate interesting experiences that will guide further theoretical sampling and coding on this topic. I will share preliminary data on the most frequently emerging strategies and

contextual variables: communication, space, and support and guidance (asterisked variables in Table 2). I define a strategies as a tool students or others involved in the project could utilize to try to navigate ambiguity. I define contextual variables as elements of the project structure that impacted success at navigating ambiguity.

<b>Table 2: Contextual Variables and Strategies</b>	
<b>Strategies</b>	<b>Contextual Variables</b>
<i>Communication</i> *: talking through problems, ask questions, engage in dialogue	<i>Space</i> *: having a physical working space in same location as sponsor available to teams daily
<i>Support &amp; Guidance</i> *: receiving mentorship, modeling, shared brainstorming, and overall support for students by someone in power (typically advisor or sponsor)	<i>Prior Experience &amp; Passion</i> : bringing previous knowledge with them (some content but mostly soft skills) and excitement for the work
<i>Learning from a Network</i> : utilizing a network of people (including prior IQP teams) to gather information to make sense of problem	
<i>Laughing, Fun, &amp; Humor</i> : using humor and fun to navigate more difficult times	
<i>Flexibility</i> : maintaining open-endedness and showcasing adaptability in changing situations	
<i>Brainstorming</i> : thinking creatively and outside the box; being willing to put ideas out there	
<i>Time</i> : maintaining ability to wait for more information to come in before making decisions	
<i>Trust</i> : knowing that a student can count on someone to believe in them, encourage them, and support them	

Communication was the most noted strategy that intersected with various types of ambiguity. Examples of students successfully moving through ambiguity using strong communication skills or getting blocked in part because of a lack of communication came up multiple times. For example, one student talked about having trouble getting in touch with a sponsor. They shared that they worked as a team to keep reminding the sponsor that they needed

a response. They called themselves “annoying” but their team ended up routinely receiving the information they needed by email from the sponsor. Another participant also struggled to get their sponsor to reply to their emails. They said, “We didn’t really like actively pursue it because it would have been more work for us...the sponsor doesn’t want to help us out and we’re not going to put in this additional work.” As a result of this, the team did not complete a goal the team had for the project as they did not try contacting the sponsor again with the question even though this was an important goal to them.

The contextual variable of physical work space in or near where the sponsor worked was a surprising discovery. Some students interviewed had workspace in the same building as their sponsors, some had workspace near where their sponsors were, and other did not have any space near their sponsors. Participants who had space where their sponsors were located talked about popping into their sponsors throughout the day and asking questions. One participant said “just being able to be there all the time, like actually work in the same building as them, where you can go down the hall and it’d be like ‘oh, we have a draft of this. Can you look at it right now?’ That was really convenient because then it got everything moving super fast.” Those with space close to their sponsors also tended to make references to having a network of people within the sponsoring organizations of whom they could ask questions. For example, one student said, “we felt kind of lucky to be able to have a space in our sponsor’s office and even if our, if the CEO wasn’t there, there were other people in the team who might’ve been there that we could talk to.” For this team, being so close to their sponsor also meant that they had to learn to say no if their sponsor asked them to do something they didn’t have time to do, but overall the benefits appear to have been positive, such as the ability to ask questions and make sense of information with guidance on a regular basis.

With the exception of a group that was very strong in communication, those who did not have space near their sponsors seemed to be frustrated by a lack of access to their sponsor. One student said, “It was kind of like a limited relationship sometimes I felt, just because there were no offices.” A similar feeling was shared by others in the interviews. They also were more likely to mention that it was hard to get in touch with their sponsors regularly and hard to get responses to emails which could hinder the sense making process.

