

Toward Sustainable Practice: Exploring Career Pathways, Supports, and Challenges,  
Sustainability and Digital Transformation in Water Engineering Practice

by

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## ABSTRACT

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Under the Supervision of Professor Sarah Blackowski

In the face of accelerating climate change and global water scarcity, the necessity for resilient, equitable, and sustainable water infrastructure has become increasingly pressing. Water engineering plays a pivotal role in addressing this challenge, yet its effective management requires more than merely technical solutions. It necessitates a comprehensive evaluation of the support, development, and retention strategies employed within the water engineering sector. This research investigates the multifaceted dimensions of sustainable practice within water engineering by conducting in-depth interviews with professionals across the sector. Using a qualitative methodology, this study employed semi-structured interviews with water sector professionals, analyzed through thematic analysis to identify recurring patterns and narratives. The study identifies six interconnected themes that influence career development and organizational effectiveness: effective communication, supportive work environments, consultancy experiences with the water industry, digital transformation, internship experiences, and gender discrimination. The findings reveal that effective communication is a foundational skill that enhances collaboration, leadership, and stakeholder engagement, especially in an increasingly

interdisciplinary and interconnected sector. Supportive work environments, defined by mentorship, open dialogue, and emotional safety, play a critical role in fostering resilience, professional growth, and long-term workforce retention. Early career experiences through internships and consultancy positions serve as vital touchpoints, helping individuals navigate complex technical projects, build confidence, and discover their professional identity.

Digital transformation is reshaping the sector not only through new technologies such as automation and data-driven monitoring but also through shifts in organizational culture, remote work, and expectations for digital literacy. In this context, self-improvement and self-learning emerge as essential tools for career advancement, enabling professionals to remain agile and ready for the future. Simultaneously, the persistence of gender discrimination continues to erode psychological safety and inclusivity in the workplace, with women in particular facing systemic barriers to recognition and leadership.

Ultimately, this study explores that sustainable practice in water engineering is not solely a matter of technical innovation, it requires an integrated approach that values interpersonal skills, continuous learning, inclusive leadership, and structural change. To meet the escalating demands of global water management and climate adaptation, the sector must invest in building work environments that are not only technically proficient but also socially conscious, digitally adaptive, and genuinely inclusive. This holistic perspective is essential to cultivating a workforce capable of driving sustainability, equity, and innovation in the 21st century.

Keyword: Global Water Scarcity, Water Industry, Career Development, Qualitative Research.

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*I want to dedicate this to my Beloved Parents, my Brothers, my Best friend, and Mankind. This work is dedicated to the professionals in the water industry, the engineers, consultants, operators, researchers, and leaders who work tirelessly to ensure the sustainability and resilience of our most vital resource.*

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## LIST OF ABBREVIATIONS

	Explanation
ABC	Explanation
SDGS	Sustainable Development Goals
UNSDGs	United Nations Sustainable Development Goals
DT	Digital Transformation
LLL	Lifelong Learning
WEF	World Economic Forum
MMSD	Milwaukee Metropolitan Sewerage District
IRB	Internal Review Board
TA	Thematic analysis
ICT	Information and Communication Technology
HR	Human Resources
PR	Public Relations

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# 1 Introduction

Freshwater is crucial for human survival and ecosystem health, but is increasingly scarce due to climate change and population growth [1]. Water scarcity is a major obstacle to sustainable human development and the achievement of the Sustainable Development Goals (SDGs) [1], [2]. Globally, the urban population affected by water scarcity is projected to rise sharply, reaching approximately 2.065 billion people by 2050, a 121.3% increase from 2016. Of this total, around 840 million are expected to experience perennial water scarcity, while approximately 1.225 billion will face seasonal water scarcity [3]. Approximately 50% of wastewater produced by humans is discharged into rivers and seas untreated, posing serious dangers to the environment and public health [4]. Population growth, urbanization, and socioeconomic development are projected to raise urban industrial and domestic water demand by 50–80% in the next 30 years, while climate change will alter water availability patterns [3], [5], [6]. These trends are expected to intensify urban water scarcity, posing significant risks to achieving SDG 6 (Clean Water and Sanitation) and SDG 11 (Sustainable Cities and Communities) [3], [7], [8].

