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UNDERSTANDING ATTRACTIVENESS OF ENGINEERING: INFLUENCING FACTORS AND POTENTIAL IMPACTS (WORK IN PROGRESS)

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ABSTRACT

Issues associated with the shortage of engineers continue to persist and have led to a proliferation of work focused on understanding the factors involved in students' decisions to pursue engineering studies and careers. Such work highlights the range of interrelated actors and factors which inform study and career choice, as well as the diversity in terminology employed in published work. Progress in the area relies upon shared understanding of attractiveness, and the concepts involved. Accordingly, this work in progress focuses on identifying and synthesising existing terms and concepts used in relation to study and career choice more widely, with the aim of enhancing mutual understanding of attractiveness and allowing identification of research gaps. In so doing, we describe several existing study and career choice theories to provide a holistic understanding of the factors involved in study and career choice by situating them within the context of engineering. We then discuss the extent to which academic institutions and industry may influence each factor. We conclude by presenting a proposed methodology for the remainder of the project, for discussion and feedback from the wider community.

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1 INTRODUCTION

The significant labour shortages within engineering continue to be highlighted by policymakers (e.g., European Commission, 2023), with shortfalls being attributed, in part, to the lack of interest young adolescents show in engineering studies. Such trends are particularly worrying given the number of societal challenges to which the engineering profession need contribute, and have led to a proliferation of work focused on understanding the factors involved in students' decisions to pursue an engineering career (e.g., Cruz & Kellam, 2018; Dias, 2011; Godwin et al., 2016; Main et al., 2021; Matusovich et al., 2010).

To this end, in 2010, SEFI established a Special Interest Group (SIG) focused on enhancing the attractiveness of engineering education, with 'Attractiveness of Engineering' being one of the thematic strands at its Annual Conference.

Progress in this area relies upon shared understanding of attractiveness, something which is complicated by the number of influencing factors and actors involved. At an individual level, students are impacted by intrinsic psychological and behavioural motivation (Atman et al., 2010; Sheppard et al., 2010), personal values, goals and needs (Matusovich et al., 2010), interest and attainment in the subject matter (Painter et al., 2017), self-efficacy beliefs (Jones et al, 2010), as well as extrinsic and financial motivations (Atman et al., 2010; Sheppard et al., 2010). Choice is also informed by experiences and those within students' lives. For example, Schrey-Niemenmaa & Jones (2011; 2015) highlight the role of quality STEM education, teachers' understanding of engineering, the presence of role models, and the perception of engineering within society, with Painter et al. (2017) describing the role of family and prior experience with engineering activities, for example through interventions and outreach (e.g., Gumaelius & Kolmos, 2016).

Other work has highlighted the role of education systems (Wint et al., 2024) in determining the available pathways to studying engineering, as well as the appeal of university programmes (Cronhjort et al., 2022). More widely, decisions to study engineering can be shaped more generally by availability of degree programmes locally, financial considerations, and institutional factors such as reputation (von Steinaecker & Serôdio, 2024; Gille et al. 2021; Serôdio et al., 2021; Widiputera et al., 2017).

The attractiveness of engineering thus appears to be influenced by a diverse range of interrelated factors whose significance varies, for example with age and geographical context. However, studies in the area of attractiveness tend to focus on the role of a limited subset of influences, making it difficult to obtain a holistic understanding of the situation at a systems level.

As argued by Ashwin (2009), no one theory can capture all aspects of higher education, and engineering education research typically makes use of multiple theories from a variety of disciplines, resulting in challenges associated with differences in disciplinary paradigms and terminology. Lönngren et al. (2023) label the resultant lack of conceptual clarity as problematic and highlight the need for conceptualisations to be explicit, thus allowing readers to interpret and judge results and for transfer between contexts.

In keeping with a need for conceptual clarity and to find underlying reasons for the low attractiveness of engineering studies, this work in progress contributes to a wider study focused on the following objectives:

- identifying and synthesising existing concepts and theories used in relation to study and career choice, and which can be applied to the attractiveness of engineering,

- developing a framework which consolidates existing concepts, and which includes actors and factors influencing study and career choices at different ages,
- assessing the need to adapt the framework for use specifically within the context of engineering.