When students were challenged by something, both personally or related to the project, the strategy of receiving support and guidance seemed to make a difference. While most times this support and guidance came from their advisors, some students did talk about receiving support from people like the sponsors. This was particularly true for one student who had space in the same building as their sponsor and had challenges with their advisor. They felt their sponsors regularly provided mentorship, which insured that their sponsor was satisfied. This student said, “We always saw it like the sponsor was the most important thing. And even though we were being graded by our advisor, we always knew that if the sponsors were super impressed then the advisor would realize this was good for them.” Another student talked about a time their sponsor asked them to take on more work and it was the support of their advisor that pushed them forward. They stated, “[our advisor is] supportive and we can take the risk. When you feel like your advisor is supportive, that allows you to take a risk because if I fail, they’ll be fine.” Having advisors model appropriate behavior for the students provided guidance that they did not necessarily receive elsewhere and that helped them learn how they wanted to navigate ambiguous situations. For example, one participant said, “in the first couple of meetings, if our sponsor started to go off on a tangent, [the advisor] would always be the ones to help redirect the conversation...we kind of saw that and were like oh, okay, this is a thing we can do.” On the other hand, feeling like support and guidance was lacking also was noted by students. One



student said, “I didn’t think [an advisor] was very present. I didn’t think she cared very much...I wish we were closer with our advisors.”

All three of the identified strategies and contextual variables seemed to appear more regularly on the ambiguity themes of *making sense of project and related pieces* and *navigating people with power*. While the sample size is too small to say definitively what theory is emerging, these examples illustrate the need to further examine the strategies and contextual variables as well as the ways they intersect with other contextual variables and types of ambiguity. Higher level theory could also give insight into the meaning and impact of these variables on helping students navigate ambiguity.

## Discussion

As stated in the literature review, current research on ambiguity even in educational settings focuses heavily on such ideas as one's tolerance for ambiguity (Banning, 2003; Huber, 2003). Additionally, while project-based learning is an approach suggested by the literature to increase a student's tolerance for ambiguity (Banning, 2003; Huber, 2003; Tallent, 2016), it does not focus on helping students learn to identify ambiguity nor provide tools for managing or responding effectively to it. In a world where students are more marketable to future employers when they have had project-based learning opportunities (*Fulfilling the American Dream*, 2018 ), we need to rethink how we train our future professionals to identify and engage with ambiguity in any setting.

Building on the research of Lingo and O'Mahoney which examines types of ambiguity and how this ambiguity is experienced in a project-based career (2010), this study begins to point to new ways of thinking about the ambiguity as a dynamic concept within project-based learning experiences. What emerged from the research was theory around the types of ambiguity students encounter and how they experience these types of ambiguity. Additionally, this research identified times when students became blocked by ambiguity and which strategies and contextual variables appear to impact students' success at navigating ambiguity. The findings build preliminary grounded theory that helps the field better understand ambiguity as a multifaceted concept experienced across networks instead of as a static concept that refers only to the individual. None of the findings suggest that tolerance for ambiguity during project-based learning is rooted in a particular personality trait; rather how students navigate ambiguity changes regularly depending on both the type of ambiguity at hand, the situational context, and who is involved.

The findings of this research also point towards the importance of understanding ambiguity within an educational context. Because many people are involved in WPI's IQP experiences, it is not enough to just understand types of ambiguity students encounter; understanding how students experience ambiguity at the intersection of themselves, their peers, their faculty advisors, and their real-world project sponsor is important for understanding how ambiguity might be managed on project teams and what role faculty advisors can play to support the process.

This study also suggests that there may be particular elements at play in ambiguous situations that impact students' success at successfully navigating ambiguity. These strategies and contextual variables warrant further research as they have the potential to lead to tools that can help students navigate ambiguity. They also can lead to ways that faculty advisors can best support their advisees.

In education, there are many skills we think of as competencies that students can develop over time. For example, writing and critical thinking skills are both skill sets incorporated into education from PreK-12 through higher education. While some students may naturally be better at these skills than others, all students are provided tools and resources to improve in these areas. Based on the preliminary findings of my research, navigating ambiguity should be treated no differently than writing and critical thinking skills.