## 1.1 Sustainability Goal

According to UNESCO and the United Nations Water Mechanism, global water demand is projected to increase by 50% by mid-century [9]. Consequently, extending the channels for water resource acquisition holds paramount importance for future human responses to the water crisis and the realization of the United Nations Sustainable Development Goals (UNSDGs). The use of digital technology to address sustainability issues has become a more prominent topic in recent years in both academic and scientific conversations. Specifically, these technologies are

considered an essential instrument for promoting advancements in the 2030 Agenda's Sustainable Development Goals (SDGs) [10]. The qualitative approach defines green jobs based on the particular skills required to carry out their associated tasks [11], [12]. Companies are key contributors to achieving the Sustainable Development Goals (SDGs) [13], [14]. Sustainable water practices have the potential to create a substantial number of jobs. Data indicates that for every \$1 million invested, approximately 10-15 jobs are generated in alternative water supply projects, 5-20 in stormwater management, 12-22 in urban water conservation and efficiency, around 15 in agricultural water efficiency and quality improvements, and 10-72 in ecosystem restoration and remediation efforts [15]. The fast-paced evolution of technology has made digital transformation (DT) a crucial factor in driving organizational growth and success [16], [17]. For businesses to maintain their edge and respond to shifting customer expectations, the long-term adoption of advanced digital tools has become a crucial part of their DT strategy [16], [18]. Global labor markets have transformed due to technology, globalization, and economic changes, creating job growth in some regions but unemployment and poor work conditions in others [19]. Reframing SDG 8 from “Decent Work and Economic Growth” to “Sustainable Work and Economic Degrowth” represents a vital step toward enhancing the internal coherence of the Sustainable Development Goals and advancing the broader vision of Agenda 2030 [20]. Co-digestion of high-strength organic waste within existing anaerobic digesters enables wastewater treatment facilities to enhance economic viability by generating revenue through tipping fees and biogas production. The profitability of this approach is contingent upon the quality of the waste, energy costs, and operational efficiency [21].

The field of civil engineering is constantly changing as a result of new research findings, advancements in technology, and modified laws. The civil engineering sector is undergoing unprecedented transformations as a result of the digital transformation wave [22]. Engineers must have a high capacity for lifelong learning in order to keep up with these developments [23]. The rapid advancement of digital technologies has profoundly transformed the workplace and operational practices [24]. The process of digital transformation, which is fueled by digital technology, causes disruptions in businesses and has a significant influence on the processes that create value, strategy, and structure [25], [26].

### 1.2 Why it matters:

Although lifelong learning (LLL) in engineering education has been widely studied, there is limited research on how engineers develop these skills in the workplace [23]. A diverse workforce across multiple economic sectors, including agriculture, industry, and municipal services, is crucial for managing, treating, and delivering freshwater to meet societal and economic demands. To address contemporary water challenges, sustainable strategies such as water reuse, conservation, and watershed restoration are expanding employment opportunities beyond conventional water-sector roles, integrating expertise in engineering, ecology, and policy [15].

