Career Trajectories in a Technology Management Program: Alumni Perspectives

Jinhua Zhao, Noemi V. Mendoza Diaz and Rufino Oregon

DOI: 10.18260/jet.42.2.3

Abstract

Technology Management (TCMG), as part of the STEM spectrum, has gained increasing interest within the engineering technology community. In the early 2000s, a TCMG program was launched at a Southwestern institution within the College of Education. In 2021, the program transitioned to the College of Engineering. Even before this transition, graduates of the program experienced significant changes in curriculum, faculty, and institutional alignment, with the first full-time, tenure-track faculty members being recruited in 2018. To understand the effects of these changes, a two-phase study was conducted to assess how alumni perceive the program's impact on their career trajectories. Utilizing Career Theory and informed by relevant research on undergraduate program's effects on graduates, two research questions were investigated: (1) How do graduates of a technology management program perceive their career trajectories? and (2) How are these perceptions related to their college experiences? The first phase of the study, involving an online survey of 75 graduates, was published in 2020. The second phase is discussed here. This phase involved follow-up interviews with ten alumni from the original participant pool, who represented diverse backgrounds in terms of years since graduation, race, ethnicity, and gender. The interviews, analyzed qualitatively, resulted in seven key themes: (1) Choice of Program, (2) Career Trajectory, (3) Career Advancement, (4) HRD-related coursework, (5) TCMG-related coursework, (6) the Management Minor, and (7) Critical Success Factors. The findings align with existing literature, offering insights into how graduates navigate evolving academic environments and providing recommendations for how universities can better support students pursuing careers in engineering technology.

1. Introduction

With the growing demand for science, technology, engineering, and mathematics (STEM) professionals, STEM majors have become increasingly popular in colleges and workplaces. According to the U.S. Bureau of Labor Statistics (2024), the STEM job market is projected to grow by 10.8% from 2022 to 2032. The United States will need over one million additional STEM workers in the next decade, prompting colleges to aim for a 34% annual increase in enrollment for STEM undergraduate programs (Jewett & Chen, 2022). The demand for these professionals highlights the importance of tracking career trajectories and improving career outcomes for STEM graduates. Prior to the COVID-19 outbreak, the call to reimagine STEM education coincided with a decline in college enrollment. In the post-COVID era, redefining college education and preparing a skilled and talented STEM workforce are critical challenges for universities (Mendoza Diaz et al. 2020). This study aims to explore how the training provided by universities contributed to students' career trajectories and success. It also seeks to explore the factors influencing students' major choices, their experiences with the courses and activities offered by a technology management (TCMG) program at an R1 institution in the Southwest, and their suggestions for enhancing the program to better support their career trajectories.

The research questions guiding this investigation are:

(1) How do graduates of a technology management program perceive their career trajectories?

(2) How are these perceptions related to their college experiences?

2. Theoretical Framework

To achieve our goals, we framed our study in career theory, success, and competencies. Career theory, as a branch of Human Resource Development, explores how professionals perceive and achieve career success. Career success is defined as "a positive outcome of a career experience and a process of achieving work-related goals" (McDonald & Hite, 2023, p. 27). Within the broader scope of career theory, several predictors of career success have been identified, including:

- Human capital (e.g., education, training, and work experience)
- Social capital
- Organizational sponsorship
- Socio-demographic variables (e.g., gender, race, and age)
- Stable individual characteristics (e.g., personality, locus of control, cognitive ability)
- Structural contextual factors (e.g., environmental or societal influences such as economic conditions, legislation, or education systems)

In addition, the theory incorporates the concept of career competencies as key enablers of success. According to DeFillippi and Arthur (1995), these competencies are categorized as "know-why," "know-how," and "know-whom," which can be understood as follows (see Figure 1):

- Know-why: Self-awareness of interests, values, and motivations
- Know-how: Job-related knowledge and career-relevant skills (e.g., training)
- Know-whom: Career-related networks and relationships that benefit both the individual and the organization.

These concepts directly informed our research design and interview protocol. For example, interview questions encouraged participants to reflect on why they chose the TCMG program (Know-why), how courses, projects, and faculty influenced their skill development (Know-how), and the role networks played in their career progression (Know-who). As with any theoretical framework, Career Theory offers a rationale for interpreting the results presented here. It provides a structural foundation for examining how graduates understand and navigate their career trajectories. Additionally, our study was framed within existing literature related to Career Theory and aligned with program characteristics.

3. Literature Review

Career Theory has gained traction in engineering technology literature, reflecting a growing interest in understanding how students conceptualize their professional paths. Several studies underscore the importance of developing specific career competencies—namely "know-how" (practical skills and experience), "know-why" (motivation and purpose), and "know-whom" (social and professional networks)—as students navigate from education to employment. Research has explored areas such as student awareness (Dyrud, 2022), engagement through co-curricular experiences (Yanik et al., 2021), and the influence of industry partnerships on skill development and workforce preparation (Sergeyev et al., 2019). These studies offer concrete insights into how academic programs shape engineering technology students' professional identity and readiness.

Academic institutions play a vital role in building these career competencies. Internships, for example, are essential for developing "know-how" by providing real-world experience and translating theoretical knowledge into practice. Prior research highlights that internships improve students' job readiness and self-efficacy, particularly in STEM disciplines (Sawyer, 2017; Matusovich et al., 2019; Powers et al., 2018; Sriraman et al., 2016). Internships also foster "know-why" by helping students clarify their professional goals through applied learning. This study builds upon this work by examining how the TCMG program's internship requirement supports the development of both skills and purpose.

