What Do Students Learn about Innovation?

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Introduction

Innovation is a complex construct. It spans a variety of processes and tasks [1,2], project and product outcomes [3,4], personal characteristics and behaviors [5,6], and environments/contexts [7]. As such, supporting the innovation-related development of engineering students is a complex task. Educators must identify key content among the varied and complex processes, outcomes, personal characteristics, and contexts of innovation and develop pedagogy that appropriately captures the nuance and challenge of these elements for engineering students. A recent study, for example, found variation in objectives, focus on processes and outcomes, and learning modalities in innovation programs [8]. Supporting the development of innovation behaviors is further complicated by variety of ways engineering students understand innovation [9] which vary across a complex array of settings and experiences [10,11].

The purpose of this study is to unpack the elements that engineering students attribute to their understanding of innovation. In addition, we utilize these understandings to provide a typology for educators and researchers interested in identifying how to prepare or teach students to learn about innovation. More specifically, we ask:

1. What distinct aspects of innovation do engineering students report learning about during substantial innovation project experiences?
2. How do these aspects of innovation map to a typology of innovation understanding among engineering students?

Literature Review

Innovation is a complex phenomenon that has been described in a variety of ways across a variety of contexts [2–4,12–14]. In part, this has led to widespread inconsistencies. The lack of agreement may stem from the complexity of innovation. Innovation may refer to specific phases and activities [1], behaviors and characteristics [5,6], organizational and team contexts or processes [7,15], or an amalgamation of these elements [2]. Innovation can also be described from multiple perspectives, such as users/customers, organizations, communities/societies, or markets [4]. Innovation may even be expressed as one of several unique constructs that vary based on the type of solution being developed and/or implemented (e.g., technological innovation, product innovation, business-model innovation [14]).

The multiplicity of competing understandings of innovation further complicates the question, "How can we teach innovation?" Duval-Couetil and Dyrenfurth [8] analyzed eight dedicated innovation programs, some of which focused directly on engineering students. They identified nine distinct categories of program-level learning objectives, including (1) creativity, (2) problem solving, (3) context/environment, (4) communication, (5) innovation process, (6) interdisciplinary team skills, (7) professional and preparation, (8) leadership, and (9) experiential learning. While these objectives were largely variable, the programs evidenced many common theories, approaches, methods, and tools for enhancing innovation. In brief, this suggests that "teaching innovation" is a multi-faceted endeavor. Even more, it suggests that an explicit focus on innovation will simultaneously incorporate many other foci that are pertinent to engineering curricula and accreditation.

While studies and programs that focus on innovation are noteworthy, students often become “innovators” even when innovation is not an explicit program or learning objective. Most notably, students engage in a variety of innovation-related activities and lessons in established engineering courses [16]. This is most recognizable in various design and project-based learning experiences [9]. In such curricular experiences, students are tasked to create a novel solution to meet variable criteria, experiment, and iterate; activities which are fundamental to innovativeness and that have been expressed by noted innovators as key to their development [17]

Nonetheless, while innovation may be an indirect benefit of myriad engineering curricular efforts, instruction may be framed in such a way as to encourage [17] (or discourage [18,19]) students’ development of innovative behaviors. Some scholars have emphasized innovation as a desirable outcome of instruction or learning environments [20,21], others as the demonstration of certain abilities [22], and yet others as appropriate conceptualizations [23]. As researchers, we might ask how goals directed towards these distinct ends vary in terms of outcomes. It might be that the ideal modality involves the integration of multiple efforts, as studies of expert innovators suggest that they demonstrate and deploy a variety of approaches and mindsets concurrently [5,6].

Theoretical Framework

The view of learning established in this study connects to a non-dualist ontology [24,25]. This framework views knowledge/understanding not only as internal characteristics of the learner or concrete aspects of the phenomenon that can be learned. Instead, understanding a phenomenon, such as innovation, is an interplay between the individual and the phenomenon (i.e., an individual’s way of experiencing the phenomenon). Learning, then, is based on (1) the unique experiences, perceptions, and mindsets one brings to their encounters with the phenomenon and (2) the aspects of the phenomenon that are present, or at least perceived to be present, during these encounters [25]. These elements coalesce (and change over time and new encounters) into a “way of experiencing” the phenomenon that is always unique, incomplete, and in flux [25].