In this initial paper we focus on the first objective by introducing a range of study and career choice theories in Section 2 with the aim of collating the key concepts involved in Section 3. We then present the proposed methodology for the remainder of the project in Section 4, for discussion and feedback from the wider community. The value of this work lies in the conceptualisation of a framework enhancing mutual understanding of attractiveness at systems level and allowing identification of research gaps for the SEFI and extended engineering education community. The framework will lay ground for the Attractiveness SIG to define focus points leading to concrete actions that will help to increase the attractiveness of engineering.

2 STUDY AND CAREER CHOICE THEORIES

Attractiveness of engineering is a complex concept that can only be described using extensive multidisciplinary approach. However, reviewing all systematically literature related to attractiveness of engineering is beyond the scope of this work. Instead, we begin by considering several existing study and career choice theories that cover a range of disciplinary perspectives for a holistic understanding of the ways in which study and career choices are conceptualised. The theories included in this paper build upon those previously used in attractiveness interventions as identified in an ongoing literature review study of 41 articles, in which the social and socio-cultural theories described in Sections 2.1 and 2.2 are most often mentioned (four times each). These were supplemented with the theories presented in Sections 2.3 and 2.4 . The theory presented in Section 2.3 adds a developmental perspective, while the theory of Section 2.4 is often used in existing study orientation instruments.

The following subsections include short summaries of the selected theories with a focus on presenting the central concepts. We then describe our efforts in synthesising these terms as well as identifying potential impacts stakeholders, such as industry and academia can exert over each factor.

2.1 Social Cognitive Theory (SCT) and Social Cognitive Career Theory (SCCT)

Social Cognitive Theory (SCT) (Bandura, 1986) is a psychological learning theory previously employed to investigate engineering study choice (e.g., Fletcher et al., 2024; Katz et al., 2024; Kim et al., 2025), with Goncher et al. (2023) highlighting its prevalence within engineering education research. It involves a tripartite system of interacting *personal/cognitive* factors (e.g., attitudes, values), *behavioural* factors (e.g., skills, practice, actions), and *environmental* factors (e.g., social norms, access to resources). It posits that individuals learn from *observation,* paying attention to behaviour and its consequences, being more likely to imitate behaviours for which they *expect* to be rewarded based on *vicarious reinforcements*. It thus emphasises the role of *self-efficacy* and agency in deciding whether to reproduce modelled behaviour, and the physical and behavioural ability to do so. The central concept of SCT is *reciprocal determinism* and thus, personal factors enable individuals to initiate and sustain behaviours that translate to effects on the environment/actions. Equally, reflection on actions and their impact feeds back to the person and can, in turn, influence their sense of self-efficacy. With respect to engineering attractiveness, this theory points towards the benefit of suitable and diverse role models, as well as the presence of a perceived reward associated with studying engineering. There is also a need to foster a supportive environment in which engineering work is perceived to be valued and which expose students to knowledge, skills and resources which support the development of cognitive and behaviour factors associated with engineering.

Social Cognitive Career Theory (SCCT) (Lent et al., 1994) is an extension of Bandura's SCT, and an attempt to unify and explain central processes and mechanisms of (a) development of career and academic *interest*, (b) career-relevant *choices*, and (c) *achievement* of performance outcomes, with a focus on late adolescence and early adulthood. The theory highlights the direct and indirect influence of *self-efficacy beliefs*, *outcome expectations*, *personal goals* and *performance attainment* for each of these three processes. Career-related interests are then formed through self-efficacy and outcome expectations and influence both educational and occupational choice goals. The model recognises that the interests are more likely to influence study and career choice in the presence of a supportive environment, and that barriers (e.g., finances, caring responsibilities) may result in a need to compromise interests. Lent and colleagues (2002) see an important role for educational institutions to support students in engaging in career exploration. Activities like job shadowing or internships but also extracurricular activities enable students to clarify their interests, values and competencies in relation to engineering. A key feature of the SCCT model is the inclusion of 'person input' (including ethnicity, gender etc) and contextual factors. Gender can thus be understood as a 'person input' which moderates the role of background contextual influences, socialisation processes, and learning experiences, which in turn contribute to self-efficacy and outcome expectancies. SCCT has been used to investigate engineering study choice (Lent et al., 2008, Liu et al., 2014, Wint, 2022) and career retention (Mozahem et al., 2019, Singh et al., 2013).