Mentorship and advising are instrumental in cultivating "know-whom" competencies, helping students access networks that shape their academic and professional journeys. Strong advising relationships guide course and career planning (Khali & Williamson, 2014; Laghari & Khuwaja, 2012) and improve retention among underrepresented groups (Belser et al., 2017; Uddin, 2019; Canaan & Mouganie, 2023; Primé et al., 2015). A longitudinal study by Fadigan and Hammrich (2004) emphasized staff availability as a major factor in student persistence. Mentorship is

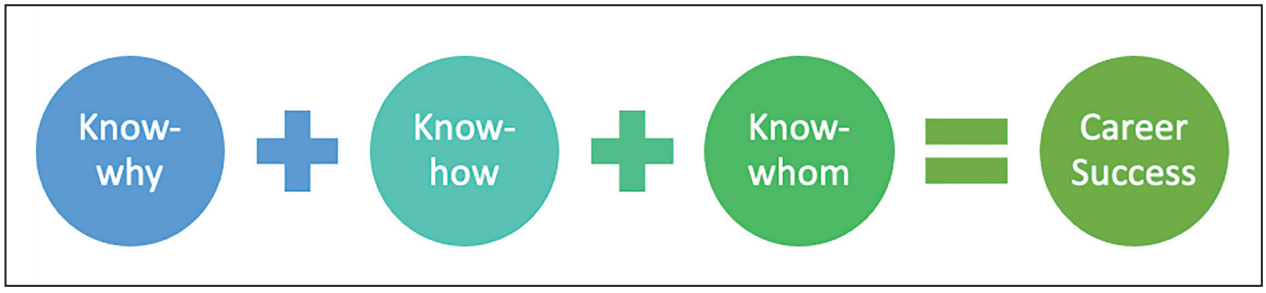

Figure 1. Career Theory Schematic based on DeFillipi and Arthur (1994).

especially important for students navigating systemic barriers: for instance, San Miguel and Kim (2015) found that multiple mentors significantly benefited Latinas in STEM, while Yanik et al. (2021) reported improved self-efficacy and engagement tied to mentorship. In engineering technology, Kaul et al. (2015) and Kaul (2019) highlighted how mentoring within undergraduate research fosters vertical integration, contributing to both retention and a stronger professional identity.

Project-Based Learning (PBL) further supports "know-how" by integrating hands-on experience, teamwork, and critical thinking. Meta-analyses by Hidayat et al. (2024) and Zhang and Ma (2023) confirm that PBL improves academic performance, attitudes, and higher-order thinking, particularly when implemented over 9–18 weeks with small student groups. Effective teamwork—a core element of engineering—requires shared goals, communication, and mutual accountability (Chowdhury & Murzi, 2019; Huang, 2021). Despite its benefits, PBL's impact on technology management remains underexplored. This study addresses that gap by analyzing how PBL in the TCMG program strengthens career readiness.

Finally, connecting learning to employment remains a persistent challenge. Graduates often face the "work experience paradox"—the expectation that they possess prior experience for entry-level jobs, even though few opportunities exist to gain that experience before entering the workforce (Perrone & Vickers, 2003). These unrealistic demands, combined with limited guidance, can lead to anxiety, stress, and feelings of unpreparedness. Abulhassn and Roberts (2021) echoed these concerns, calling for greater engagement with professionals and the inclusion of more job-readiness content. This study investigates how the TCMG program integrates internships, mentorship, PBL, and advising to equip students with the "know-how," "know-why," and "know-whom" competencies essential for a successful career transition.

4. Methodology

4.1Research Setting

The year 2021 marked an important event for a technology major in a Southwestern institution. As part of the restructuring of the university, this technology program transitioned from the College of Education to the College of Engineering becoming an Engineering Technology major. Before this move, the program was part of the Human Resource Development Department and contained seven courses in this discipline. Other seven technology-oriented courses were revised and established by the current faculty keeping a minor in management from the University's Business School. The program started graduating students in the late 2000s, yet it did not house any tenure track faculty until 2018. With all these changes occurring, the need for a study that investigated the career trajectories of its graduates as well as the college experiences influencing these trajectories became critical. This study investigated graduates' perceptions prior to the college transition and serves as a baseline for future studies that investigate the effects of this transition. This manuscript presents the second phase of a larger research project sponsored by the institution's Office of Diversity. The overarching goal of the project was to explore the connections between pre-college experiences and graduates' career paths, with a particular focus on the experiences of underrepresented minority groups.

4.2 Research Design

To meet both the programmatic needs and the sponsor's goals, both of which were aligned, a mixed-methods approach was employed. Mixed-methods designs integrate qualitative and quantitative data to provide a more comprehensive understanding of the phenomenon of interest (Creswell & Clark, 2018).

Because the quantitative and qualitative components of our study occurred sequentially rather than concurrently, and because the first phase informed the second, the research design qualifies as a sequential mixed-methods study. The first phase (quantitative) involved an online survey, while the second phase (qualitative) consisted of interviews with selected participants whose survey responses warranted further exploration.

The initial phase recruited 75 graduates from the TCMG program to complete an online survey comprising both closed- and open-ended questions. The survey addressed: (a) factors influencing participants' careers after graduation, (b) perceptions of their college experiences, and (c) suggestions for program improvement. The findings from this first phase were published in 2020 (Mendoza Diaz, 2020).

The second phase, presented in this manuscript, consisted of follow-up semi-structured interviews with a subset of the original 75 participants. This phase aimed to deepen our understanding of how participants perceive their career trajectories and how they connect their professional experiences to the preparation they received in the TCMG program.

The research design for this phase employed content analysis, a method that combines thematic analysis with frequency counts, making it a form of mixed-methods research in its own right, though still considered interpretive and qualitative in nature. As described by Teddlie and Tashakkori (2003) and Sandelowski (2003), this approach is often referred to

as the quantification of qualitative results. Content analysis enables valid inferences through coding, allowing large volumes of text to be categorized into key content areas. These areas may be generated deductively using a predefined coding system, inductively from the data itself, or through a combination of both (Weber, 1990). In the fields of technology and engineering education, content analysis has been widely applied, for example, by Pawley et al. (2016) in gender studies and by Chou and Chang (2010) in engineering education research.