Aligning with a non-dualist ontology and framing learning in terms of ways of experiencing presents several implications for this study. First, this framing acknowledges that knowledge can be fragmented but that aspects of a way of experiencing are integrated. Thus, students may be aware of aspects of innovation, but these aspects are not learned until they are connected to other aspects of students’ awareness in meaningful ways. Second, a way of experiencing represents a lived understanding that ties together elements of the phenomenon and how they have been experienced. In this way, learning is more closely tied to action, approach, and experience. For example, students may be aware that innovation takes time and proceeds iteratively through several phases. However, until they have participated in such extensive projects or found distinct ways to connect that awareness to their experiences, that awareness is not part of their way of experiencing innovation. Thus, framing learning in terms of a “way of experiencing” places conservative bounds on what constitutes student learning but also ensures that such learning is not superficial or disconnected.

Methods

To address the research questions, we employed thematic analysis [26] to a set of critical incidents representing changes in the ways engineering students experienced innovation. These critical incidents were identified in a previous study [11], but the new focus on discrete aspects of learning, aligned with the theoretical framework, formed the basis for the development of the typology of engineering student innovation learning.

Participants

Participants included 16 engineering students enrolled in a large Midwestern university (see Table 1). These participants were selected among a pool of 33 participants based on differences in their holistic ways of experiencing innovation found in a previous study [9]. Where possible, sampling prioritized differences in academic major, year in school, gender, and types of innovation experiences. These dimensions of variation were based on observed differences in previous studies [9–11]. Such variety was desirable to ensure maximum coverage of the types of learning experienced by the participants.

Data Collection

Students participated in a 1–2 hour semi-structured interview. Interviews were developed for a previous study [9] to elicit participants' experiences with and conceptualizations of innovative design. The interviews occurred in six stages: (1) participant background, (2) initial definition of innovation, (3) experiences during innovation projects, (4) comparison of innovative and non-innovative projects, (5) general conceptions of innovation, and (6) closing thoughts. An increased emphasis was placed on participant background, empathy for the participant, and increased follow-up questioning to provide additional personal and contextual detail.

The richness and focus of these interviews proved useful for the current study, as participants thoroughly described several innovation experiences and connected these experiences to their understanding of innovation. Further, the emphasis on background, empathy, and follow-up questions supported deeper and more comprehensive portraits of each participant for the current study, which supported a more holistic understanding of the distinct "pieces" of learning and how they fit a more comprehensive whole.

Participants also completed a short multiple choice and open-response survey which primarily included demographic information. Participants received a small cash incentive for their time. All interviews were audio-recorded and later transcribed for analysis.

Table 1. Participant Overview

Pseudonym	Way of Experiencing Innovation	Major	Year	Gender	Engineering Innovation Project Experience
Chris	Develop radically new technology	Nuclear	Graduate	Male	Long-term personal start-up
Dylan	Develop new technology for societal progress	Biomedical	Senior	Male	Senior design, Internships
Ella	Develop new solutions for client benefit	Industrial	Senior	Female	Internships, Service learning, Personal projects, Service learning club
Elon	Develop new solutions to make a difference for users	Mechanical	Senior	Male	Co-op, Internships, Sophomore design, Design competition club team, Personal projects
Esteban	Identify and fill a market gap	First-year	First-year	Male	Self-initiated start-ups; First-year engineering design projects
Hannah	Redesign to meet stakeholder criteria	Chemical	Sophomore	Female	Service learning, Design competition club team
Jerry	Realize technological function	First-year	First-year	Male	Design competition club team; Personal projects
Jessica	Identify and fill a market gap	Biological	Sophomore	Female	Course projects, Club projects, Personal projects
John	Develop radically new technology	Acoustical	Senior	Female	First-year engineering course, Service learning, Internship
Maria	Clarify and solve a stakeholder problem	Industrial	Junior	Female	Internship, Class Projects, Student Organization
Matt	Realize technological function	Mechanical	Senior	Male	Sophomore design, Service learning
Sarah	Develop new solutions to make a difference for users	Chemical	Senior	Female	Service learning, Internships
Snow	Redesign to meet stakeholder criteria	Mechanical	Senior	Male	Co-op
Taylor	Develop new technology for societal progress	Computer	Senior	Female	Junior-level course projects, First-year engineering course, Internship, Student organizations, Personal robotics project
Tony	Clarify and solve a stakeholder problem	Industrial	Senior	Male	Service learning, Senior design
Verdasco	Develop new solutions for client benefit	Mechanical	Junior	Male	Service learning, First-year course project