The Career Self-Management (CSM) model (Lent & Brown, 2013), a more recent theory in the stream of career development learning approaches, builds on SCCT by incorporating *conscious self-directedness or self-management*. The latter is required so that students can use their knowledge, experience, and emotions in choosing a career in a context of uncertainty and change, helping them to develop clear ambitions or concrete outcome expectations. In the context of engineering education, this is only possible when students can identify with engineering and envision themselves as future engineers.

2.2 Expectancy-Value Theory (EVT) and Situated Expectancy-Value Theory (SEVT)

Expectancy-Value Theory (EVT) is based on research by Tolman (1932), Lewin (1951) and Atkinson (1957) and addresses the psychological and social/cultural determinants that influence people's motivation and affect the way they make their performance-related decisions (Lin et al. 2016). The theory states that a person's motivation to undertake a task is determined by two main components: *expectancy beliefs* (i.e., confidence in one's ability to be successful in the task) and the *subjective value* they place on the task (i.e., the perceived importance, usefulness, or enjoyment of the task) (Eccles & Wigfield, 2020). According to this model, the value of a task is divided into four components: performance value, intrinsic value, utility value and cost (cf. Flake et al., 2015). The expectancy-value model states that the expectations of success and the value of the task are determined by a combination of factors. These include *personal characteristics and environmental influences* (Urhahne & Wijnia, 2023). For

example, within engineering, beliefs around value may depend on the image and status of engineering within society, information regarding renumeration.
Situated Expectancy Value Theory (SEVT) (Eccles & Wigfield, 2020) extends EVT by incorporating a situated perspective and recognising that motivation is not always static but instead develops in a dynamic way through immediate social, cultural and contextual influences (Urhahne & Wijnia 2023). SEVT is more adequate than EVT in current times whereby individuals are influenced on a daily basis through social media. It considers how expectancy beliefs and subjective values are shaped by concrete experiences, specific learning environments and societal expectations. This fits in with the widening participation rhetoric that engineering educators are trying to promote to establish a more diverse workforce.

2.3 Gottfredson's Theory of Circumscription and Compromise (GTCC)

The theory of Gottfredson (1981) proposes a framework for the development of young people's study and career choice, focusing on the evolution of their perception of available occupations. Within this, *circumscription* involves eliminating career options which appear to be incompatible with an individual's *self-concept* and involves several stages: orientation to size and power (age 3-5), where children admire authority figures; orientation to sex roles (age 6-8), associating occupations with gender stereotypes; orientation to social values (age 9-13), understanding social status and prestige; and orientation to internal, unique self (age 14+), where adolescents define their desired place in society based on their values, interests, and attributes.
The second phase of the process is *compromise* which involves the alignment of occupational aspiration to the external reality. As part of this, individuals may reject roles which more strongly align with their *self-concept*, in favour of those which appear to be more accessible. A variety of factors can then impact *accessibility* including knowledge acquisition and availability of training, labour market conditions, social networks etc. In relation to the attractiveness of engineering, this model highlights the role that the status and image of engineering play from an early age, and efforts should focus on the use of diverse role models and overcoming gender stereotypes associated with the profession. It also points to a need to make engineering more accessible, for example by providing different development opportunities, as well as information about the routes into the profession.