### 1.3 Professional Career Pathway:

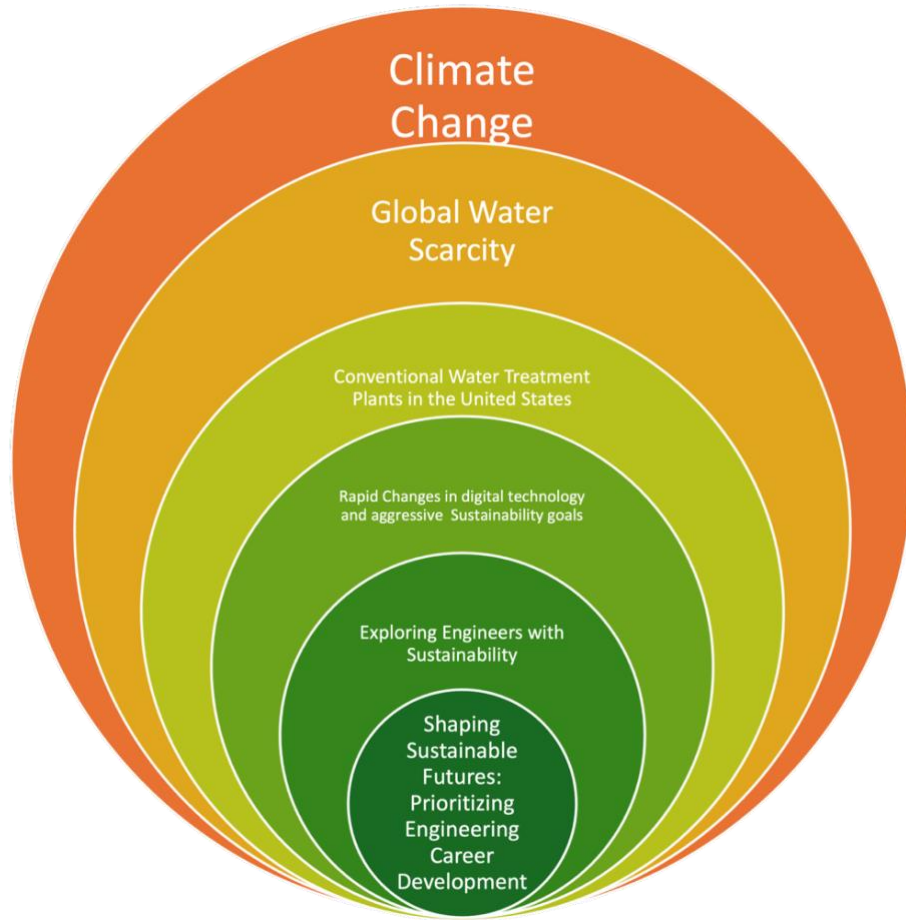
Engineers transitioning between jobs must adapt to new cultural, social, political, and practical norms, which differ depending on the similarity between organizations [23], [27]. The transition from academic settings to professional environments can be particularly difficult, given that professional engineering encompasses intricate social dynamics and numerous social and technical limitations, in contrast to engineering education, which predominantly focuses on technical knowledge [28], [29]. It is crucial to comprehend job alternatives beyond academia and

how engineering graduate students perceive their career aspirations, particularly since a substantial portion of engineering degree holders are employed in the government and private sectors [30]. The process of socialization plays a vital role in shaping the professional growth of engineers [27]. Collaborative work and peer learning were identified as key forms of learning gained through social interaction [27], [31]. In the contemporary workplace, information has become a crucial currency, and individuals who possess the ability to exchange it proficiently frequently attain greater success. Central to effective information exchange lies the writer's capacity to customize documents or presentations to align with the unique requirements of the intended audience [32]. Practicing engineers address technical problems within the context of complex social interactions involving diverse teams [29], [33]. The water industry requires competent applicants [34]. There must be a chance to obtain experience once the general public realizes that the water industry offers fascinating job options. After graduating from college or high school, the majority of candidates lack practical skills [34]. An internship is an excellent opportunity to introduce trainees to the notion of a career in the water business and to educate them that positions in this sector are typically stable [34].

As globalization accelerates and the knowledge economy evolves, individuals must continuously enhance their skills to maintain their competitiveness in the global market [35]. Traditionally, environmental engineering professionals have focused on enhancing water, sanitation, and hygiene in developing regions. Nevertheless, its expertise is equally crucial for broader sustainability objectives, including health, climate resilience, food and energy security, economic growth, and reducing inequality [36]. While environmental engineers have historically

fronted sustainability initiatives, contemporary challenges necessitate more intricate solutions that address the complexities of global transformation [36]. Consequently, the career pathway of water engineers holds paramount significance, as it underpins public health, environmental sustainability, and climate resilience.