Data Analysis

Data analysis began with identification of critical incidents that represented changes in participants' ways of experiencing innovation. This analysis and the resulting incidents were reported in a previous study [11]. In the current study, we iteratively and inductively identified incidents based on three criteria, per established guidelines of critical incident technique [27]:

1. Detailed description of an experience or series of experiences that are directly attributable to the aspect(s) of their way of understanding or approaching innovation.
2. Description or demonstration of one or more aspects of understanding or approaching innovation. (Note: Direct connections to innovation were preferred, but this connection could be inferred from a participant's way of experiencing innovation (as seen in the previous study [9]) or contextual cues in the excerpt or elsewhere in the interview.)
3. A clear change, refinement, or crystallization in one's view of innovation, especially as it addressed aspects of that participant's way of experiencing innovation.

A total of 140 incidents were identified and categorized based on how learning about innovation occurred [11]. Each incident spanned between one paragraph and four pages of transcript and featured a discussion of anything between a personally meaningful "eureka" moment and a subtle revelation based on repeated and/or long-term exposure to one or more facets of innovation.

In this study, we thematically analyzed [26] the previously identified 140 critical incidents. Thematic analysis is an inductive process that supports the identification of patterns within a dataset. Here, the patterns (themes) were meant to comprise categories that represented unique features of student learning about innovation. We did not base analysis on any a priori codes or themes to allow results to be situated in students' social reality, Per the theoretical framework, we recognize that this socially reality is a co-construction that is dependent on both the individual's way of experiencing a phenomenon and the phenomenon itself. By adapting Braun and Clarke's [26] recommendations, we were guided by a five-stage process:

1. **Reading and rereading the critical incidents** – This was to re-familiarize researchers with the scope and details of the data. As researchers were familiar with these data from a previous study, it was important to refresh perspectives with the new research focus in mind.
2. **Generating emergent codes/elements** – These codes were developed a priori and meant to represent any aspects of innovation that participants learned (i.e., integrated into their way of experiencing innovation) as a result of the critical incident under review. Critical incidents could feature more than one code if distinct aspects were learned. We applied codes to critical incidents when the incident provided potential evidence of learning. Further, coded passages must have resonated with a participant's broader way of experiencing innovation as evident in the entirety of the transcript.
3. **Identifying themes and elements –** Codes (elements) were reorganized, refined, and categorized to identify patterns within the aspects that students learned about innovation. These patterns represented the themes that would form the basis of the typology presented in this study. Each theme was comprised of multiple codes or elements that added nuance or clarity to the overarching theme.

4. **Checking themes** – We cross-compared themes and their underlying elements to ensure (a) similar aspects were grouped together and (b) themes conveyed different types of student learning related to innovation. Thus, themes were checked intrinsically by asking, "Is this an accurate depiction of the comprising elements and critical incidents?" Themes were also checked holistically by asking, "Does this comprehensively describe the learning apparent across the elements and critical incidents?"
5. **Building narratives** – This step further described the themes in a typology of student innovation learning. The focus here was twofold: (a) to accurately convey the themes and their overarching structure and (b) to present sufficient detail to support understanding and utility in the engineering innovation teaching and research communities.

Results

We generated six themes: (1) Definition; (2) Process; (3) Approaches and Mindsets; (4) Necessary Conditions; (5) Realities of Innovation; and (6) Self as Innovator. In total, themes contained 51 elements. The following sections describe each theme and the associated elements.

Definition

This theme represented students coming to define innovation experientially rather than based on external sources (e.g., social media, engineering textbook, idealistically). Students described distinctions between engineering innovation and other engineering work (e.g.., "routine" course projects, internships, research experiences). They did so primarily by identifying characteristics of innovative solutions and, in some cases, features or outcomes of the processes that led to those solutions. The learning related to this theme often involved moving from a self-identified naïve understanding to a more informed understanding. The more informed understanding generally connected to features of projects that students had personally led or participated in.