2.4 Person-Environment (P-E) Fit Theory (PEFT) and RIASEC

Within the context of study and career choice, P-E fit theory (French et al., 1982) proposes that congruence between individuals and their occupational environment results in positive outcomes. The theory encompasses both *person-job fit*, and *person-organisation fit*. Within this, person characteristics may include needs, values, goals, abilities, and personalities, all of which are non-static, whereas environmental factors may include intrinsic and extrinsic rewards, demands of a job or role and organisational culture. The focus on the working environment means that application of the theory may be more suited to work which considers retention of engineers within the workplace. However, it does highlight a need to help students further understand their needs, values and abilities and explore how they may align with the diverse roles available within the engineering sector. Holland's RIASEC model (1997) is a well-known example of a model based on P-E fit theory. Holland developed his theory on the idea that career choice is based on personality, resulting in *six personality types*. People will search for environments where they can use their competencies and express their values and attitudes. For example, an investigative type who is likely to be precise, analytical, curious, and intellectual, will more likely be happy to work in an investigative environment that matches these competencies. Although P-E fit theories are still relevant, these choice theories also have a narrow focus on career choice that implies a more or less stable society and they rather overlook the process of career decision. To increase attractiveness, it is important to present the diversity in engineering roles, required competencies and values, so that diverse pupils/students may perceive a fit with their personality.

3 SYNTHESIS OF MODELS

Several factors which influence attractiveness are included within the presented study and career choice theories, which converge in several key areas, as summarized in Table 1 together with whether academic institutions and industry may influence each factor. In this section we review these factors, while also situating them within the context of engineering and identifying possible leverage points.

Table 1: Overview of key concepts from different theories, with explanation and malleability (M) by industry and/or academia. Three categories of factors were included, following SCT theory: personal (P), Environmental (E) and Behavioural (B).

	Factor	Theory	Explanation	Malleable
P	**Self-efficacy beliefs**	SCCT	People's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances	x
	Expectancies for success	EVT	Individual beliefs about the likelihood of performing successfully on a specific task influenced by past experiences, feedback, and perceived difficulty.	x
	Academic self-concept	EVT, GTCC	A learner's relatively stable perception of their own academic abilities (formed over time through experiences, social comparison, and feedback)	x
	Outcome expectations	SCCT	Personal beliefs about probable response outcomes: social, material, and self-evaluative	x
	Cost	EVT	Competition with other goals	x
	Intrinsic value	EVT, PEFT	Personal enjoyment	x
	Attainment value	EVT, PEFT	Importance of doing well	x
	Utility value	EVT, PEFT	Perceived usefulness for future goals	x
	Vocational interest	SCCT	Patterns of likes, dislikes and indifferences regarding career-relevant activities and	x
	Person inputs	SCCT, EVT	E.g., gender, ethnicity, social class, culture, health/disability status	
	Personality traits	PEFT	RIASEC theory: Realistic, Investigative, Artistic, Social, Enterprising, Conventional	
	Circumscription	GTCC	Process of eliminating career options which appear to be incompatible with an individual's self-concept, in different stages	x
E	**Person-environment fit**	PEFT	Both person-job fit, and person-organisation fit / objective and subjective	x
	Compromise	GTCC	Process of alignment of occupational aspiration to the external reality	x
	Social and societal	SCCT	E.g., family, peers, mentors, personal career network contacts, role model exposure,	x
	Economic	SCCT	E.g., financial stability, resources	x
	Institutional	SCCT, PEFT	E.g., access to training, opportunities, task exposure, demands of job role, organisational culture (workplace)	x
B	**Performance attainment**	SCCT	Level of accomplishment and indices of behavioral persistance	

Figure 1 shows a schematic of ways in which the various concepts included within the theories interact, this being summarised by the points below:

- *Person inputs* (e.g., gender, ethnicity, social class) or *characteristics* and *background* (e.g., hometown, birthplace) are considered in both social cognitive and expectancy-value theories and appear to mediate factors including *learning experiences*. For example, it is likely, particularly when considering GTCC, that stereotypes regarding who is viewed by society as being an engineer, mediate the experience of underrepresented students during *learning experiences*.

