A Review of Career Development Theories and Their Applications in Engineering

Mandana Ashouripashaki, The Ohio State University

Mandana Ashouripashaki is a PhD student in the Department of Engineering Education at The Ohio State University and the Associate Director of Licensing and Business Development at The Ohio State University's Innovation and Commercialization Office. Mandana holds a BSc in Chemical Engineering from The University of Tehran and dual MSc degrees in Environmental and Water Resources Engineering and Chemical Engineering from The University of Texas at Austin.

Dr. Krista M Kecskemety, The Ohio State University

Krista Kecskemety is an Associate Professor of Practice in the Department of Engineering Education at The Ohio State University and the Director of the Fundamentals of Engineering for Honors Program. Krista received her B.S. in Aerospace Engineering at The Ohio State University in 2006 and received her M.S. from Ohio State in 2007. In 2012, Krista completed her Ph.D. in Aerospace Engineering at Ohio State. Her engineering education research interests include investigating first-year engineering student experiences, faculty experiences, and the research to practice cycle within first-year engineering.

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Abstract

Career development theories play a pivotal role in advancing engineering education research by providing insights into how students navigate career choices, develop skills, and progress in their professional journeys. In the dynamic landscape of engineering, understanding the grounds of career development becomes imperative. This review aims to explore the history and the status of these theories, highlighting their significance in ongoing engineering education research.
The research question driving this review is how various career development theories contribute to addressing challenges and seizing opportunities in engineering education, while also identifying gaps in their application for cultivating meaningful career paths. The review examines a spectrum of theories shedding light on possible career motivations in engineering and other vocations. The exploration extends to developmental, learning, and transition theories, offering crucial insights into self-concept, career aspiration refinement, and the impact of unplanned events in career development. Understanding how individuals interpret events in their career development, the role of cognitive processes, and the pursuit of meaning in a fulfilling career and life are contemporary perspectives that offer nuanced insights.
As engineering continues to evolve, this paper underscores the foundational importance of career development theories in shaping effective education that addresses current and future challenges. Recognizing the relevance of these theories is essential for guiding individuals towards meaningful and fulfilling careers, making it a crucial area for future exploration in engineering education research. Furthermore, this review serves as a foundational step towards conducting a systematic literature review in the future.

Introduction

Navigating the Landscape of Career Development Theories

Career development theories provide invaluable frameworks for comprehending the complex and multifaceted journeys individuals embark upon towards professional growth, job satisfaction, and goal achievement. Grasping the nuances of these theories is essential for individuals to identify their strengths, weaknesses, core values, and ultimately, their ideal career paths. While each theory boasts distinct characteristics and approaches, they are united by a common thread: the critical role of fostering a positive emotional connection with work and the work environment in cultivating meaningful professional aspirations.

The process of career development theory comes from four disciplines:

- Differential Psychology: This field investigates the psychological variations between individuals, particularly concerning their work-related preferences and aptitudes.
- Personality: This discipline examines the individual as an active agent in shaping their own experiences, recognizing the unique personality traits that influence career choices and trajectories.

- Sociology: This field focuses on the social and cultural factors impacting occupational mobility, highlighting the interconnectedness of career development and societal dynamics.
- Developmental Psychology: This discipline concerns itself with the "life course" approach, examining how career development unfolds across different stages of an individual's lifespan.

Collectively, these diverse perspectives paint a vibrant landscape of approaches to understanding individual needs, organizational fit, and the path to fulfilling career journeys. In essence, career development theories serve as potent tools for individuals to navigate the complexities of career choices, aligning their unique traits, personality types, interests, values, and cultural backgrounds with suitable work environments.

Purpose

While no single theory reigns supreme, certain empirically supported frameworks have earned considerable recognition within the engineering field. Leveraging these established theories empowers engineers to shape satisfying and impactful careers that contribute meaningfully to both their personal development and societal progress.

The goal of this work is to conduct a comprehensive review of career development theories and examine their practical applications within the engineering field. By exploring the historical context, core principles, and real-world implementations of these theories, this literature review aims to provide insights into how engineers can utilize established frameworks to shape fulfilling and impactful careers.