### **Aggregate Dimensions**

Due to the limitations of sample size in this pilot study, further research into the three aggregate dimensions is needed to better understand deeper trends across different situations. Perhaps most critical is the aggregate dimension that deals with emotions and the personal realm. In general, education sometimes thinks about more personal topics as separate from educational experiences and processes. My research suggests that in terms of navigating ambiguity,

understanding personal issues and how students experience these elements is more deeply connected to project-based work than previously anticipated. Based on my findings, it is important to think about ambiguity across both the project and the person working on the project.

In terms of the aggregate dimension of *navigating power*, it makes sense that not all students feel comfortable navigating the power dimension as many are used to a more traditional classroom setting with the faculty member as the leader of the classroom. This became evident when one student encountered advisors giving conflicting feedback. They wondered, “Whose comment do we pick?” They then informed me that their team figured out which advisor would be grading them and towards the end of the project, just always picked that advisor’s comments to try to receive a better grade. This approach to mitigating the ambiguity of having conflicting feedback is an example of being blocked by ambiguity on some levels. While this approach may have been successful for this project, if the intent is to prepare students for the real-world, it is important to help them fully navigate difficult situations like receiving conflicting information from two people in authority or with greater power and making sense of that information to move forward in the project. In their future careers, they might be evaluated by both of these individuals and have to develop stronger ambiguity navigational skills.

It was interesting to find that students were most successfully able to navigate ambiguity in the aggregate dimension of *creating successful outcomes*. In my findings, I suggested this is due to the fact that there is often significant communication throughout the project network (of teams, advisor, and/or sponsor) about this dimension. While the word ambiguity is not regularly used to describe what is happening here, much attention is given to discussing the scope of the project, figuring out how to create successful teams, and learning to make sense of new information. This further strengthens my argument that ambiguity should not be measured by

how one tolerates it but instead as a skillset that is teachable when we intentionally seek to provide tools and support for student learning in this area.

Lastly, the dimension of *navigating power* is interesting in great part because it is something that is inherently part of higher education experiences. Within project-based settings, especially those with real-world sponsors, students are being graded but yet are also trying to learn to become experts capable of solving projects that don't have a defined solution. I would argue that the role of the student as an expert within the project is not fully defined and thus they wrestle with the idea of should they push for their desired solution or just listen to those with more power. This is an important question to learn more about and discuss openly with students.

### **Future Research**

Because of the limited sample size of this study, participant demographics were not discussed. From the many emails I sent seeking participants, almost all who responded were women so it is critical to look at ambiguity with a larger, more diverse group of students to investigate if any trends across demographic groups such as gender and race/ethnicity occur. I feel it is also important to study this topic for students who are first-generation in their families to go to college and do not have families who have previously navigated the world of higher education.

Additionally, it is my hope that future research will take what was learned in this pilot and continue to study ambiguity in project-based learning. It will be important that further theoretical sampling and data saturation occurs to draw deeper conclusions from the work. Additionally, to better validate the work, a second person should code the interview transcripts independently from my codes to continue to refine the work.

Future work on this project will hopefully include research studying participants in real-time, project-based experiences. Interviews and journal entries done in real time when

ambiguous situations are arising are likely to give deeper insights into the aggregate dimensions. This information will help to deepen the aggregate dimensions.

Another area for future research is more work that aims to more deeply understand the idea of students getting stuck in ambiguity. As shown in Figure 6, students appear to get more stuck in *wrestling with personal issues* and less stuck in *creating successful outcomes*. While I believe part of this is impacted by how much students and their networks communicate about the ambiguity faced in these issues (little communication in *wrestling with personal issues* and more communication in *creating successful outcomes*), there may be other reasons for patterns of where students get stuck that could be more deeply investigated.

Furthermore, additional investigation into elements that impact ambiguity in project-based learning is needed. It is important to not only investigate what the most impactful contextual variables and strategies are for mitigating ambiguity, but also to understand which of these elements have the greatest impact on a student's ability to move through ambiguity. This information should not be used to lessen the amount of ambiguity students experience but instead to help model for students why they might be experiencing ambiguity and how they might work through it.