- *Learning experiences* are varied and include both curricular and non-curricular (e.g., hobbies, summer camps, work placements) activities which expose students to engineering work and tasks. The ability for students to access such opportunities will depend upon contextual and environmental factors such as opportunity, supportive family, as well as finance. Whether such learning experiences result in increase in *self-efficacy* and change of *self-concept,* or increased *expectations of success* depend on aspects such as the quality of such experiences.
- Both person inputs (e.g., culture) and environment (e.g., family pressure, public perception of engineering) are likely to impact upon values. Expectancy value theories describe how *intrinsic value* (enjoyment), *attainment value* (importance of success) and *utility value* (usefulness for future goals), as well as *perceived costs* (e.g., time) influence the desirability of a career path. The presence of intrinsic value assumes that students are exposed to engineering related *learning experiences* that they find enjoyable. Meanwhile, the *utility value* reflects that they are informed about the pathways to engineering such that they value the need to study engineering or value the engineering profession as providing what they desire of a job (e.g., pay, security, impact).
- Both P-E fit theory and, to a lesser extent, GTCC, consider the congruence between the individual and job roles or organisations. A key distinction here is the difference between objective fit and subjective fit, the former referring to actual/measurable characteristics of the person and the environment and the latter on perceptions of the individual and their fit. Subjective fit is likely to be influenced by a variety of factors including public perception, family support, presence of role models. The existence of differences in objective and subjective fit has several implications. For example, people may choose not to pursue engineering because of a perceived lack of congruence. Both GTCC and SCCT include the need to compromise interest and fit, for example because of barriers (e.g., finances, caring responsibilities, lack of opportunities). This results in the individual pursuing a career less suited to their values, interests and attributes.

Both CSM and SEVT extend pre-existing models (SCCT and EVT respectively) to take account for dynamic adaptation and development across an individual’s career, by taking account for factors such as self-regulatory behaviours, the influence of experience and changing values and environments.

4 PROPOSED FUTURE WORK AND RECOMMENDATIONS

In this paper, we explored several study and career choice theories to identify overlap and potential differences and to identify factors determining attractiveness of engineering. We established factors that appear across the study and career choice theories and analysed them in the perspective of engineering and in view of which factors can be influenced by academia and the industry. As such this was the first step of establishing a framework of attractiveness of engineering that will help guide future efforts in the area.

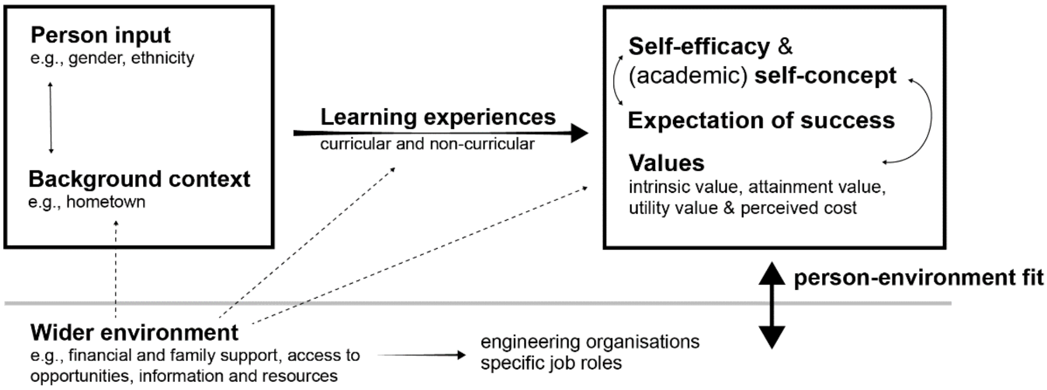

Figure 1: Schematic showing aspects influencing attractiveness of engineering derived from study and career choice theories.

4.1 Proposed future work

The next phase of our work in progress involves further consolidation of existing theoretical constructs and extending them through a scoping literature review. The literature review will help establish relevant theory-derived factors for building a holistic framework of attractiveness. Additionally, the review will allow for identification of research gaps and opportunities for alignment with ongoing or future research projects of the Attractiveness SIG or beyond.
The future work will also include a study whereby experts help to identify relevant actors, such as educators, peers, families, industry representatives, academics, and policy makers. Additionally, the expert feedback will involve assessing whether there are factors specific to engineering that are not fully represented/reflected in existing theories, and reflect on how to adapt and implement the framework to/in the engineering context.