Literature Review

In this literature review, various existing theories that contribute to understanding of career development from diverse perspectives will be discussed. These theories can be broadly categorized into four high-level categories: Maslow's Hierarchy of Needs, Trait and Type Theories, Developmental, Learning, and Transition Theories, and Contemporary Perspectives in Career Development Theories. Each category offers unique insights into how individuals navigate their professional journeys, highlighting the complex interplay between personal aspirations, societal influences, and environmental factors. Throughout the exploration, there will also be a brief discussion of the applicability of each theory to the field of engineering, considering how these frameworks can inform career paths, transitions, and professional development within this specialized domain.

Maslow's Hierarchy of Needs: A Lens for Understanding Career Motivations

While not explicitly a career theory, Abraham Maslow's Hierarchy of Needs [1], [2] sheds light on the motivational forces driven by different levels of human needs. Maslow's model proposes a pyramid structure, where individuals progress through five levels of needs, each requiring fulfillment before moving to the next:

- Physiological Needs: These fundamental survival needs include air, food, water, shelter, and warmth.
- Safety and Security Needs: This level focuses on the desire for protection, security, law, order, and stability.
- Love and Belonging Needs: This involves building relationships with family, friends, intimate partners, and colleagues.
- Esteem Needs: Here, individuals seek recognition, status, responsibility, and a positive reputation.
- Self-Actualization Needs: This level centers on achieving personal growth and fulfillment.

Essentially, Maslow's Hierarchy provides a valuable framework for understanding individual motivations and tailoring career guidance accordingly. In the context of choosing a career in engineering, Maslow's hierarchy can be applied to understand the decision-making process. At the foundational level, individuals may initially consider practical aspects such as job stability and financial security, addressing their physiological and safety needs. Moving up the hierarchy, the prospect of utilizing one's skills and education in engineering satisfies the need for esteem and accomplishment. Finally, the pursuit of a career in engineering, driven by a passion for innovation and problem-solving, aligns with the highest level of Maslow's hierarchy—self-actualization [3]. In essence, the decision to enter the engineering field can be seen as a progression through these motivational stages, reflecting an individual's desire for personal growth, achievement, and the fulfillment of their intellectual and creative potential.

Trait and Type Theories

Trait and Type Theories in career development provide frameworks for understanding individual characteristics, preferences, and their alignment with occupational factors. Exploring these theories facilitates a nuanced understanding of how people can navigate their career paths based on traits, preferences, and the inherent connection between personality and professional choices.

Trait and Factor Theory

Parsons' Trait and Factor Theory [4] aims to pinpoint the individual's characteristics (traits) and the environmental or job prerequisites (factors), enabling job seekers to discover careers closely aligned with their personal attributes [5], [6]. Parsons incorporated a self-knowledge component into the process of matching an individual's traits with occupational factors, emphasizing:

- Self-Assessment: Individuals undertake a thorough self-exploration to understand their traits, including their attitudes, abilities, interests, strengths, and limitations.
- Job Analysis: Individuals gain comprehensive knowledge about the factors associated with different occupations, such as tasks, pay, advancement opportunities, and work environment.
- Matching Process: Individuals carefully compare their self-identified traits with the factors required by specific occupations, aiming to find the best possible match for their unique profile.

While the popularity of the Trait and Factor Theory declined in the 1950s as more complex theories emerged, its influence on career development and vocational psychology remains undeniable [5]. Also, not extensively studied, the fundamental concepts of Parsons' theory continue to influence career development strategies for individuals pursuing engineering careers.

Myers-Briggs Type Theory

The Myers-Briggs Type theory, initially rooted in structural personality theory and later adapted for career development [7], has its foundation in the 1920s when Katharine Briggs explored Carl Jung's theory of psychological types. Over the following two decades, she observed and categorized people, with her daughter, Isabel Myers, joining the effort in the 1940s. Together, they developed the Myers-Briggs Type Theory, utilizing personality types to categorize human behavior [8]. The Myers-Briggs Type Indicator (MBTI) is a renowned personality assessment tool that examines individual preferences and behaviors.

The foundation of the MBTI lies in four fundamental dimensions, each represented by a pair of opposing traits:

- Extraversion (E) – Introversion (I): This dimension focuses on where individuals direct their attention and energy. Extraverts gain their energy from external sources and thrive on social interaction, while introverts find solace in their inner world and prefer reflection.
- Sensing (S) – Intuition (N): This aspect relates to how individuals process information. Sensing types rely on concrete details and present realities, while intuitive types prioritize abstract concepts and future possibilities.
- Thinking (T) – Feeling (F): This dimension highlights decision-making styles. Thinkers prioritize logic and objectivity, while feelers consider personal values and emotions when making choices.
- Judging (J) – Perceiving (P): This final dimension reflects how individuals deal with the external world. Judging types prefer structure and organization, while perceiving types embrace flexibility and spontaneity.