While engineers are crucial for sustainable development, engineering education has historically emphasized technical and computational skills rather than sustainability literacy [37]. Engineers play a pivotal role in shaping society, driving social and economic progress through innovation and technological solutions. This influence comes with significant responsibility. Most countries have established engineering codes of ethics to guide professional practice and education, often emphasizing sustainability as a fundamental principle [37]. These professionals design and maintain systems that ensure clean drinking water, manage wastewater, and control stormwater, preventing pollution and waterborne diseases. Their work supports environmental protection through innovative solutions like green infrastructure and resource recovery, while also helping communities adapt to climate change and modernize aging infrastructure. By contributing to both local needs and global goals such as the UN's Sustainable Development Goals, water engineers play a key role in building healthier, more sustainable, and more resilient societies.



*Figure 1: From Global Challenges to Professional Practice: A Systems View of Water Scarcity, Sustainability, and Engineering Career Development*

## 2 Literature Review

Water scarcity and climate change pose substantial concern in the 21<sup>st</sup> century, impacting human societies, ecosystems, and the economy [38]. The United Nations World Water Development Report (2020) highlights that climate change intensifies water scarcity by altering precipitation patterns, increasing temperatures, and triggering extreme weather events, all of which negatively impact water availability and quality [38]. Water capacity serves as a pivotal indicator of production efficiency, quantifying the volume of water utilized to economic output. It highlights the paramount significance of water management in sustaining the vitality of national economies [39]. Water scarcity is getting worse due to a combination of rising water demand and declining water supply in many parts of the world. This necessitates the adoption of various institutional, technological, and financial solutions [40].

As of 2010, the United States had 52,873 regulated community water systems, which provided water to approximately 300 million people. Additionally, there were 87,672 transient non-community systems, such as those at campgrounds or restaurants, serving roughly 13 million people intermittently, primarily through individual rural water supplies. Another 19,400 non-transient non-community systems, like those in schools or factories, regularly supplied water to the same populations, typically relying on independent rural sources as well [41]. Many older cities in the United States are currently dealing with the problems of outdated and insufficient water infrastructure [42]. Outdated sewer systems contribute to poor stormwater management, posing risks to both public safety and the health of natural waterways [43]. Municipalities have started utilizing a variety of stormwater management techniques to lessen the impact of disruptive weather events and control the consequences of floods due to the vulnerability of

water infrastructure [42]. Many US cities do not want to cede authority to nearby cities or private companies because they see providing water services as both a duty to their citizens and an essential component of their local sovereignty [44]. Additionally, water services give the communities a source of income. Despite the fact that wastewater is routed to regional treatment plants and bulk treated water is acquired from another supplier, this circumstance might lead to several small independent utilities providing water services, which is remarkable [44]. Urban water management has evolved over two centuries, influenced by societal aspirations and technological advancements. This evolution reflects changes in hydro-social contracts and institutional frameworks [45]. The need for comprehensive water solutions that incorporate economic, social, and political disciplines in addition to technology has never been greater [46]. Furthermore, environmental consultants have never had a more important function or a greater responsibility to give decision-makers thorough advice on how to handle the challenges that lie ahead [46].

In the current global landscape, traditional businesses encounter novel challenges and opportunities [10], [47]. The rise of technology and increased competition have reshaped the business environment. Moreover, enhanced process management, accelerated delivery times, and sustainable growth have emerged as key drivers of success [10], [47]. The Sustainable Development Goals (SDGs) outlined in the UN 2030 Agenda are essential, non-negotiable targets for the survival of both organizations and society [10], [48]. Companies are increasingly adopting innovative digital technologies to address sustainability challenges and effectively contribute to the achievement of the SDGs [10], [48]. Studies have indicated that the generation of creative

ideas by employees is contingent upon three fundamental conditions: the availability of diverse and novel information, sustained engagement in their professional responsibilities, and the presence of socioemotional or instrumental support [49]. Bucciarelli highlights that a fundamental aspect of engineering work, namely design, is inherently a social process. This process is understood collectively and is distributed among participants through the coordination of tasks and the materialization of artifacts such as reports, charts, and products [29], [50].

Organizations are crucial in tackling climate change, as building a sustainable economy demands significant transformation in both the public and private sectors [51]. In the 21<sup>st</sup> century, the workplace environment and methods of working have undergone profound transformations. Organizations have been profoundly affected by advancements in industry, socioeconomic factors, and technological innovations [52]. While understanding the interactions among the SDGs is essential for advancing sustainable development broadly, analyzing how companies interact with the SDGs is crucial for developing systemic corporate sustainability strategies. Such an understanding also offers valuable insights into how businesses can align their operations to maximize their overall contribution to the SDGs [14].