The responses to the online survey (first phase) served as the foundation for both the interview protocol and the initial codebook, which was further refined during the interviews and subsequent data analysis (see Appendix). Purposeful stratified convenience sampling, a technique aimed at ensuring representation from as many groups in the population as possible, was employed (Creswell, 2021). This approach targeted all minority participants in the sample (n = 31), including all female participants (n = 10), all Hispanic participants (n = 20), and students from diverse racial and ethnic backgrounds (n = 11). For white male participants, individuals were selected to reflect diversity in age and years since graduation. A total of 10 participants agreed to take part in the second phase, with demographic details presented in Table 1 and age information shown in Table 2. Table 3 provides job positions of participants at the time of the interview.

4.3 Data Collection and Interview Protocol

An interview protocol was designed to collect participants' responses, enabling the exploration of the research questions (see Table 4).

Figure 2 presents a logic model illustrating the links between the research questions and the developed interview questions. As mentioned earlier, the interview questions were developed based on participants' responses from the first phase (online survey)—for example, question 7. They were also shaped by the research questions and grounded in

Table 1. The demographics of the participants.

	White/ Non-Hispanic	African-American/ Non-Hispanic	White/ Hispanic	Multiracial/ Hispanic	Total
Female	2	1	0	1	4
Male	3	1	2	0	6
Total	5	2	2	1	10

Table 2. Age and years after graduation.

Age	22	23	25	25	26	27	30	31	33	39
Years after graduation	1	0	2	3	4	7	8	9	10	10

Table 3. Job position of participants.

Participant 1	Business Analyst
Participant 2	Cybersecurity Analyst
Participant 3	Technology Director
Participant 4	Infrastructure Architect
Participant 5	Cybersecurity Product Manager
Participant 6	Systems Administrator
Participant 7	Cloud Systems Engineer
Participant 8	System Analyst
Participant 9	Systems Engineer
Participant 10	Manager in a centralized IT organization

Table 4. Interview protocol.

	Interview Questions
1	Describe your career trajectory after graduation. What do you do in your job?
2	How did you grow in your career? What learning activities have you been engaged in?
3	Did your college degree help you in your current career?
4	How do you associate your college experience with your career?
5	Does the course selection matter?
6	What attracted you to TCMG?
7	Advice to incoming students? Or According to your responses to the online survey, you have certain recommendations for the Technology Management Program. Can you elaborate on those recommendations?
7a	How are these perceptions related to your college experience, translated into strengths and weaknesses of the program?
8	In your survey response, you listed XXXX factors that impacted your career negatively or positively after graduation. Can you please elaborate?
9	How do you define a career?
10	For minority students: As a minority in the TCMG program, how would you say your experience was different (if any) from the majority population?

the theoretical frameworks guiding this study: career theory and the concept of career success.

4.4 Data Analysis

We performed content analysis based on predefined and emerging themes, along with their associated frequencies. Frequency counts reflect the importance participants assign to the phenomenon under investigation. Each participant's statement was treated as an independent unit of analysis, allowing for an unbiased assessment of how often specific categories were mentioned (Stemler, 2001).

Based on methodological norms of qualitative inquiry and content analysis (Miles & Huberman, 1994; Strauss & Corbin, 1997), interview transcripts were coded systematically under different categories. With the help of the literature review and the results of the first phase of the study, the research team created an initial codebook that served as the basis for the categories. The codebook was iteratively revised and the last version of this codebook can be consulted in the appendix.

The codebook includes seven themes, including Choice of Program, Career Trajectories, Career Advancement, HRD-related Coursework, TCMG-related coursework, Management Minor, and Critical Success Factors (for Program), and thirty subthemes that will be described next.

Using the initial codebook, each transcript was manually coded by two members of the research team using Microsoft Excel to organize and track themes. To promote validity and reliability, the study used Inter-rater reliability (IRR) to check coding results and evaluate how coders agreed (Holsti, 1969; Trochim, 2006).

$$IRR = \frac{2 * number\ of\ agreements}{Juger\ 1st's\ coding\ number\ +\ Juger\ 2nd's\ coding\ number}$$

After comparing the coding and frequency counts of three transcripts by two coders, the initial inter-rater reliability (IRR) was relatively low at 67%. In behavioral science, an agreement of at least 80% is typically recommended (McHugh, 2012). Much of the disagreement stemmed from differing interpretations of the codebook. As part of the qualitative inquiry protocol, discussions, clarifications, and codebook revisions were undertaken, resulting in an improved IRR of 88%. For example, under the theme "Career Advancement," a subtheme titled "Certifications Supported On-the-Job" was added to better capture this aspect of career progression and reduce overlap with other themes.

To ensure trustworthiness, this study incorporated peer debriefing and audit trails. The interviewers had significant experience in qualitative research, and peer debriefing occurred during weekly research group meetings, where ideas and interpretations were analyzed, discussed, and contrasted. The principal investigator (PI) documented all discussions in meeting minutes, stored them on an electronic shared drive, and included communications with participants, referring to them when relevant. Transferability—defined as the "researchers' responsibility to provide the