Individuals are categorized according to their preferences on these four dimensions, resulting in a unique four-letter code (e.g., ENFP) that represents their personality type. Scores can range from 0 to 30, indicating the strength of each preference. The MBTI, although not initially designed for career development, was expanded to include a list of occupations associated with various personality types [9], making it a valuable career development tool.

In the early 2000s, studies challenged engineering stereotypes by utilizing the Myers-Briggs Type Indicator (MBTI) to evaluate the personality profiles of engineering students. The results highlighted the significance of aligning one's personality preferences with their chosen career paths [10]. Subsequently, there was a push for greater use of personality type instruments in the formation of engineering design teams, with advocating for the consideration of personality types in team composition [11]. The suggested approach involved employing personality type choice sets for team selection.

The research expanded its scope to Software Engineering significantly, revealing prevalent thinking and judging preferences within the community of software engineers [12]. A Systematic Literature Review [13] explored the connection between personalities of software professionals, team climate, and team performance, underscoring the significance of comprehending personality assessments and evaluating the work environment in software development. Another study investigated team roles and personality types in software development, classifying preferences based on strength and concluding with an appeal for heightened attention to personality-based research in software development [14].

Additionally, in a study conducted in 2019, researchers examined the application of MBTI in categorizing freshman engineering students and explored its correlations with their interests in engineering fields. The outcomes of this investigation indicated potential strategies that could be employed for recruiting and retaining a diverse student population in the field of engineering [15].

Interests: Vocational Personalities and Work Environments Theory

Also recognized as Vocational Choice Theory, John L. Holland [16], [17] conceived that the key to optimal job placement lies in matching individuals with careers that resonate with their personalities, particularly their interests. Emphasizing the significance of personality over other factors, Holland's Theory of Types underwent extensive research in the 1960s and has since become one of the most extensively studied and applied career theories.

Holland initially categorized careers into six major types (RIASEC), studying individuals within each category. Each type describes a unique blend of personality traits and preferences best suited to specific work environments.

- Realistic (R): Individuals who thrive on concrete tasks, physical work, and hands-on engagement.
- Investigative (I): Independent and analytical thinkers who excel in research, data analysis, and complex problem-solving.
- Artistic (A): Self-expressive individuals with a passion for creative endeavors, imagination, and introspection.
- Social (S): Individuals with a strong desire to help others and build relationships.
- Enterprising (E): Ambitious and persuasive individuals who thrive in leadership roles and dynamic environments.
- Conventional (C): Individuals who value order, structure, and detail.

Holland visualized relationships within and between types, creating a hexagon model where closer types resembled each other more closely. He recognized that individuals often fell into combinations of types, developing a consistent pattern, and intentional order (R-I-A-S-E-C) on the hexagon model. Consistency was identified between adjacent types, while inconsistency was noted between opposite types [17], [18].

Moreover, the combination of types indicated the most crucial elements for an individual's career choice congruent with their personality. Holland's differentiated scores, reflecting high scores on primary interests and low scores on others, indicated certainty in interests, while flat profiles

suggested uncertainty. Holland's Theory of Types remains widely used in career counseling centers today, supported by instruments like the Strong Interest Inventory, Self-Directed Search, and Vocational Preference Inventory, aiding individuals in aligning their personalities with potential occupational choices [18].

In examining Holland's vocational personality types among college seniors, significant differences in Vocational Preference Inventory (VPI) scores emerged across major groups [19]. This exploration illuminated the nuanced aspects of vocational preferences in this demographic. Building on this insight, a subsequent investigation delved into gender disparities within academic disciplines, aligning with Holland's theory and emphasizing the intricate influence of various factors on career choices [20]. Furthermore, underscoring the relevance of Holland's Theory in career decisions, another study emphasized the pronounced effect of a strong Person-Environment (PE) fit [21]. Within this comprehensive framework, factors such as career education, financial stress, and gender and cultural differences emerged as influential elements significantly contributing to the decision-making process.

Recently, Archana et.al, introduced the G-CAPS system in 2023 [22], presenting a pioneering approach tailored specifically for engineering students. This innovative system utilizes Convolutional Neural Networks (CNN) to analyze handwriting features, generating RIASEC codes that represent individual personality traits. Through machine learning algorithms and leveraging the O*NET database, G-CAPS predicts suitable engineering career paths. The overarching goal of G-CAPS is to elevate the success, growth, and job satisfaction of engineering students by aligning specific character traits with associated interests in engineering careers.

