Investigating Student Engagement in Emerging Technology Career Pathways

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Abstract

This study asks the question: How do rural undergraduate engineering students perceive emerging technologies (ET) in relation to their educational and career goals? Conducting semi-structured interviews and using in vivo coding, results are grouped into three themes: defining emerging technology, choosing ET pathways in a sociocultural context, and academic and industry preparation. The findings highlight the complexity of aligning engineering education with evolving industry needs, especially as technologies like generative AI, advanced manufacturing, and biotechnology reshape the workforce. Students are drawn to ET for career aspirations, societal impact, or ethical and philosophical exploration, yet schools often lack opportunities to cultivate these interests. Out-of-school experiences, such as internships, play a key role in skill development. The study suggests that framing ET careers as a means to address societal challenges, rather than focusing solely on skill acquisition, could better align engineering programs with student aspirations. This research emphasizes the need to consider sociocultural factors when designing ET pathways and calls for a broader integration of ethical considerations into engineering curricula. Ultimately, this work challenges traditional engineering education models and advocates for more flexible, forward-thinking approaches to preparing students for an ever-changing technological landscape.

Keywords: Emerging Technologies, Engineering Education, Student perceptions, Career plans

1 Objectives

This study investigates how rural students in postsecondary STEM-related degree programs perceive emerging technologies relative to their college and career plans. We ask: **How do undergraduate engineering students perceive emerging technologies (ET) in relation to their educational and career goals?**

Historically, technology has altered the nature of work. In recent years, the usefulness of specific STEM skills in the labor market is rapidly decreasing (Deming & Noray, 2020). Newly emerging technologies (ET; e.g., generative AI, advanced manufacturing, and biotechnology) are likely to accelerate this trend. Given these changes, tightly coupling postsecondary education offerings with the technical skills-related needs of industry partners may not meet the long-term needs of students or the labor market.

Furthermore, students are drawn to ET-related educational pathways for many reasons. In addition to career interests, students may view ET as a problem-solving tool to address critical societal issues (Nazar et al., 2019) or see themselves as “philosophers of technology” (Vakil & McKinney De Royston, 2022) who critically examine the social, political, and ethical issues related to new and ETs. Framed this way, students may not be interested in applying technology skills in traditional STEM occupations but are still eager to engage with ET as part of their studies. Attracting students to technology-based college and career pathways already presents a challenge. Technology students are motivated by out-of-school experiences (Smit et al., 2020; Peppler and Warschauer, 2011) because schools provide few opportunities to develop technology-related interests, identities, and aptitudes (Puckett, 2019). Designing ET educational programs to meet the needs of prospective students and workforce stakeholders is a pressing and complex issue with little evidence about student perceptions of ET to draw from.

This exploratory, qualitative study investigates ET-related interests of students in postsecondary STEM or computing degree programs. Through preliminary analysis of in-depth interviews, we identified three major themes present in student interests: defining emerging technology concerning their future interests, choosing an ET pathway in sociocultural contexts, and preparation in academia and industry. The quality of educational programs to prepare students for ET in academia and industry. Future research can differentiate emerging technology careers from traditional STEM-related pathways by making visible the multitude of sociocultural factors associated with emerging technology interests as it relates to workforce-related goals. Furthermore, practitioners can better attend to student interests by framing ET as a tool to address larger societal issues rather than context-free skills development.

2 Theoretical Framework

Selecting a program of study is an achievement-related choice shaped by an interplay of personal beliefs, perceived values, and socio-cultural context. **Situated Expectancy-Value Theory** (SEVT; Eccles & Wigfield, 2020) offers a lens for understanding such choices by emphasizing two proximal determinants: **Expectancy of Success (ES)**—the belief in one's ability to succeed in a specific task or program—and **Subjective Task Value (STV)**—the perceived worth or importance of that task. STV consists of four components:

- **Utility value** – the perceived usefulness of the activity for achieving current or future goals.
- **Intrinsic value** – the enjoyment or interest derived from the activity itself.
- **Attainment value** – the personal importance of doing well in the activity as it aligns with one's identity or core values.
- **Cost** – the perceived negatives, such as time, effort, stress, or the loss of alternative opportunities.

In STEM education, degree choices are frequently framed in terms of **utility value**—for example, selecting computer science as a pathway to a software engineering career (Jacob et al.,2021) However, research indicates that appealing solely to utility value may be insufficient for sustaining long-term engagement, particularly for students whose motivations are rooted in broader goals such as solving societal problems or engaging in ethical, political, or philosophical inquiry related to technology (Rosenzweig et al., 2022).

Traditional applications of SEVT in STEM tend to operationalize expectancy and value through quantitative measures focused on performance in academic math and science courses. While this has produced useful insights, such approaches have proven less effective when examining career aspirations in non-traditional or sub-baccalaureate pathways (Gottlieb, 2018) or in understanding why students pursue degrees in emerging technology fields (Perry, 2022). Furthermore, this quantitative orientation often overlooks the socio-cultural factors, informal learning experiences, and identity-based motivations that significantly influence decision-making.