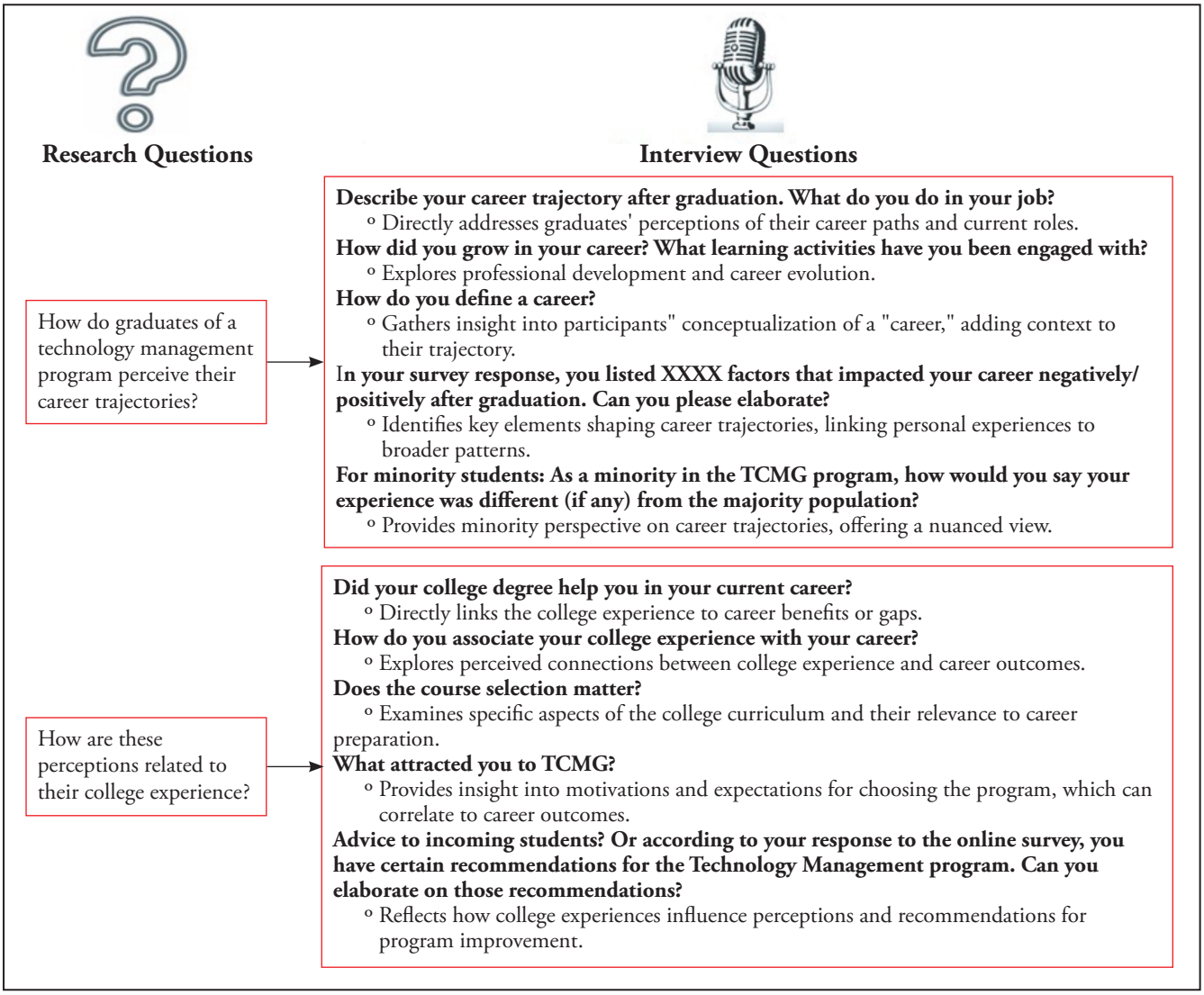

Figure 2. Logic model showing the links between research and interview questions.

database that makes transferability judgments possible on the part of the potential appliers"—is ensured by describing the study's setting and the specificities of the case presented (Lincoln and Guba, 1985).

5. Results

This study explored students' perceptions of their career path and their associations with college experiences. Using a thematic analysis approach, 205 student responses were categorized into 7 themes and 30 subthemes, allowing for a structured interpretation of career perceptions and academic experiences. Since answers to the two research questions were closely related, their findings are presented together.

Table 5 presents the seven general themes along with their definitions. Career Advancement was the most frequently mentioned theme during the interviews, highlighting students' focus on the factors that support job attainment and workplace progression, such as internships, on-campus jobs, mentors, networking, self-directed learning, and certifications. The second most common theme was Critical Success Factors for both the program and the students, which included elements like faculty, courses, project-based assignments, and alumni feedback. The least mentioned theme was Management Minor, reflecting students' attitudes toward the Business School courses and the minor itself.

As shown in Table 6, each theme included a varying number of subthemes. Within the "Choice of Program" theme, the most frequently mentioned subtheme was students' interest in learning and working with technology as their primary reason for choosing the major. Notably, seven out of the ten students in the study transferred to the TCMG program from other majors, primarily engineering. This sug-

Table 5. The results of themes.

Themes	Definition	Frequency
Choice of Program	The factors/experiences for choosing TCMG	30
Career Trajectory	The current career experience	30
Career Advancement	The factors helping with getting jobs and advancing	51
HRD-related coursework	The attitudes toward HRD courses	15
TCMG-related coursework	The attitudes toward TCMG courses	34
Management Minor	The attitudes toward Mays courses	5
Critical Success Factors	The factors promoting the success for programs and students	40

Table 6. Subthemes and codes.

Themes	Subthemes Codes and Frequency Counts
Choice of Program	Wanted to do/started in Engineering (n=9)
	Interest to learn technology and work in technology (n=12)
	Some other major to TCMG (n=7)
	TCMG advised/informed by family (n=2)
Career Trajectory	Satisfied with current title/job (n=9)
	Had to work to get where they are (n=6)
	Expected more from the job (n=5)
	Age affected negatively (interpret with care) (n=2)
	Gender affected negatively (interpret with care) (n=8)
Career Advancement	Participated in internship (n=11)
	Internship helped get job (n=5)
	On-campus job helped (n=2)
	Networking helped (n=4)
	Alumni network (recognition, self-endorsement) (n=6)
	Mentor helped (n=5)
	Learning/self-directed approach utilized (n=8)
	Certifications on-the-job supported (n=10)
HRD-related Coursework	Learned from them (n=7)
	Unnecessary (n=6)
	Neutral perception (n=2)
TCMG-related Coursework	Took technology courses on neighbor college campus (n=3)
	More technical classes needed (n=4)
	Happy with the coursework (n=27)
Management Minor	Immediately applicable to current career (n=2)
	Helpful in the long term (n=3)
Critical Success Factors	The importance of TCMG faculty (n=4)
	Widen course selection range (future) (n=5)
	More project-based assignments (n=7)
	Promotion and public communication (n=2)
	Alumni feedback (n=22)

Table 7. The examples of recommendations as part of the critical success factors.