Developmental, Learning, and Transition Theories

These theories provide insights into the stages of personal and professional growth, the mechanisms of learning in a career context, and the crucial transitions that influence career trajectories. By intertwining these aspects, these theories offer a nuanced understanding of how individuals navigate and shape their careers.

Super's Life Span, Life Space Theory

Donald Super's (1953) Life-Span, Life-Space theory offers a comprehensive framework for understanding individual career development [23]. It emphasizes three key elements:

- Self-Concept: The core of Super's theory lies in the concept of self-concept, which he defines as the individual's perception of themselves, including their abilities, interests, and values. This self-concept is a dynamic entity, shaped by personal experiences, social interactions, and reflections.
- Life Span: Super recognized that career development is a lifelong process, encompassing five distinct stages:
    - Growth (0-15): This stage focuses on physical development, self-concept formation, and exploration of early interests and aptitudes.
    - Exploration (15-25): Individuals actively explore different career options, engage in specific training, and begin transitioning into the workforce.

    - Establishment (25-45): This stage involves establishing a stable career path, making significant contributions to the chosen field, and taking on increasing responsibility.
    - Maintenance (45-65): The focus here is on maintaining a steady career trajectory, continuously updating skills to stay competitive, and planning for retirement.
    - Disengagement (65+): This stage marks a gradual withdrawal from work, with individuals shifting their focus to leisure activities, family life, and community engagement.
- Life Space: Super emphasizes that individuals inhabit various "theaters" (home, work, school, community) throughout their lives. Within each theater, they play multiple roles (e.g., student, worker, parent, citizen) that evolve and change over time. These roles impact one another and contribute to the overall career development journey. To illustrate this complex interplay, Super developed the "Life-Career Rainbow," a visual representation of the various roles individuals assume across their lifespan.

In the context of engineering career, Super's theory can be applied to understand the career development of engineers. Super's theory also emphasizes the importance of multiple social roles and their interaction across the life span. Engineers have multiple social roles, such as being a professional, a family member, and a community member. The interaction between these social roles can influence the career development of engineers.

Theory of Circumscription and Compromise

Linda Gottfredson, in her work from 1981 and 1996, perceives career choice as an ongoing process rather than a singular event. Her theory aims to explain the variations in vocational expectations based on factors such as sex, race, and social class, with a specific emphasis on the cognitive development of children [24], [25].

Gottfredson theorizes that individuals refine their career aspirations through two key processes:

- Circumspection: This refers to the gradual elimination of unacceptable occupational choices based on an individual's evolving cognitive abilities and social awareness. This process unfolds in four stages, each characterized by increasing age and complexity:
    - Orientation to size and power (3-5 years).
    - Orientation to sex roles (6-8 years)
    - Orientation to social valuation (9-13 years)
    - Orientation to the internal, unique self (14+ years)
- Compromise: This process acknowledges the limitations of an individual's abilities and circumstances, leading them to accept less desirable career choices when their initial aspirations are deemed unattainable.

Gottfredson's model underscores the dynamic nature of career development, emphasizing the interplay between cognitive growth, social influences, and individual preferences in shaping career aspirations.

In engineering, Gottfredson's theory of circumscription and compromise reveals that traditional gender stereotypes and social class biases can limit career choices. Circumscription may subtly deter women, while societal messages create self-imposed barriers for some. Compromise often

involves engineers balancing specialization and broad interests, with career pragmatism sometimes outweighing personal preferences.

Positive influences, like exposure to successful female engineers and mentorship programs, counteract stereotypes and encourage diverse participation. As societal attitudes evolve, there's a gradual expansion of choices in engineering, fostering inclusivity. Understanding these factors enables us to collectively work towards creating an empowered and diverse space in engineering careers.

Happenstance Learning Theory (Planned Happenstance Theory)

In applying Bandura's 1986 [26] social learning theory to career development, John Krumbolz [27] proposed that career development and personal growth largely stem from unexpected events and chance encounters. This theory challenges traditional career planning models that emphasize long-term goals and linear career paths.