4.2 Recommendations for industry and academia to enhance the attractiveness of engineering

Identification of future practice and research work, and the roles different actors can play in this, is an explicit part of the future phases. Nevertheless, based on this work, we can propose several ways in which practitioners and researchers may contribute to work in the area of attractiveness of engineering:

- Focus on ways in which engineering can be introduced into the school curriculum, thus allowing universal exposure to learning experiences, tapping into students' (changing) interests and values, which may foster self-efficacy and an understanding of the work engineers do.
- Evaluate learning experiences aimed at attractiveness of engineering to ensure they result in increased self-efficacy and expectation of success.
- Work to overcome stereotypes associated with engineering and improve the image of engineering in society and perceived fit with engineering.
- Develop mentoring and role model programmes which reflect the diversity of engineers.
- Ensure the accuracy and diversity of information pertaining to engineering roles and employers.
- Focus on understanding the barriers that students face in studying engineering or entering the engineering profession.

REFERENCES

Ashwin, P. (2009). Analysing teaching – learning interactions in higher education: Accounting for structure and agency. Continuum.

Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. Psychological Review, 64(6, Pt.1), 359–372. https://doi.org/10.1037/h0043445

Atman, C. A. J., Sheppard, S. D., Turns, J., Adams, R. S., Fleming, L. N., Stevens, R., Streveler, R. A., Smith, K. A., Miller, R. L., Leifer, L. J., Yasuhara, K., & Lund, D. (2010). Enabling Engineering Student Success: The Final Report for the Center for the Advancement of Engineering Education. Morgan & Claypool. http://www.engr.washington.edu/caee/final_report.html

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Prentice-Hall, Inc.

Cronhjort, M., Nobuoka, J., Ängskog, P., Haga, A., & Mårtensson, G. (2022). Efforts to improve attractiveness of lower level engineering education. *SEFI 2022 - 50th Annu. Conf. Eur. Soc. Eng. Educ. Proc.*, 1103–1112. https://doi.org/10.5821/conference-9788412322262.1444

Cruz, J., & Kellam, N. (2018). Beginning an Engineer's Journey: a narrative examination of how, when, and why students choose the engineering major. *Journal of Engineering Education, 107*(4), 556–582. https://doi.org/10.1002/jee.20234

Dias, D. (2011). Reasons and motivations for the option of an engineering career in Portugal. *European Journal of Engineering Education, 36*(4), 367–376. https://doi.org/10.1080/03043797.2011.593096

Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology, 61*, 101859. https://doi.org/10.1016/j.cedpsych.2020.101859

European Commission (2023). *Employment and social developments in Europe 2023.* Publications Office of the European Union. https://data.europa.eu/doi/10.2767/089698

Flake, J. K., Barron, K. E., Hulleman, C., McCoach, B. D., & Welsh, M. E. (2015). Measuring cost: The forgotten component of expectancy-value theory. *Contemporary Educational Psychology, 41*, 232–244. https://doi.org/10.1016/j.cedpsych.2015.03.002

Fletcher, T., Hooper, K., Alfonso, D. F., & Alharbi, A. (2024). Gender and STEM Education: An Analysis of Interest and Experience Outcomes for Black Girls within a Summer Engineering Program. *Education Sciences, 14*(5), 518. https://doi.org/10.3390/educsci14050518

French, J.R.P. Jr.; Caplan, R.D.; Harrison, R.V. (1982). *The mechanisms of job stress and strain*. London: Wiley.