To address these limitations, our study applies SEVT within a **qualitative, constructivist research design**. The constructivist perspective recognizes that students' perceptions and choices are formed through lived experiences, personal agency, and social context. We use SEVT not as a rigid measurement framework, but as a conceptual guide for interpreting how students weigh different forms of task value and assess their likelihood of success in ET pathways. This framing informed both our interview protocol—ensuring that questions probed multiple facets of task value—and our thematic analysis, allowing us to connect participants' narratives about identity, motivation, and socio-cultural context to the expectancy-value components.

By integrating SEVT with a constructivist approach, we aim to provide a richer, contextually grounded understanding of **how rural undergraduate engineering students perceive emerging technologies in relation to their educational and career goals**. This blended framework enables us to examine both the cognitive evaluations students make when selecting ET pathways and the socio-cultural environments that shape and sustain their engagement.

3 Methods

3.1 Participants

Three undergraduate engineering students from rural backgrounds in the midwestern United States participated in this study. "Rural" is defined here as residing in communities with fewer than 25,000 residents, located at least 50 miles from a major metropolitan area, and with a local economy primarily based on agriculture or resource-based industries. Participant demographics included: one mature-age student with a young family and prior work experience as a career and technical education (CTE) instructor; one traditional-age student with extensive family involvement in farming; and one homeschooled student with a strong interest in national security. All participants were enrolled in STEM-related degree programs at a public research-intensive university.

3.2 Recruitment

Participants were recruited via targeted emails to students in engineering and technology-related programs, using purposive sampling to identify individuals from rural backgrounds. Inclusion criteria required current enrolment in an undergraduate STEM-related program and residence in a rural area.

3.2 Data Collection and Analysis

Data were collected through semi-structured interviews conducted via Zoom. Each interview lasted approximately 45–60 minutes. The interview protocol included open-ended questions designed to elicit participants' definitions of emerging technology, motivations for pursuing ET pathways, perceptions of academic and industry preparation, and the socio-cultural factors influencing their educational and career choices.

Interviews were transcribed verbatim and analysed using in vivo coding (Saldaña, 2013) to capture participants' own language in describing their experiences. Initial codes were organized into thematic categories aligned with the research questions. Coding proceeded iteratively, with constant comparison across cases to refine categories. Themes were reviewed for coherence and were interpreted through the lens of Situated Expectancy-Value Theory (SEVT), focusing on expectancy of success and subjective task value components.

4 Results

Preliminary results from this coding process resulted in three main codes: defining emerging technology, choosing ET pathways in a sociocultural context, and preparation in academia and industry.

4.1 Defining ET

Study participants were asked to provide a definition of ET, including concrete examples. The participants defined ET in contrast to "existing" or "old" technology. From their vantage point, ET is often "technology or ideas that we already have… in theory. But it has not until now been practical." That is, when a technology is becoming widespread and useful, it becomes an emerging technology rather than a research and development project.

The specific examples of ET al. came from the participants' direct experiences, including artificial intelligence, additive manufacturing, biotechnology, and unmanned aerial systems. In their descriptions, participants described other key aspects of ET to provide efficiencies for end users, provide access to new scales of engineering (e.g., nanotechnology in medical applications), and its ability to "push the limits" of what is possible.

Additionally, each participant defined engineering as a tool to solve problems they were interested in. Participant #1 was very interested in using ET to improve his experiences as an outdoors enthusiast (a lifelong pastime and the industry he plans to work in). Participant #2 provided many examples of applying ET to real problems in his life running his family's farm and his rural community, and participant #3 was very interested in national security issues and saw ET as central to solving difficult problems in the industry.

4.2 Choosing ET pathways in a sociocultural context

Each student ascribed various factors associated with their choices to pursue a STEM-related degree program and to engage with emerging technologies. These factors, viewed through the lens of SEVT, include students drawing from multiple identities to bolster their attainment value in ET, seeing their postsecondary degree programs a merely a means to an end, and displaying a high degree of expectancy of success that they can be successful in ET-related pathways.

Identities

Each student described numerous identities contributing to their education choices and career aspirations. Participant #2 went as far as to declare, "I am emerging technology." Each participant described their identities in relation to being different from a standard student profile. Participant #1 was older, with a young family and a fourth-generation farmer. Participant #3 ascribed his identity as being a homeschooler which made him different from most of his classmates. The participants did not position themselves as "STEM people," generally, or in relation to any discipline. In fact, Participant #1 explained that being a "math person" was not needed to be proficient in the ET field he teaches, advanced manufacturing, and that math is a barrier for many students who might otherwise continue in ET pathways.

Postsecondary Education as Means to an End

Two of the three participants described their educational choices in terms of the external validity a STEM degree will provide (i.e., utility value). Participant #1 wants to remain in his current position as a two-year college CTE instructor and the other wants to work in the defense industry. They were all, "sick of being student[s]," as participant #2 put it, but acknowledged the importance of credentials to unlock career opportunities. The first participant felt the same way about his degree but also emphasized the intrinsic value of working with technology. He said, "for me it's a lot of my personal interest in the industries… that is where I enjoy spending my free time." While each participant acknowledged the utility value of their degree, it is not the most important factor driving their ET-related choices.