The Happenstance Learning Theory (HLT) is grounded in several fundamental beliefs including:

- Unplanned events drive career development and personal growth.
- Learning types:
  - Direct experience: Learn from consequences of your actions (e.g., studying leads to good grades).
  - Observing others: Learn by watching and modeling others' successful behaviors.
- Reinforcement: Positive and negative consequences shape behavior.

Happenstance Learning Theory encourages individuals to embrace the unplanned, learn from diverse experiences, and actively explore possibilities to navigate their careers and lives. Central to HLT are five skills:

- Curiosity: exploring new learning opportunities
- Persistence: exerting effort despite setbacks
- Flexibility: changing attitudes and circumstances
- Optimism: viewing new opportunities as possible and realistic
- Risk Taking: taking action in the face of uncertain outcomes

When tailored to engineering, HLT introduces varied learning types, including direct experience (learning from the consequences of actions) and observing others (learning by watching and modeling successful behaviors). The concept of reinforcement, where positive and negative consequences shape behavior, resonates strongly within the dynamic and evolving landscape of engineering. It becomes a strategic approach for navigating the ever-evolving landscape of technological advancements and professional opportunities. Embracing happenstance learning aligns with the inherent nature of engineering, where innovation often arises unexpectedly, and successful engineers leverage chance encounters to shape their unique and fulfilling career paths.

Schlossberg's Transition Theory

Life is full of transitions, both expected and unexpected. These changes can be exciting or stressful, depending on our individual circumstances and resources. To understand and manage

these transitions effectively, Nancy K. Schlossberg [28] developed her Transition Theory and the 4S model. Schlossberg defines a transition as any event or non-event that results in a change of roles, routines, or relationships.

These can include:

- Expected events: Getting a job, starting school, getting married, having children, retiring.
- Unexpected events: Illness, job loss, death of a loved one, accidents.
- Non-events: Not getting the job you wanted, not getting accepted into school, not having children.

To help individuals navigate transitions, Schlossberg developed the 4S model, which identifies four key factors that affect our ability to cope:

- Situation: Timing, duration, and nature of the transition.
- Self: Personal characteristics, values, and coping abilities.
- Supports: People and resources, quality, accessibility, and willingness to accept help.
- Strategies: Coping mechanisms for managing stress and change. Ability to develop new strategies as needed.

The timing and nature of engineering transitions, influenced by modern events like the global pandemic, pervasive AI integration, and evolving business expectations, play crucial roles. Engineers, facing unprecedented challenges, must showcase resilience and adaptability. Personal characteristics gain significance, particularly in embracing technological advancements like AI. Supportive networks, both physical and virtual, become vital for collaboration and mentorship amid rapid industry changes. Coping mechanisms need to adapt to the accelerated pace of change, emphasizing flexibility and proactive skill development. Staying updated on contemporary resources emerges as an essential strategy for managing stress and uncertainty in the dynamic landscape of choosing and pursuing an engineering career.

Contemporary Perspectives in Career Development Theories

In the domain of career development, "Contemporary Perspectives in Career Development" encompasses a diverse range of postmodern approaches that transcend traditional narratives. This evolving framework acknowledges the fluidity of career paths, involving the dynamic interplay of individual experiences, societal influences, and emerging trends. It encourages individuals to navigate their professional journeys with flexibility and self-authorship, recognizing that careers are not linear but rather complex narratives shaped by personal values, passions, and evolving societal landscapes.

Social Cognitive Career Theory

The Social Cognitive Career Theory (SCCT), pioneered by Hackett and Betz [29] in 1981 and further developed by Lent et al. [30] in 1994, explores the fascinating realm of how individuals interpret events within the context of their career development. SCCT intricately explores the personal constructions people place on events, introducing a comprehensive framework:

- Self-Efficacy Beliefs: Individuals foster a belief in their capability to achieve their desired goals. This foundational element shapes their perceptions of personal competence in navigating the complexities of the career landscape.
- Expectancy Outcomes: Aligned with their self-efficacy beliefs, individuals anticipate outcomes that substantiate and reinforce their confidence. Positive expectations set the stage for a proactive approach to career pursuits.
- Interests Development: The interplay between beliefs and outcome expectancies actively contributes to the formation and refinement of individual interests. These interests serve as integral components in shaping one's career trajectory.
- Goal Prediction: Interests, as a result of this intricate interplay, emerge as predictors for personal goals within the dynamic realm of career decision-making. Goals become the compass guiding individuals toward meaningful vocational directions.
- Activity Selection: With goals as guiding beacons, individuals make deliberate choices in selecting and engaging in activities that align with their envisioned career paths. This strategic approach enhances the likelihood of goal attainment.
- Success and Goal Fulfillment: The successful execution of chosen activities becomes a conduit for goal fulfillment and overall career attainment. This cyclical process reinforces the reciprocal relationship between belief systems, interests, goals, and successful outcomes.