The importance of TCMG faculty (n=4)	There were a few professors who I would say had helped. I couldn't off the top of my head remember their names but that kind of helped me. {In many cases, they helped} gain a little more self-confidence of what I was capable of doing.
Widen course selection range (n=5)	My focus is more on the data scientist and business analysis side. I feel like I wasn't fully exposed to the various opportunities the major can offer. Instead of having four or five classes that just touch on the subject, I think it would be more beneficial to focus deeply on it. Perhaps we could really explore the different paths available within the major, rather than just giving us a surface-level introduction.
More project-based assignments (n=7)	I like that a lot of the classes were just focused on working in the lab with your peers figuring out how to build the systems and figuring out how to solve all these problems in order to create real solutions in real-world applicability.
Promotion and public communication (a selling point) (n=2)	I think students limit themselves as to what their opportunities really could be. Usually, they lock themselves too specifically into exactly what they want to do. I would better sell the entire program to a recruiter, than come up saying, I want to be a desktop support person; I get that a lot. Being able to sell the entire program and all of the experiences they get in the program would better sell them to a company.
Alumni feedback (n=22)	Maybe past alumni will also come and speak just to show the current student what you can do with that degree in what's possible

gests that, despite their departure from engineering, they still pursued careers connected to technology. The least mentioned reason for choosing the major was being advised or informed by family members, highlighting the need to increase awareness of this program.

In terms of Career Trajectory, students expressed satisfaction with their current job titles or positions nine times. However, it was mentioned six times that they needed to work harder or acquire more skills to meet job demands. Interestingly, gender bias in the workplace was a recurring theme, mentioned eight times. While some students agreed that women face more challenges, others felt there was no difference between male and female experiences in the workplace. Two participants expressed age bias.

For Career Advancement, participants mentioned completing internships, emphasizing that these internships helped them secure full-time jobs after graduation. Certifications were also seen as essential for career growth, noted ten times by seven participants. Alumni Network connections and personal networks were highlighted as significant factors in their career advancement, along with self-directed learning.

Participants had varied attitudes toward HRD-related coursework, expressing positive views seven times, negative views six times, and neutral opinions twice. Neutral responses indicated that some participants did not have clear comments or experiences with HRD-related coursework. In contrast, for TCMG-related coursework, 'satisfaction with the coursework' was a common sentiment, mentioned twenty-seven times. However, it was strongly emphasized that more technical classes should be added to the program. Regarding the Management Minor coursework, participants shared positive opinions, noting its usefulness in their current or future careers. Overall, TCMG-related coursework received more positive feedback compared to HRD-related and Management Minor coursework.

Finally, the recommendations reflect many aspects of students' college experiences and their perceptions of career paths, therefore we called these recommendations the critical success factors. Alumni feedback and support played a significant role, followed by project-based assignments that align the college experience with job market demands. Participants also emphasized the importance of faculty and course selection, suggesting that, alongside hands-on experiences, the curriculum should include more technology-focused coursework. Table 7 provides examples of these suggestions.

6. Discussion

The results are based on interviews with 10 graduates from the TCMG program who are currently working in related careers. Participants shared commonalities in (a) their reasons for choosing the TCMG program, (b) career trajectories and advancement, (c) perspectives related to HRD and TCMG, (d) experiences with management coursework, and (e) critical success factors for the program. These insights enrich the existing literature on Career Theory and offer practical implications for the design and improvement of technology and engineering programs.

To reiterate, Career Theory identifies six predictors of career success: (a) human capital, (b) social capital, (c) organizational sponsorship, (d) socio-demographic variables, (e) stable individual characteristics, and

(f) structural contextual factors. The themes and subthemes emerging from our findings align with these predictors. For example, within the theme of career trajectory, the subthemes of age and gender—both socio-demographic characteristics—played a significant role in graduates' career experiences. Female participants, in particular, reported challenges related to focused working time, promotion opportunities, mentorship, and workplace setbacks. These findings align with the Career Success framework, which shows women are less likely to report feelings of career success (McDonald & Hite, 2023).

The Career Advancement theme yielded the richest data across all forms of capital utilized by graduates in their professional development. Participants frequently cited the impact of institutional alumni networks. Internships, mentorship, and advising—core elements of both human and social capital—also stood out as key institutional supports. An emerging theme was the critical role of networking. Participants emphasized that professional connections helped them secure internships and jobs post-graduation. Alumni feedback further enhanced academic and career development. Networking, as a form of social capital, was consistently recognized as a powerful contributor to career success and student marketability (DeFillippi & Arthur, 1994; McDonald & Hite, 2023), exemplifying the "know-whom" component of Career Theory competencies.

Regarding coursework, participants consistently favored technical over non-technical training. This preference reflects the know-how competency in Career Theory, emphasizing the value of skill development. Project-based courses, access to faculty support, and opportunities for self-directed learning were cited as instrumental in skill acquisition. For example, one participant described a capstone course focused on real-world problems that provided practical experience in technology management. This emphasis on know-how supports prior research on professional conceptualization, co-curricular experiences, and the value of industry partnerships in engineering technology (Dyrud, 2022; Yanik et al., 2021; Sergeyev et al., 2019).

The know-why competency was reflected in participants' narratives about changing majors. Many cited personal interests, career goals, and family influence as key reasons for transitioning into the TCMG program. Some noted a lack of engagement with traditional engineering coursework, which led to decreased motivation. Family also played a significant role—either directly, through advice on choosing a major, or indirectly, through occupational influence. These factors shaped participants' educational decisions and subsequent career trajectories.