Gille, M., Moulignier, R., & Kövesi, K. (2021). Understanding the factors influencing students' choice of engineering school. *European Journal of Engineering Education, 47*(2), 245–258. https://doi.org/10.1080/03043797.2021.1993795

Godwin, A., Potvin, G., Hazari, Z., & Lock, R. (2016). Identity, Critical Agency, and Engineering: an affective model for predicting engineering as a career choice. *Journal of Engineering Education, 105*(2), 312–340. https://doi.org/10.1002/jee.20118

Goncher, A., Hingle, A., Johri, A., & Case, J. M. (2023). The role and use of Theory in Engineering Education Research. In A. Johri (Ed.), *The International Handbook of Engineering Education Research* (pp 137-155). Routledge. https://doi.org/10.4324/9781003287483-9

Gottfredson, L. S. (1981). Circumscription and compromise: A developmental theory of occupational aspirations. *Journal of Counseling Psychology, 28*(6), 545–579. https://doi.org/10.1037/0022-0167.28.6.545

Gumaelius, L., & Kolmos, A. (2016). Outreach and attractiveness – a never ending story or a new approach? *European Journal of Engineering Education, 41*(6), 585–588. https://doi.org/10.1080/03043797.2016.1158795

Holland, J. L. (1997). *Making vocational choices: a theory of vocational personalities and work environments.*

Jones, B. D., Paretti, M. C., Hein, S. F., & Knott, T. W. (2010). An Analysis of Motivation Constructs with First-Year Engineering Students: Relationships Among Expectancies, Values, Achievement, and Career Plans. *Journal of Engineering Education, 99*(4), 319–336. https://doi.org/10.1002/j.2168-9830.2010.tb01066.x

Katz, J., Rajarathinam, R. J., Shao, Y., & Chen, Y. (2024). Understanding the Influence of a Week-Long Electrical and Computer Engineering Summer Camp on Middle School Students' Interests in STEM (RTP). *ASEE Annual Conference and Exposition, Conference Proceedings.* https://doi.org/10.18260/1-2--48197

Kim, H., Ottens, M., Jacob, M., & Qiao, X. (2025). Examining STEM preferences in autistic students: the role of contextual support, Self-Efficacy, and outcome expectations. *Exceptional Children*. https://doi.org/10.1177/00144029241312777

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45*(1), 79–122. https://doi.org/10.1006/jvbe.1994.1027

Lent, R. W., Brown, S. D., Talleyrand, R., McPartland, E. B., Davis, T., Chopra, S. B., Alexander, M. S., Suthakaran, V., & Chai, C. M. (2002). Career choice barriers, supports, and coping strategies: College students' experiences. *Journal of Vocational Behavior*, *60*(1), 61–72. https://doi.org/10.1006/jvbe.2001.1814

Lent, R. W., Sheu, H., Singley, D., Schmidt, J. A., Schmidt, L. C., & Gloster, C. S. (2008). Longitudinal relations of self-efficacy to outcome expectations, interests, and major choice goals in engineering students. *Journal of Vocational Behavior, 73*(2), 328–335. https://doi.org/10.1016/j.jvb.2008.07.005

Lent, R. W., & Brown, S. D. (2013). Social cognitive model of career self-management: Toward a unifying view of adaptive career behavior across the life span. *Journal of Counseling Psychology, 60*(4), 557–568. https://doi.org/10.1037/a0033446

Lewin, K. (1951). Field theory in social science: Selected theoretical papers. Harpers

Lin, A., Ettekal, A., Simpkins, S.D. (2016). Expectancy Value Models. In: Levesque, R. (eds) *Encyclopedia of Adolescence*. Springer, Cham. https://doi.org/10.1007/978-3-319-32132-5_251-2

Liu, Y., Lou, S., & Shih, R. (2014). The investigation of STEM Self-Efficacy and Professional Commitment to Engineering among female high school students. *South African Journal of Education, 34*(2), 1–15. https://doi.org/10.15700/201412071216

Lönngren, J., Direito, I., Tormey, R., & Huff, J. L. (2023). Emotions in engineering education. In A. Johri (Ed,), *The International Handbook of Engineering Education Research* (pp 156-182). Routledge. https://doi.org/10.4324/9781003287483-10