SCCT argues that individuals struggling with low self-efficacy beliefs or expectations may encounter obstructions in navigating the complexities of their career aspirations [31], [32]. This multifaceted theory provides a nuanced understanding of how cognitive processes influence and shape the trajectory of an individual's career development journey.

SCCT has received more attention in studies related to engineering and career development compared to traditional-era career development theories. Some studies have delved deeper into investigating minorities and women in engineering, showcasing a shift towards a more inclusive examination of career pathways. While traditional career development theories are applicable across various careers based on individual personality and attitude, there is a scarcity of studies that comprehensively explore the societal impact of career choices—a dimension that modern theories like SCCT emphasize. SCCT, with its focus on social influences, offers a more holistic perspective that considers broader societal contexts, contributing to a nuanced understanding of career development beyond individual traits.

In a 2009 study, Lent et al. [33] focused on engineering students at historically Black universities, engaging in a comprehensive longitudinal exploration of SCCT factors. This investigation considered variables such as self-efficacy, outcome expectations, interests, goals, and environmental supports and barriers. The findings highlighted temporal relationships, positioning self-efficacy as a precursor to outcome expectations, interests, goals, and supports. The study spotted a mutual connection between interests and self-efficacy, revealing that supports and barriers did not uniquely contribute to variations in self-efficacy. This research advanced the application of SCCT in engineering and emphasized its pivotal role in addressing challenges and opportunities for underrepresented groups in STEM fields, aligning with broader societal goals of diversity and inclusion.

Building on this, a subsequent study by [34] applied SCCT to predict engineering interest and major choice goals among 579 sophomore engineering students. The results demonstrated the effective fit of the SCCT model for both genders, revealing gender differences in self-efficacy beliefs and interest in engineering. Women exhibited lower self-efficacy beliefs and less interest in engineering compared to men, although no significant differences were found in outcome expectations and goals. Women were more likely to perceive support, particularly from peers and family, while men tended to perceive family barriers.

Later in a 2018 study, Lent et al. [35] extended the application of SCCT to analyze interest and choice aspects within science, technology, engineering, and mathematics (STEM) domains. This meta-analytic study utilized data from 143 studies over a 30-year period, encompassing 196 independent samples. The results of meta-analytic path analyses revealed that the interest/choice model fit well across all samples, including those primarily composed of different gender and racial/ethnic groups. SCCT consistently explained significant variance in interests and choice goals. While demonstrating general predictive utility, the study noted parameter estimates differing by group, presenting both similarities and differences. These findings carry implications for future research, interventions, and theory refinement in understanding career choices in STEM domains.

Integrative Life Planning Theory

Developed by career development expert Sunny Hansen [36], Integrative Life Planning Theory (ILPT) emphasizes the central role of finding meaning in shaping a fulfilling career and life. This theory, forged over 35 years of experience in the field, recognizes the interconnectedness of work, community, families, and cultural context in individual development [37], [38].

Hansen's extensive observations revealed six critical life tasks that interconnect important concepts:

- Finding Purposeful Work: Identifying work aligned with personal values in a changing global landscape.
- Weaving Meaning into Work: Integrating values into work for purpose and satisfaction.
- Connecting Family and Work: Balancing roles and relationships within families while pursuing career aspirations.
- Embracing Diversity: Valuing cultural differences for inclusivity and growth.
- Mastering Change: Adapting to personal transitions and organizational transformations effectively.
- Seeking Spirituality and Meaning: Exploring personal purpose and spirituality for a deeper understanding of life's meaning.

These six critical tasks underscore Hansen's belief that the search for meaning and connection is fundamental to a fulfilling life. ILPT encourages individuals to explore their life purpose, integrate personal values into work, and navigate relationships within different contexts. By doing so, individuals can create a career and life that resonates with their deepest values and aspirations [37], [6].