Table 2. Elements Comprising the Definition Theme

Element	Description
Balances needs of many stakeholders	Recognizing that innovation involves many stakeholders (e.g., users, individuals in the company, engineers) and that innovative solutions address the needs of each.
Change for people	Defining innovation based on the degree to which it helps users or changes their lives and/or environments.
Novel connections between existing ideas	Recognizing that innovative solutions often represent unique and simple associations.
Personal growth	Recognizing that innovators develop new skills, knowledge, and understandings throughout an innovation project and viewing these developments as defining features of the innovation experience.
Solution to novel problem	Defining innovation not by features of the outcome but based on the degree to which the target problem has been previously addressed.
Taking a novel approach	Determining innovation based not on the outcome but how it was developed.
Technological advancement	Defining innovation based on scale of technological developments. Thresholds for degree of technological advancement differed from incremental/local to global/radical.
Viable	Recognizing that regardless of creativity, technical achievement, and/or user satisfaction, innovations must be viable in the developing organization/team.
Wide scope	Taking a broader view of the scale of innovative solutions. Often paired with other elements to represent recognition that innovation comes in many forms.

Nine elements comprised this theme (Table 2). Each of these elements provided one facet of how a participant defined innovation. Participants often, but not always, described multiple elements. These were not necessarily elements that participants regularly sought in their engineering work, but ways to assess, often post hoc, whether a project or experience was innovative. Further, this theme demonstrated students learning that innovation may not necessarily be the creation of an engineering solution alone, but also that innovation may be defined in terms of the effects of the development and implementation has on people and groups. Some effects were personally meaningful (e.g., *personal growth*, *novel connections between existing ideas*) whereas others indicated socially beneficial outcomes (e.g., *balances needs of many stakeholders*, *change for people*).

Process

This theme described engineering and design phases or activities that participants viewed as part of the innovation process (Table 3). These elements were not the only activities participants completed or recognized as occurring during innovation work. Rather, they were the elements that participants described as the most critical to and representative of the nature of innovation. The learning presented here featured understanding a phase's essence, mechanics, and overall connection to innovation. For example, students identified how ideation contributed to innovation, broadly, as well as the underlying characteristics of the ideation process that were most critical.

Table 3. Elements Comprising the Process Theme

Element	**Description**
Conceptualizing solutions	A key activity in the innovation process is finding promising ideas to pursue. This activity is essential because it is the genesis of innovative solutions.
Data gathering	A key activity in the innovation process is collecting operational data within the implementation context. This activity is essential because it may produce insights that inform scoping of innovation problems or eventual solutions.
Ideation	A key activity in the innovation process is generating new ideas, often through proven techniques or creative mindsets. This activity is essential because it opens innovators to new possibilities and may support conceptualizing solutions.
Macro-iterative cycle	A key feature of the innovation process is building upon the ideas, solutions, and contexts from previous innovation projects and creating new solutions and contexts that can be built upon.
Marketing	A key activity in the innovation process is considering the target audience and modifying/detailing the solution to improve acceptability. This activity is essential because innovative solutions must be accepted and used to become true innovations.
Problem-finding	A key activity in the innovation process is identifying a market gap, user need, or other problem opportunity. This activity is essential because innovations must address relevant, not trivial, problems.
Realization	A key activity in the innovation process is concept realization. This activity involves iterative technical development and is essential because an innovative idea must be implemented to become an innovation.
User research	A key activity in the innovation process is user research. This activity involves interaction with and/or consideration of target users, typically early and often throughout the innovation process. This activity is a defining feature of the innovation process for those defining innovation as change for people.

Approaches and Mindsets

This theme described the essential approaches and individualized mindsets that participants recognized as contributing to innovation (Table 4). Often, the elements comprising this theme connected to the *Process* theme by providing additional detail on how to be successful within specific phases or activities; other elements spanned the entire innovation process.

In general, learning in this theme extended beyond realization of the importance of these comprising elements. Instead, learning came from a place of personal experience, as students embraced or internalized an approach or mindset. There were, however, some differences in the degree to which participants accepted and inhabited these elements. For example, *Let go of selfish innovation* was typically an important realization for participants, but one they often struggled to persistently embrace.