7. Conclusion

In summary, the career choices and trajectories of TCMG program graduates align with Career Theory and existing research on undergraduate technology and engineering programs. The findings demonstrate the importance of fostering students' competencies in knowing "why, how, and whom" — regardless of the academic unit housing the program.

The study is limited by the number and composition of participants, and, as with most qualitative studies, the transferability of results is intended to inform and benefit other programs rather than offer broad generalizations. The implications for practice include enhancing the guidance and mentorship students receive, facilitating internships and industry connections, creating networking opportunities among graduates, and raising awareness of structural barriers faced by women and other demographic groups. The implications for research highlight the importance of conducting more comprehensive investigations into program aspects based on graduates' perspectives. At the time of writing this manuscript, data is being collected to examine students' perceived impacts of the transition between colleges. This study provides a critical baseline for future research efforts.

References

Abulhassn, A., & Roberts, E. P. (2021). Exploring the impact of an NSERC CREATE program on job readiness among science and engineering graduate students and postdoctoral fellows. *Education for Chemical Engineers*, 36, 176-189.

Belser, Christopher T., Diandra J. Prescod, Andrew P. Daire, Melissa A. Dagley, and Cynthia Y. Young. 2017. "Predicting Undergraduate Student Retention in STEM Majors Based on Career Development Factors." *The Career Development Quarterly* 65(1): 88-93.

Canaan, S., & Mouganie, P. (2023). The impact of advisor gender on female students' STEM enrollment and persistence. *Journal of Human Resources*, 58(2), 593-632.

Chou, P. N., & Chang, C. C. (2010). Research characteristics and patterns in engineering education: Content analysis 2000-2009. *World Transactions on Engineering and Technology Education*, 8(4), 462-470.

Chowdhury, T., & Murzi, H. (2019, July). Literature review: Exploring teamwork in engineering education. In *Proceedings of the Conference: Research in Engineering Education Symposiu*m, Cape Town, South Africa (pp. 10-12).

Creswell, J. W. (2021). *A concise introduction to mixed methods research*. SAGE publications.

DeFillippi, Robert J., and Michael B. Arthur.1994. "The Boundaryless Career: A Competency-based Perspective." *Journal of organizational behavior* 15(4): 307-324.

Dyrud, M. A. (2022). What Is a Professional?. *Journal of Engineering Technology*, 39(1).

Fadigan, Kathleen A., and Penny L. Hammrich. 2004. "A Longitudinal Study of the Educational and Career Trajectories of Female Participants of an Urban Informal Science Education Program." *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching* 41(8): 835-860.

Hidayat, H., Anwar, M., Harmanto, D., Dewi, F. K., Orji, C. T., & Mohd Isa, M. R. (2024). Two Decades of Project-Based Learning in Engineering Education: A 21-Year Meta-Analysis. *TEM Journal*, 13(4).

Holsti, O. R. (1969). Content analysis for the social sciences and humanities. *Reading. MA: Addison-Wesley (content analysis)*.

Huang, J. (2021). *Smells Like Team Spirit: Enhancing Teamwork in Undergraduate Engineering Education* (Doctoral dissertation, Monash University).

Jewett, Elizabeth C., and Rong Chen. 2022. "Examining the Relationship between AP STEM Course-taking and College Major Selection: Gender and Racial Differences." *Journal of Engineering Education* 111(3): 512-530.

Kaul, S. (2019). Triangulated Mentorship of Engineering Students-Leveraging Peer Mentoring and Vertical Integration. *Global Journal of Engineering Education*, 21(1).

Kaul, S., Chang, G. A., Yanik, P. M., & Ferguson, C. W. (2015, June). Development of a mentorship program in engineering and engineering technology. In *2015 ASEE Annual Conference & Exposition* (pp. 26-523).

Laghari, M. S., & Khuwaja, G. A. (2012). Course advising & planning for electrical engineering department. *Journal of Education and Instructional Studies in the World*, 2(2), 172-181.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry.* Sage.

Matusovich, H., Carrico, C., Harris, A., Sheppard, S., Brunhaver, S., Streveler, R., & McGlothlin Lester, M. B. (2019). Internships and engineering: beliefs and behaviors of academics. *Education+ Training*, 61(6), 650-665.

McDonald, Kimberly S., and Linda M. Hite. 2023. "Career Theory and Concepts". in *Career Development: A Human Resource Development Perspective* (2nd ed.). Routledge.

McHugh ML. Interrater reliability: the kappa statistic. Biochem Med (Zagreb). 2012;22(3):276-82. PMID: 23092060; PMCID: PMC3900052.

Mendoza Diaz, Noemi V., Barhate, Bhagyashree, Johnston, Austin, & Jabarkhail, Sam. (2020). Career trajectories in a technology management-HRD programme. *Human Resource Development Internationa*l, 26(2), 201-212.

Miles, Matthew B., and A. Michael Huberman. 1994. *Qualitative Data Analysis: An Expanded Sourcebook*. Sage.

Pawley, A. L., Schimpf, C., & Nelson, L. (2016). Gender in engineering education research: A content analysis of research in JEE, 1998–2012. *Journal of Engineering Education*, 105(3), 508-528.

Perrone, Lisa, and Margaret H. Vickers. 2003. "Life After Graduation as a 'Very Uncomfortable World': An Australian Case Study." *Education+ Training* 45(2): 69-78.

Powers, K., Chen, H., Prasad, K., Gilmartin, S., & Sheppard, S. (2018, January). Exploring How Engineering Internships and Undergraduate Research Experiences Inform and Influence College Studentsâ€™ Career Decisions and Future Plans. In *Proceedings of the American Society for Engineering Education Annual Conference*, June 24-27, 2018. Salt Lake City, Utah..