Integrative Life Planning Theory (ILPT) aligns with Maslow's Hierarchy of Needs [1], [2] by recognizing the broader context in which individuals develop and plan their lives. ILPT emphasizes the interconnectedness of various life aspects, including work, community, and family. By emphasizing the central role of finding meaning, ILPT aligns with the higher-level needs in Maslow's Hierarchy, particularly focusing on aspects related to esteem and self-actualization. ILPT suggests that individuals, when planning their lives, should consider not only basic needs but also the pursuit of meaningful work, personal development, and contributions to the community.

In essence, ILPT complements Maslow's Hierarchy by providing a framework that encourages individuals to integrate higher-level needs and aspirations into their life planning, fostering a more holistic and fulfilling approach to personal and career development.

Career Construction Theory & Life Design

The career construction theory, introduced by Savickas in 2005 [39], [40], expands upon Super's foundational framework [23] by incorporating a narrative approach to meaning-making. Instead of relying solely on assessments, the theory encourages counselors to consider an individual's entire story, including their context, interactions, and how they derive meaning. Key elements of career construction theory include:

- Self-Construction: Individuals evolve from childhood "actors," to "agents" with growing autonomy, and ultimately become "authors" of their lives and careers.
- Career Adaptability: Expanding on Super's "career maturity," this concept involves assessing career concerns, identifying developmental tasks, and exploring skills and resources needed to resolve them. It comprises four dimensions:
    - Concern: Acknowledgment of planning and optimism for future career options, contrasting with indifference, apathy, or pessimism.
    - Control: Ability to take charge of career choices, contrasting with indecision, confusion, procrastination, and impulsivity.
    - Curiosity: Embracing exploration of interests and alternatives, contrasting with unrealistic beliefs about self and the environment.
    - Confidence: Increased self-efficacy and belief in career success, contrasting with career inhibition.
- Life Themes: Guiding career choices, this address why individuals choose certain careers, what personality types might fit with those careers, and how individuals can adapt to their chosen careers [41].

In engineering, where technology evolves rapidly, career transitions are common. The Career Construction Theory encourages a focus on adaptability and the individual's capacity to construct new meanings in response to changing circumstances. This is particularly relevant in engineering, where professionals may need to navigate shifts in their roles or industries. Also engineering often involves collaborative work, which emphasis on interactions and relationships can be applied to understanding how individuals navigate teamwork, leadership roles, and communication styles within engineering teams.

Chaos Theory of Careers

Chaos Theory of Careers takes a departure from traditional predictive models in career by addressing the dynamic realities of career decision-making, emphasizing factors such as complexity, change, constructivism, and chance. Pryor and Bright [42] introduced the concept of attraction to describe patterns of behavior in response to life challenges.

There are four types of attractors identified in Chaos Theory of Careers:

- Point Attractor: Individuals focus on finding the perfect career "fit" by matching their personality, interests, and skills. This approach often minimizes the role of chance and uncertainty.
- Pendulum Attractor: Individuals oscillate between conflicting needs or desires, struggling to find a stable point between two extremes. This often leads to frustration and compromise that may not satisfy either need.
- Torus Attractor: Individuals rely on routine, predictability, and structure to maintain a sense of control over their lives. They categorize and organize everything to avoid the discomfort of the unknown.
- Strange Attractor: Individuals exhibit open-mindedness and adaptability, embracing the potential for change and growth. This approach allows for continuous learning and flexibility in navigating an unpredictable world.

Chaos Theory of Careers also integrates the concept of spirituality into career development, recognizing five key dimensions:

- Connection: Feeling a sense of belonging to something larger than oneself, whether it be community, the world, or a spiritual force.
- Purpose: Discovering meaning and significance in one's life and career.
- Transcendence: Belief in a higher power or a connection to something beyond oneself.
- Harmony: Finding a sense of balance and coherence within oneself and in the world around them.
- Calling: Feeling a strong sense of direction and purpose, believing that one is meant for a particular career path.

Finally, Chaos Theory of Careers introduces the concept of shiftwork, which describes the process of changing and reorganizing one's life to adapt to new circumstances. This theory utilizes eleven phase shifts, guiding individuals from a state of prediction and control to one of trust and acceptance, embracing the uncertainties that life presents [32].

By understanding the concepts of attraction, spirituality, and shiftwork, individuals and career counselors can develop a more flexible and adaptable approach to career development. This allows for greater resilience in the face of change and leads to a more fulfilling and meaningful career journey.

Value-based Career Decision Making

Value-Based Career Decision Making (VBCDM), conceptualized by Douglas T. Brown [43], [44], is a contemporary theory in career development that underscores the pivotal influence of

individual values on career choices. The theory acknowledges that aligning one's profession with personal values is essential for attaining enduring career satisfaction and fulfillment.