Table 4. Elements Comprising the Approaches and Mindsets Theme

Elements	Description
Apply critical thinking	Critical and reflective thinking are essential at key points in the innovation process to ensure one is on the right path.
Avoid fixation	Individuals can become stuck in specific ways of thinking (e.g., organization, disciplinary) or become overly attached to a specific design concept. They must realize when they are fixated and seek/apply alternative perspectives.
Balance feasibility and novelty	Innovation involves developing concepts that can be implemented but are also different enough to produce meaningful change. Innovators need to know when to minimize one aspect to sufficiently improve the other. Different innovators find different balances.
Balance user needs and technological change	Innovation involves meeting user needs often through technological change. Innovators should not pursue greater technological advancements if they do not produce meaningful change for users.
Be willing to take risks/go above and beyond	Innovation is inherently riskier and more complex than more routine projects. Participants must embrace this risk and apply effort beyond typical projects.
Build trust with users	Innovation involves meeting user needs and, thus, requires deep understanding of users and their contexts. Continued access to these contexts requires a positive and symbiotic relationship. Trust built on one project can also support later innovations in the same community.
Consider context and the whole user base	Innovators may become narrowly focused on one aspect of an innovation context or one sub-group of the user population. Taking a more comprehensive focus can improve the efficacy of innovation outcomes.
Do your own thing	There is no “roadmap” to innovation; innovators must find their own path, which often differs from project to project. Innovators must leverage their unique expertise and perspectives to find this path.
Let go of selfish innovation	During innovation, innovators may be tempted to pursue concepts they alone value (e.g., novel, technically interesting). When these paths do not align with user, team, or company needs, they must realign their focus to said user/team/company needs.
Support effective teamwork through systems and structures	Innovation projects can involve many participants and complex networks of teams and sub-teams. Organizational and motivational structures are needed to keep the whole team on track and productive.
Think outside the box	Particularly during ideation, one must be willing to envision and entertain potentially infeasible, unviable, and undesirable ideas because they have the potential to support eventually innovative solutions.
Use an unstructured or fluid process	It is important to remain flexible during innovation in order to respond to new developments, pivot when necessary, and not become stuck in a way of thinking.

Necessary Conditions

This theme complemented the *Approaches and Mindsets* theme, but here the focus is on personal and environmental conditions that supported innovation approaches or mindsets. The five elements herein (Table 5) were typically framed by students as requisite to innovation work (e.g., "You must have *freedom of thought* to successfully identify and develop innovative ideas."). Like previous themes, this theme did not present distant or hypothetical knowledge. It emphasized conditions that participants attributed to successful innovations, or conditions that were missing from their innovation failures.

Table 5. Elements Comprising the Necessary Conditions Theme

Elements	Description
Freedom of thought	Innovators must be given the appropriate opportunity and agency to take on new perspectives, apply their unique expertise, and identify/develop "crazy" ideas.
Organizational/team support	Innovation often occurs within team and organizational settings. Support from these entities in the form of opportunities, collaborative and nurturing environments, and support for innovation projects is vital to innovation success.
Passion/responsibility	Innovation cannot be driven by engineers who are not passionate about or do not feel responsible for the project. Innovators must find their own passion/responsibility and support this in others.
Sufficient expertise	Innovators must have expertise (e.g., technical, social) in areas relevant to the innovation context, process, and idea.
Sufficient resources	The level of innovation possible is connected to the technical, physical, and knowledge resources available to the innovator/team.

Realities of Innovation

This theme presented non-trivial realizations about the nature and experience of innovation. Elements of this theme (Table 6) provided additional guidance or understanding for participants as they completed and reflected on their innovation work. These elements often connected to individual elements of the *Approaches and Mindsets* theme, but here they offered wisdom that informs as they embrace mindsets and approaches. For example, *Innovation comes from need, not personal fancies* reminded participants to *Let go of selfish innovation*.

Table 6. Elements Comprising the Realities of Innovation Theme

Element and Description
Criteria shape the innovation process
Innovation comes from need, not personal fancies
Innovation is complex and must be managed
Innovation stems from a problem or opportunity
Innovation takes time, be patient
Innovation work is not always innovative/fun
Synergy between engineering and business is critical to innovation
Technology provides a platform for innovation
There is no one way to be innovative, you find your own way
You can't try to do too much
You don't need to start from scratch, innovation often comes from simple, novel associations and extensions
You shape innovation through interest, expertise, and unconscious decisions

Self as an Innovator

This theme represented the participants learning about themselves as they contributed to innovation (Table 7). While each of the previous themes incorporated some aspect of the self—for example, participants recognized the need to personally utilize the approaches and take the mindsets with the *Approaches and Mindsets* theme—this theme focused specifically on developing one's own sensibilities, motivations, and self-awareness in relation to their innovation work. This theme placed the self as central to the innovation process and supported deeper understanding of how one could, and preferred to, contribute to innovation. For example, an important milestone for many participants was the *Can contribute to innovation* element, where they learned that innovation was not just a distant process completed by more experienced people but something in which they could also participate and excel.