One study on ambiguity begins to tackle this work of examining strategies that might impact students' ability to navigate ambiguity, although it does not examine determining types of ambiguity students face. The study investigates the use of comedy improvisation and its impact on navigating ambiguity within an urban planning educational experience (Inam, 2010). Inam says the urban architectural students (all in-service professionals) originally "felt uncomfortable about...[the] deliberately designed ambiguity [of the urban design class]. The comedy improv exercises helped them to enjoy the process more and discover abilities they may not have recognized themselves" (2010, p.23). This type of research, examining the value of tools that

may help students feel more comfortable navigating ambiguity within an educational setting, coupled with further work from this study, could help in the development of impactful strategies to teaching students how to navigate ambiguity. Once future research determines the most impactful elements that impact students' abilities successfully move through ambiguous situations, it will be important to build on Inam's study and creatively look at what tools best help student internalize these elements and build skills that they know impact their ability to handle ambiguity.

All of the above dimensions deal with students trying to learn to make sense of ambiguity. Current research on sensemaking, or "the process through which people work to understand issues or events that are novel, ambiguous, confusing, or in some other way violate expectations" (Maitlis & Christianson, 2014, p.57) does not consider how students specifically learn to manage ambiguity (Maitlis & Christianson, 2014). Further research that connects findings from this thesis to research on sensemaking may help to deepen the understanding of how students process ambiguity.

While more research is needed on the experiences of students in project-based learning, additional research is also needed around how faculty and even the project sponsors experience ambiguity. This information will help faculty and sponsors to have a greater awareness of their own ambiguous experiences in the project and how they tend to react to these situations. This extension of the research will also help to develop faculty specific tools and strategies that support students and other stakeholders in these situations.

## **Conclusion**

In conclusion, this research began the process of filling large research gaps around ambiguity in undergraduate, project-based learning experiences. It highlighted not only types of ambiguity that emerged from the interviews, but also built preliminary grounded theory around how the types of ambiguity interconnected and impacted students. Lastly, the research found ways that students successfully and unsuccessfully navigated the ambiguity and presented preliminary elements that impact this navigation. Overall, the research concludes that it is important to move away from talking about how students engage with ambiguity as their tolerance for ambiguity, and instead move to similar language that one would use to describe any skill-building learning process.



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## Appendix

### Appendix 1: Interview Protocol - Retrospective Interview Questions – Students

1. Grand tour question: Can you tell me about your IQP project from beginning to end? How did the project unfolded—in terms of scope of project, understanding of the question, team dynamics, relationship with your sponsor? Relationship with your advisor?
2. Let's dive in a bit more about your team dynamics... What were the dynamics like at the start? How did that change (if at all)? What did you like about the way your team operates? Why? What would you change to improve the dynamics? Why? (\*Probe for how communicate, how divide up work and roles, commitment to the project, power dynamics, etc.)
3. What kinds of questions or concerns did you usually bring to your faculty advisors? Why? What questions did you NOT bring to your advisor and why?
4. Now let's turn to your sponsors...How did you interact with them? What questions or clarifications did you talk to them about? Why?
5. Is there any ways you wish you had more, less or different support from anyone involved?
6. Can you talk to me about two or three times you've felt a lot of emotion during the project so far? Tell me about those times.
7. When did you feel the most success on this project and why? When were you the most frustrated on this project and why? What were the most unexpected parts of your IQP experience? What happened exactly as you thought it would? What do you wish you knew more about prior to coming to IQP?
8. Projects can be more or less open-ended in nature—in terms of outcome, process, relational dynamics, etc... Could you share with me some of the open-endedness your teams experienced? How did you handle this? How did this make you feel?
9. What are two pieces of advice you would give to future IQP teams about handling ambiguity in the IQP? What are two things you wish you had learned or done before coming to IQP that would have better helped you manage ambiguity in your project?