Employability refers to an individual's ongoing capacity to secure, retain, or create employment through the effective utilization of their competencies. These competencies encompass the knowledge, skills, and abilities necessary to execute job-related tasks and responsibilities proficiently, as well as the adaptability to changes in both the internal and external labor markets [53], [54]. Employability is a term that has expanded beyond the ability to get employment. In the contemporary job market, it encompasses the development of adaptable

skills, the capacity to adapt to change, and, most importantly, a profound understanding of the impact of sustainability on the labor market [55]. Within the water industry, professionals may invest several decades in honing their skills and becoming intimately acquainted with the standards and expectations of their respective disciplines [34]. Individuals who acquire subject matter expertise in their fields through immersion in specific areas become invaluable mentors to younger staff members, effectively transmitting their knowledge and accumulated experiences to the next generation as institutional knowledge [34].

Engineering education equips students with the information, skills, and competencies needed to become professional engineers [56]. An individual's interest in engineering signifies their inclination to pursue studies, engage in engineering-related activities, and seek employment opportunities within the engineering field. Recognition refers to the acknowledgment of one's engineering status by others, including friends, family, and instructors [30]. Interpersonal skills competence, a component of professional skills competence, is the cornerstone of our model of engineering graduate student identity [30]. Graduate engineering students pointed out that having strong communication skills is crucial for engineers [30], [57]. According to one of the most widely used models for quantitative research on undergraduate engineering identity, engineering identity is composed of three distinct components: engineering performance or competence, engineering interest, and the recognition accorded to an engineer by others [30], [58], [59].

Research suggests that Educational Technology and Smart Education are the fundamental pillars of Engineering Education, equipping engineers to address the challenges and opportunities of Digital Transformation [60]. Digital transformation brought about substantial advantages, including customer-centric collaboration, self-service capabilities, mobile access to real-time data, sophisticated analytics for decision-making, and cloud-based efficiency throughout the organization [61], [62]. The water industry faces mounting pressure to embrace digital technologies [62]. A 2019 survey conducted among 279 North American water organizations indicated a notable surge in adoption, with 15% implementing a comprehensive and fully integrated data management system. This represents a substantial threefold increase from the 5% adoption rate recorded the previous year [62]. The World Economic Forum (WEF) recognized digital competency as an essential skill for modern organizations [63], [64]. Digital transformation has many potential and powerful forces, but it will also be slowed by certain obstacles. Lack of internal skills, knowledge, and capacity is a major barrier to digital transformation for water enterprises [62], [65]. The necessity of digitization aligns with several developments and challenges confronting the water sector. Aging water infrastructure leads to substantial annual losses of treated drinking water and untreated wastewater. Additionally, it exacerbates leaks and pipe breaks, resulting in substantial financial burdens for the water sector, amounting to billions of dollars [62], [65], [66].

## 2.1 Knowledge gap:

Although extensive research has concentrated on assisting undergraduate students in developing lifelong learning abilities, considerably less empirical research has investigated the development and application of these skills in engineering job settings [23]. Mazzurco et al.

(2021) identified a significant gap in the literature on engineering practice, with less than 10% of studies addressing workplace learning. Notably, there is a lack of understanding regarding the development of specific engineering competencies and the factors that facilitate or impede learning. Furthermore, the authors highlighted the necessity of conducting more context-specific research across diverse engineering disciplines and sectors [23], [67]. Most existing studies emphasize recent graduates, whose learning curves may be steeper, but they often overlook the ongoing learning required in the later stages of an engineer's career [23]. This research focuses on experienced civil engineers with 10 to 27 years of professional practice.