Main, J. B., Griffith, A. L., Xu, X., & Dukes, A. M. (2021). Choosing an engineering major: A conceptual model of student pathways into engineering. *Journal of Engineering Education, 111*(1), 40–64. https://doi.org/10.1002/jee.20429

Matusovich, H. M., Streveler, R. A., & Miller, R. L. (2010). Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values. *Journal of Engineering Education, 99*(4), 289–303. https://doi.org/10.1002/j.2168-9830.2010.tb01064.x

Mozahem, N. A., Ghanem, C. M., Hamieh, F. K., & Shoujaa, R. E. (2019). Women in engineering: A qualitative investigation of the contextual support and barriers to their career choice. *Women's Studies International Forum, 74*, 127–136. https://doi.org/10.1016/j.wsif.2019.03.014

Painter, J. K., & Snyder, K. E., & Ralston, P. A. (2017), Why Engineering? Students' Reasons for Choosing an Engineering Major. In *2017 ASEE Annual Conference & Exposition* http://dx.doi.org/10.18260/1-2--29126

Serôdio, M., Sá, M., & Kövesi, K. (2021). Introspection into Portuguese universities' attractiveness: a focus on industrial engineering and management students. In Heiß, H.-U., Järvinen, H.-M., Mayer, A., & Schulz, A. (Eds.), *Blended Learning in Engineering Education: challenging, enlightening and lasting? SEFI 49th Annual Conference* (pp. 482-490). European Society for Engineering Education (SEFI), Berlin, Germany. https://doi.org/10.5281/zenodo.14647077

Schrey-Niemenmaa, K., & Jones, M. E. (2011). Attractiveness in engineering education: Is all as it seems? *SEFI Annual Conference 2011*, 433–436.

Schrey-Niemenmaa, K., & Jones, M. E. (2015). Attractiveness in Engineering Education - culture and challenges. *Proceedings of 43rd SEFI Annual Conference 2015 - Diversity in Engineering Education: An Opportunity to Face the New Trends* *of Engineering.*

Sheppard, S., Gilmartin, S., Chen, H.L., Donaldson, K., Lichtenstein, G., Eriş, Ö., Lande, M., & Toye, G. (2010). *Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES)* (CAEE-TR-10-01). Seattle, WA: Center for the Advancement for Engineering Education. http://www.engr.washington.edu/caee/APPLES_report.html

Singh, R., Fouad, N. A., Fitzpatrick, M. E., Liu, J. P., Cappaert, K. J., & Figuereido, C. (2013). Stemming the tide: Predicting women engineers' intentions to leave. *Journal of Vocational Behavior, 83*(3), 281–294. https://doi.org/10.1016/j.jvb.2013.05.007

Tolman, E. C. (1932). *Purposive behavior in animals and men*. Century/Random House UK.

Urhahne, D., & Wijnia, L. (2023). Theories of Motivation in Education: an Integrative Framework. *Educational Psychology Review, 35*(2). https://doi.org/10.1007/s10648-023-09767-9

von Steinaecker, M., & Serôdio, M. (2024). University Attractiveness And Covid-19 Influence: A Focus On Industrial Engineering And Management Students. *Proceedings of the 52nd Annual Conference of SEFI,* Lausanne, Switzerland. https://doi.org/10.5281/zenodo.14254896

Widiputera, F., De Witte, K., Groot, W., & Van Den Brink, H. M. (2017). The attractiveness of programmes in higher education: an empirical approach. *European Journal of Higher Education, 7*(2), 153–172. https://doi.org/10.1080/21568235.2016.1275976

Wint, N. (2022). Why do students choose to study on engineering foundation year programmes within the UK? *European Journal of Engineering Education, 48*(1), 157–179. https://doi.org/10.1080/03043797.2022.2047895

Wint, N., Craps, S., Deprez, H., & Mottl, P. (2024). Exploring The Role Of National Education System On Pathways Into Engineering: A Comparitive Study (Research). *Proceedings of the 52nd Annual Conference of SEFI, Lausanne, Switzerland*. https://doi.org/10.5281/zenodo.14254780