Primé, D. R., Bernstein, B. L., Wilkins, K. G., & Bekki, J. M. (2015). Measuring the advising alliance for female graduate students in science and engineering: An emerging structure. *Journal of Career Assessment*, 23(1), 64-78.

San Miguel, Anitza M., and Mikyong Minsun Kim. 2015. "Successful Latina Scientists and Engineers: Their Lived Mentoring Experiences and Career Development." *Journal of Career Developmen*t 42(2): 133-148.

Sandelowski, M. 2003. Tables or tableux? The challenges of writing and reading mixed methods studies. In Handbook of mixed methods in social and behavioral research, eds. A. Tashakkori and C. Teddlie, 321–350. Thousand Oaks, CA: Sage Publications.

Sawyer, Katina. 2017. "Keeping It Real: The Impact of HRD Internships on the Development of

HRD Professionals." *Advances in Developing Human Resources* 19(2): 176-189.
Sergeyev, A., Kinney, M. B., Kuhl, S. A., Alaraje, N., Highum, M., & Mehandiratta, P. (2019, June). University, Community College, and Industry Partnership: Revamping Robotics Education to Meet 21st Century Workforce Needs–NSF-sponsored Project Final Report. In *2019 ASEE Annual Conference & Exposition*.
Sriraman, V., Spencer, B. J., Talley, K. G., & Ortiz, A. M. (2016, June). Early Internships for Engineering Technology Student Retention: A Pilot Study. In *2016 ASEE Annual Conference & Exposition*.
Stemler, Steve (2001). An overview of content analysis. *Practical Assessment, Research & Evaluation*, 7(17). Retrieved August 18, 2006 from https://ericae.net/pare/51~getvn.html#google_vignette
Strauss, Anselm, Corbin Juliet M. (1997). *Grounded theory in practice*. Sage.
Teddlie, C., and A. Tashakkori. 2003. Major issues and controversies in the use of mixed methods in the social and behavioral sciences. In Handbook of mixed methods in social and behavioral research, eds. A. Tashakkori and C. Teddlie, 3–50. Thousand Oaks, CA: Sage Publications.
Trochim, W. M. n.d. "Reliability." *Conjointly*. Accessed December 21, 2023. http://www.socialresearchmethods.net/kb/reliable.php.
U.S. Bureau of Labor Statistics. 2024. "Employment in STEM Occupations." U.S. Bureau of Labor Statistics. Accessed September 21, 2024. https://www.bls.gov/emp/tables/stem-employment.htm.
Uddin, M. M. (2019). Best practices in advising engineering technology students for retention and persistence to graduation. *The Journal of Technology, Management, and Applied Engineering,* 36(1).
Weber, R. P. (1990). Basic content analysis. Newbury Park, CA: Sage.
Yanik, P., Ferguson, C., Kaul, S., & Yan, Y. (2021). Enhancement of Engineering Student Engagement. *Journal of Engineering Technology*, 38(2), 24-36.
Yanik, Paul, Chip Ferguson, Sudhir Kaul, and Yanjun Yan. 2021. "Enhancement of Engineering Student Engagement." *Journal of Engineering Technology* 38(2): 24-36.
Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in Psychology*, 14, 1202728.

Appendix: Codebook

Themes	Subthemes	Description	Quote
Choice of Program	Wanted to do/started in engineering	Talk about why they choose the program and mention they wanted to do engineering	In my case, I actually thought I wanted to go into industrial distribution or engineering technology and turns out I'm not very good at calculus, engineering, math, so those were kind of pushed to the side of it.
	Interest to learn technology and work in technology	Talk about why they choose the program and mention they were interested or wanted to work in technology fields.	I didn't know much about technology but I think it's something that I really enjoy learning about and that I'm really passionate about. And when you bring in diversity. It definitely helps someone feel more comfortable being themselves and learning as much as they can and sharing the ideas with other people.
	TCMG advised/informed by family	Talk about why they choose the program and mention they got advisors from others or were influenced by others.	When I had talked to my now husband. At the time I knew he was in this major and he didn't land in this major to start with. He thinks he started as a math major or something like that. And it took him some time to find his way to tech management. So when I was getting ready to graduate {HS} and getting ready to apply I had asked him straight. I was like what college should I be applying for because this is the stuff I like to do this is why I would like to continue doing. And he's the one that actually ended up saying "hey yeah okay tech management.".

Career Trajectory	Satisfied with current title/job	Mention they are happy and satisfied with current job or title	I love it, it's a great job. I have so many resources to, you know, further my career and develop, it's a great tech company, I love it.
	Had to work to get where they are	Hard to catch or follow others' steps; work harder; they need to learn new things because they did not learn from colleges; learn more	I've worked very hard to get to where I am today, and I think I bring a lot to the table and I'm definitely always willing just to learn something new.
	Expected more from the job	Having more expectations than others	So, yeah I don't want to do like the little simple jobs where I'm just going to work and I'm just doing it for the paycheck. Actually I want to love what I'm doing. I want to, you know, build a career
	Age affected negatively (interpret with care)	Perception of age impacting negatively their professional experience	I feel almost like I have to instill confidence that oh yeah I can do this, and I think a lot of it still goes back to that perception that she's young {talking about how she was perceived} and she really hasn't been here that long.
	Gender affected negatively	Perceptions of gender biases	Well we've experienced with some of the women that we hired that they were always on their phone, and we needed them to be continuously working.
Career Advancement	Participated in Internship	Mentioned of the effect of internships in their advancement	I did internships during summers that weren't part of the coursework required and so I interned as a project management intern. It was in the pharmaceutical company up in X city and then I interned for my official internship in an ecommerce company in Y city.
	Internship helped get job and advance	Mentioned internship helped towards obtaining jobs	It has been and has always treated me really well, I moved up in the company {since internship}. They were bought out by a company called X company, and X company got rid of everyone else except for me. So, it is my knowledge, my expertise and what my skills are that I bring to the table. The only people that they kept were me, and the clientele and that's it. So now I work with X company.
	On-campus job helped	Mentioned how on-campus job helped	Yeah, so I was basically a student and wanted to get some experience. And so I feel like that was the easiest path, that way I could go to school… So yeah I got a lot of experience from being student technicians, I would recommend. I've had students reach out to me and I recommend getting a student technicians are just so they teach you the basics and you can get some hands on experience. So that was very beneficial for me.
	Networking helped	Mention the network of professors, advisor, bosses in the internship, etc.	I'm pretty shocked to find a job next week because I have a network that I have worked on since college. So, absolutely. Yeah, that's great. That's actually how I got the internship connection. Yeah, I'll elaborate on this.
	University Alumni Network (recognition, self-endorsement)	Point out alumni network as factor influencing advancement	A person also went to my university but he got his degree in water management, or something like that. It wasn't in the IT department but he did help me find out about the job.
	Mentor helped	Point out mentors' help to advance in job	So make sure you have mentors who can help you understand how much the waiting time of the system is necessary because sometimes there are policies and things in place but yes, nobody is responsible for your career growth but yourself.