Self-efficacy through self-learning

Self-efficacy is the belief that one can be successful in a specific task (Bandura, 1977) and is very similar to expectancy of success in the SEVT model. Each participant described their self-efficacy with ET-related tasks deriving from their ability to work outside of formal contexts. Participant #1 described having 3-D printers in their dorm room and being self-taught through YouTube. Participant #2 feels like he's always had an aptitude for mechanical thinking developed through the encouragement of his family and access to tools at home. Participant #3 explained how the homeschooling environment helped him become a voracious reader and resourceful networker to facilitate "just-in-time" emerging technology learning. These examples all come from experiences outside of formal educational environments.

4.3 Preparation for academic and industry

Study participants described the role of emerging technology with respect to their views of academia and industry. Participant #2, who is heavily involved in research at the university, suggested that academia needs to focus on "the weird" because industry cannot take the risk to develop new technologies. Instead, what students learn in academic settings should transfer into industrial and consumer applications. Rather than being focused on learning technology, the participants described their interests as being driven to make a difference in a particular industry (outdoor sporting, healthcare, and national defense). Context-free, disciplinary learning was not of interest.

Without prompting from the interviewer, each student reflected on pedagogy in their classes and how it prepares them to engage with emerging technology. Universally, they found limited access to ET in coursework and within the university. As their confidence to be successful comes from their ability to self-teach, they prefer learning environments that foster this approach to learning. For example, one student chose a degree program because the department fully adopted an interest-driven, problem-based approach to learning even though the content area was not his first choice. Another suggests, "[ET]seems like it's easier to be picked up when it's not taught conventionally. When it's something you just have to want to use." Participants created ways to engage with and learn ETs despite little to no opportunity in their coursework or through university channels.

5 Discussion

This study set out to explore **how rural undergraduate engineering students perceive emerging technologies (ET) in relation to their educational and career goals**. The findings suggest that these perceptions are shaped by a combination of personal interests, local socio-cultural contexts, and self-directed learning experiences, rather than by the formal curriculum. Participants valued ET not only for its utility in securing a credential or career advancement but also for its potential to address issues they care about—such as improving agricultural processes, enhancing outdoor recreation, or contributing to national security.

Through the lens of Situated Expectancy-Value Theory (SEVT), these perceptions reflect both **expectancy of success**—often grounded in skills developed outside formal education—and varied forms of **subjective task value**. While utility value was acknowledged, intrinsic and attainment values appeared more central to participants' engagement. Notably, all participants described formative ET learning experiences occurring outside of coursework, indicating that formal programs are not fully meeting their needs for hands-on, interest-driven engagement.

This research also highlights the influence of rural contexts on how students form their perceptions of ET. Participants' understandings of ET were closely tied to technologies with clear relevance in their local communities. This local grounding served as a strong motivator, yet it also risked limiting awareness of the wider possibilities ET offers. Providing curricular opportunities to engage with a broader spectrum of technologies and their societal applications could help rural students imagine a wider range of potential roles and career pathways.

From a theoretical perspective, this study demonstrates that SEVT can be meaningfully applied to the study of ET in rural engineering education, but that a purely quantitative operationalization may overlook key socio-cultural influences. A constructivist approach allowed these influences to emerge, providing a richer understanding of how perceptions are formed and sustained.

5.1 Limitations

This preliminary work is based on three participants already engaged in STEM pathways; as such, the results may not generalize to rural students with different levels of exposure to ET. Further research should examine a larger, more diverse sample, including those not currently in STEM programs, to capture a broader range of perceptions.

6 Scholarly Significance

These preliminary results provide scholarly implications for applying SEVT in ill-defined domains (e.g., emerging technology) and revisiting the degree to which coupling postsecondary education programs and local labor market trends serves student needs. Students interested in emerging technology career pathways were largely interested in "traditional" technology-based postsecondary education and ascribed their trajectory into ET pathways as being largely unrelated to any formal school-based experiences. The kinds of formal learning experiences students sought (pedagogically and technologically), were mostly absent at the university. While previous technology-based career studies find student interests are largely driven by out-of-school experiences (Smit et al., 2020), these students are similar and they also create ET-related learning experiences outside of formal learning environments.

Furthermore, the results from this study provide a framework to scope the domain of “emerging technology.” As more student data is collected in the scope of the larger project from which this data is drawn, including from a more diverse group of students who may not already be pursuing ET-related pathways, a more coherent student-centered definition of ET can be generated. The definition could be tested in more traditional SEVT survey research to address the limitations of math- and science-centric approaches to STEM career pathways studies (Gottlieb, 2018; Perry et al., 2022).

Future research can also build from these results to consider two aspects of pedagogical change to create and sustain ET pathways. First providing youth access to ET during the school day, a known issue in technology-related pathways (Puckett, 2019) is a critical issue. Second, creating more problem-based learning experiences that focus on addressing community needs through ET (e.g., Nazar et al., 2019) would be appealing to many young people who may not choose traditional STEM programs but are engaged with ET.

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