Table 7. Elements Comprising the Self as Innovator Theme

Element	Description
Can contribute to innovation	Students with previously limited experience and/or self-efficacy recognized that they had the ability, opportunity, and temperament to contribute to and/or lead innovation.
Can develop expertise in process	Students, who typically believed innovation required some threshold of expertise in certain areas, recognized that they could develop substantive expertise during innovation projects, often through increased motivation and active and social learning opportunities.
Innovation supports personal goals/interests	Students recognized that participating in innovation projects often fulfilled one or more personal goals or interests. These included, but were not limited to, making a difference for others, creating interesting and technologically advanced solutions, building businesses, and working with others.
Personal motivation to innovate	Students recognized unique facets of innovation work that motivated them to dedicate the necessary time and physical, emotional, and cognitive effort.
Unique ability to contribute	Students recognized that not only could they contribute to innovation, but became increasingly aware of the unique expertise, competencies, and perspectives they could bring to innovation projects.

Closing Discussion

This paper presented a typology of what students learn about innovation through analysis of critical incidents based on a non-dualist ontology. This typology was meant to provide a framework for what students do and can learn about innovation but with a unique focus on "way of experiencing" rather than externalized knowledge or specific skills. The typology consisted of six themes (*Definition*, *Process*, *Approaches and Mindsets*, *Necessary Conditions*, *Realities of Innovation*, and *Self as Innovator*) that represented the distinct types of learning students experienced and 51 unique elements of learning that comprised these themes. The latter were not meant to present a comprehensive picture of all the concepts/aspects students can and do learn about innovation. Rather, they provide context for the overarching themes and serve as a starting point in identifying ways to teach innovation in the engineering curriculum.

It is not surprising that four of the themes (*Definition*, *Process*, *Approaches and Mindsets*, and *Necessary Conditions*) related to four lenses through which innovation is commonly viewed, i.e., product, process, person, and press [2]. However, the framing of the themes provided an experiential and personal focus to these lenses. The personal focus continued with the addition of the *Self as Innovator* theme. Additionally, the *Realities of Innovation* theme highlighted the wealth of nuanced and often tacit knowledge that students can glean through their encounters with innovation. Collectively, these themes presented innovation as not simply something to learn about in abstract modalities, but something to experience with an embracing mindset. This further suggests the importance of diverse, meaningful experiences within an innovation learning trajectory [8,10,11,17], specifically if students are to progress to more comprehensive ways of experiencing innovation.

Interactions between the themes also seem important. While correlations were not explored in depth, especially notable overlaps were described throughout this paper. Similarities in individual elements within each theme demonstrate connections inherent in students' ways of experiencing innovation, which suggests that developments in any one theme are likely to be supported by/co-evolve with developments in other themes. Cross-theme relationships were also notable, with many elements and themes having an apparent direct relationship to the *Approaches and Mindsets* theme (and thereby, an indirect relationship to all other themes).

The data analyzed herein largely involved student experiences wherein "innovation" was not an explicit or predefined outcome. Nonetheless, the findings highlight a diversity of aspects of innovation that students reported learning. In short, this suggests that innovation is inevitably being learned by students, whether explicit curricular program objectives are directed towards this end. However, active-based learning strategies lend themselves to support deeper reflections on innovation as evidenced in the themes *Necessary Conditions* and *Realities of Innovation*.

We would also posit that the ideal mode for promoting student perceptions of *Self as Innovator* would also require that students engage in authentic and personally meaningful innovation experiences. With that said, recent scholarship on engineering identity has also described the importance of performance/competence for success, although these considerations alone are insufficient for encouraging the pursuit of an engineering career [28]. Rather, performance and competence are mediated by interest and recognition. As we draw a parallel, it may be that confidence in one's ability to *be* innovative is insufficient for identifying as an innovator. Simultaneously, one might also need personal and external recognition, and one might also require an interest in innovation in of itself. The latter aspect is captured by several of the elements encapsulating the *Self as Innovator* theme, whereas the former is largely absent.

Finally, these findings may inform specific prompts for promoting innovation. For example, educators might utilize the *Definition* and *Process* themes and ask students to reflect on what it means to be innovative, where they have acted innovatively, or what processes support innovation. Naturally, educators might seek to introduce specific processes or approaches to students, but based on these results we encourage educators to simultaneously consider challenging students to critically reflect on their own perspectives, values, or mindsets when engaging in such processes.

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