Career Advancement (continued)	Learning/self-directed approach utilized	Mentions self-directed learning	I mean in any kind of technology field, you have to be willing to learn yourself because you know you're not gonna know everything you have to, you know, do it. You have to be self-taught a lot of things because there's not only so much specialization out there.
	Certifications on-the-job supported	Mentions the importance of certification in pursuing jobs or talk about getting certification for jobs	Now one thing I would like to see if I can go back and do it again. I would like one of the requirements to not just be to take the class, but to actually go out and get the certification that be part of the curriculum is that you have to go and take and pass the certification, which would be useful going into the job market to where you have the experience as well as the certification and the degree that would make you a kill shot in my opinion from a resume standpoint.
HRD-related coursework	Learned from HRD	Talk about how and what benefits of classes they got	And so a lot of those human development classes. I think it helped me understand how to be an employee and drive a team to actually deliver something, not just how to do something.
	Unnecessary	Did not feel any benefit from the class content	Two or maybe additional HRD courses that were beneficial but I don't feel like it was necessary because I feel like you guys are just trying to fill it in. Because there was a lot of organization and changes and so, we needed something in our curriculum and so you just didn't have the personnel
	Neutral perception	Talk from both side or mention some pains and gains	And I don't do any of that, I don't do a data analysis of my company {talking about the HRD research class}. So it's not something that applies to me, my career and my workforce. At the moment, it may come in later though, I mean who knows.
TCMG-related coursework	Took Technology courses on a neighboring Campus	Point out another neighboring campus and technology classes	Yes, let me elaborate on the hands-on classes that we took network, network plus, and all the other coding courses we took at the neighboring college.
	More technical classes needed	Emphasized the need to provide more technical classes	I was kind of hoping for more technical classes. A proper term would be more creative. So like the video editing type of courses, I was more interested in the technical courses, relating to software.
	Happy with the coursework	Mention they got a lot from courses and think they are useful	The DevOps course was really beneficial.
Management Minor	Immediately applicable to current career	Contribute to finding jobs due to some skills.	I use HTML because if you're a new hire for example and you need an email. The email was straight HTML, so I took business owner info from the business minor. That's where I learned HTML. All that class is very helpful…The information from that one is extremely helpful. The XML pivot system, so helpful.
	Helpful in the long term	Point out the long term positive effect	I think that the courses that I took, like I said earlier, were extremely helpful in setting that mindset, because yeah there was a lot of stuff especially around project management, business acumen, financial acumen, that I had absolutely no clue about before going into the major.

Critical Success Factors	The Importance of TCMG faculty	Point out faculty is really helpful with being successful	There were a few professors that I would say had helped me. I couldn't off the top of my head remember their names but that kind of helped me. And a lot of cases just gain a little more self-confidence and what I was capable of doing.
	Widen course selection range	Mention they need more varied courses/ there is not wide enough courses for them to choose from	My position is more on the data scientist- business analyst. I feel like I wasn't really exposed to different things you can actually do with the major.
	More project-based assignments	Mention project/capstone/ practice assignment	The capstone course that I had with Dr. X was really beneficial. I like that a lot of the classes were just focused on working in the lab with your peers figuring out how to build the systems and figuring out how to solve all these problems in order to create real solutions in real world applicability.
	Promotion and public communication	Mentioned students need to self-market and present themselves	I think students limit themselves as to what their opportunities really could be. Usually, they lock themselves too specifically into exactly what they want to do… I would better sell the entire program to a recruiter, then coming up saying, I want to be a desktop support person, I get that a lot. Being able to sell the entire program and all of the experiences they get in the program would better sell them to a company.
	Alumni feedback	Alumni help/network/feedback	Maybe past alumni will also come and speak just to show the current student what you can do with that degree in what's possible, and this is confidential.

Jinhua Zhao

Jinhua Zhao is a Postdoctoral Faculty Fellow at the Communication University of China. She holds a Ph.D. in Educational Administration and Human Resource Development from Texas A&M University. Her research centers on education policy, particularly STEM education, examining how educational systems and policies shape students' experiences. She aims to bridge research and practice to promote equity and innovation in STEM pathways.

Noemi V. Mendoza Diaz

Noemi V. Mendoza Diaz, Ph.D., is an Assistant Professor in the Technology Management Program within the College of Engineering at Texas A&M University. Her areas of expertise include computer education and the participation of minorities in engineering. She serves as the faculty advisor for three student organizations: the TCMG Society, the Society of Hispanic Professional Engineers (SHPE), and Latinos in Engineering and Science (MAES).

Rufino Oregon

Rufino Oregon holds a B.S. in Technology Management and is passionate about research in technology, engineering, and education. He has conducted research at TAMU, Rice, and LSU, contributing to data analysis, visualization, and fieldwork. He's co-authored a CS education paper, presented at Rice, and worked with leading scholars using Python, R, and SQL.