The key concepts of this theory are:

- Values: Core beliefs and principles that guide an individual's behavior and decision-making.
- Value Congruence: The degree to which one's work aligns with their values.
- Value Identification and Clarification: Individuals need to actively identify and clarify their core values through introspection, self-reflection, and career exploration activities.
- Value-Based Career Planning: Utilizing identified values to guide career decisions, including choosing educational paths, exploring job options, and setting career goals.

Value-Based Career Decision Making offers individuals a powerful framework for navigating the complex world of career choices. By prioritizing values and aligning work with what matters most, individuals can create a fulfilling and meaningful career journey. For engineers, whose work often involves complex problem-solving and innovative contributions, aligning career decisions with personal values can lead to a more fulfilling professional journey. VBCDM encourages engineers to reflect on their core beliefs and principles, guiding them to make career choices that resonate with their intrinsic values. By considering the ethical dimensions, societal impact, and personal fulfillment in engineering endeavors, individuals can navigate their careers in a way that not only aligns with their values but also contributes to a meaningful and rewarding impact in their professional lives.

Social Cognitive Career and Motivation Theory

The Social Cognitive Career and Motivation Theory (SCCMT), recently introduced by Dos Santos in 2021 [45], [46], builds upon the foundations of the Social Cognitive Career Theory [30] and Bandura's self-efficacy theory [47]. This innovative framework asserts that the intricate interplay of internal and external factors shapes individuals' motivations, career decisions, and decision-making processes. Internally, psychological aspects and self-efficacy play a pivotal role, influencing motivations, career decisions, and decision-making processes. Academic interests, personal considerations, and achievements in education and career goals constitute key dimensions within these internal factors. Externally, societal and environmental factors contribute significantly to individuals' and groups' motivations and decisions. Interests in career development, financial considerations, and the influence of surrounding environments and individuals emerge as crucial elements within these external factors.

This theory provides a nuanced understanding of the multifaceted nature of motivations and career decisions, recognizing the interconnectedness of internal psychological factors and external environmental influences [48].

Discussion

The diverse landscape of career development theories offers valuable insights for engineers navigating their professional journeys. While Maslow and Trait Theories lay the foundation for understanding motivations and preferences, theories like Happenstance and Constructivism

highlight the dynamic nature of career paths and individual meaning-making. Contemporary perspectives like SCCT and ILPT further address societal context and holistic life planning. For the engineering field, this richness of theories underscores the importance of a personalized approach, considering individual strengths, values, and adaptability within a rapidly evolving landscape. Recognizing this complexity, future research should focus on bridging theory and practice, developing practical tools for engineers and career advisors to navigate the path towards fulfilling and resilient careers in the age of constant change within the dynamic and technology-driven world of engineering. The need for continuous learning and adaptability aligns perfectly with Constructivist and Chaos Theory concepts, urging engineers to embrace change and see setbacks as opportunities for growth. Additionally, frameworks like SCCTM and VBCDM can be tailored to address specific challenges faced by underrepresented groups in engineering, promoting inclusivity and fostering diverse talent pipelines. Ultimately, integrating these diverse theoretical perspectives into practical tools and resources can empower engineers to craft meaningful and adaptable career paths, unlocking their full potential within a constantly evolving professional landscape.

Conclusions and Future Work

This literature review aimed to provide a comprehensive understanding of career development theories and their practical applications within the engineering field. By examining historical context, core principles, and real-world implementations of these theories, this study has uncovered insights into how engineers can leverage established frameworks to cultivate rewarding and influential careers. The review has also revealed several notable trends and patterns in the implementation of career theories within engineering professions, emphasizing the importance of a personalized approach that considers individual strengths, values, and adaptability in navigating the rapidly evolving landscape. However, gaps were identified in the adaptation of certain theories to address the specific challenges faced by underrepresented groups in engineering, highlighting the need for further research and tailored interventions to promote inclusivity and diversity within the field.

The future work for this review involves conducting a systematic literature review (SLR) to further dive into existing career development theories in the engineering field. A thematic synthesis process will be conducted based on the final publication set from the SLR. This method involves three stages: free-coding of primary studies, developing categories, and the development of themes. Thematic synthesis is particularly suited for synthesizing qualitative information and will provide a structured approach to extracting meaningful insights from the reviewed literature [49].

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