### **3 Method:**

#### **3.1 Overview:**

This paper draws on the qualitative research (individual interviews) with water industry professionals. This qualitative study employs a combination of data sources, starting with my work on a systemic literature review which guided interviews with engineering professionals. I conducted semi-structured interviews with 11 professionals in the water industry to explore their career paths, experiences thus far, personal characteristics, and interests in careers within the water industry. The interviews provided insights into various successful and unsuccessful work experiences, methods of defining success, and practical strategies that contribute to success in the field. The interviews were audio-recorded, transcribed, and analyzed thematically. For the participants selection, I did snowball sampling. One of the most often used sampling techniques in qualitative research is snowball sampling, which relies heavily on networking and referral features [68]. Typically, the researchers begin with a limited number of initial contacts, or "seeds," who meet the research requirements and are asked to participate in the study. Following that, the agreeable participants are asked to suggest more connections who meet the research

requirements and who could also be willing participants. These contacts then suggest further possible volunteers, and so on. As a result, researchers utilize their social networks to create preliminary connections, and sampling momentum grows from these to recruit a growing number of participants [68].

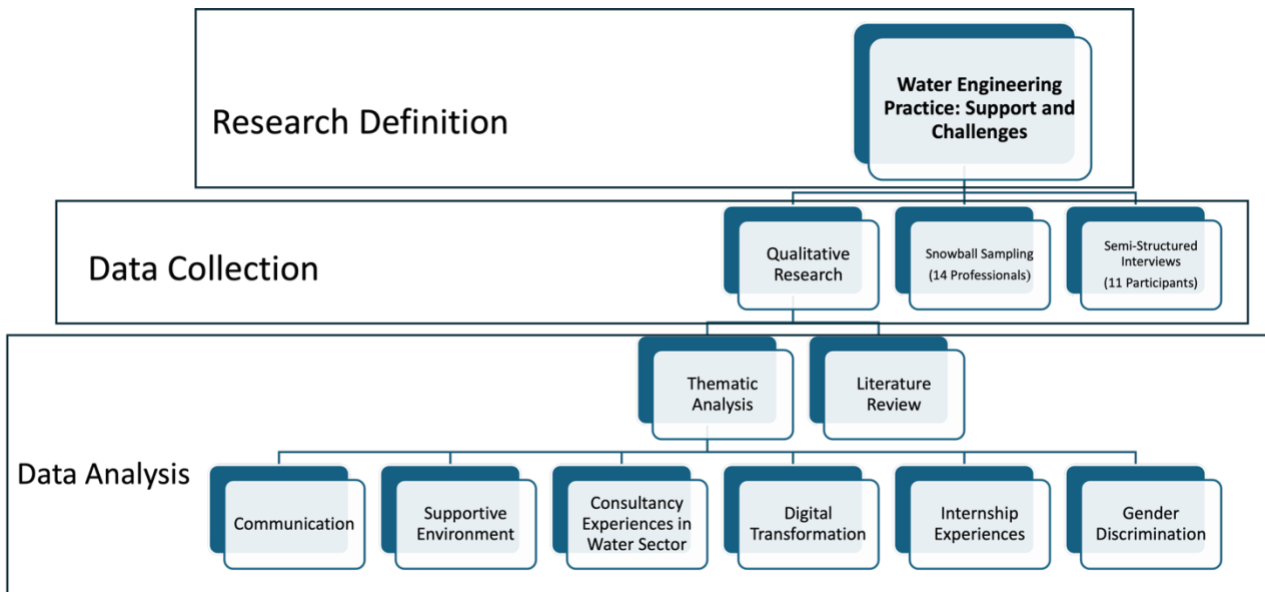


Figure 2: Research Methodological Approaches

### 3.2 Context

The five Great Lakes; Superior, Michigan, Huron, Erie, and Ontario; compose the largest freshwater surface area globally, harboring 20% of the world's freshwater reserves [69], [70]. The Great Lakes play a pivotal role in supporting the commercial, industrial, and recreational activities of both residents and tourists. They are deeply ingrained in the region's culture, economy, and communities, fostering a strong connection among residents who feel both practical and profound emotional ties to the Lakes [70].

The Milwaukee Metropolitan Sewerage District (MMSD) is a regional governmental entity that renders water reclamation and flood management services to over one million residents of 29 communities within the Greater Milwaukee Area. Safeguarding the public health and the potable water supply for millions of individuals necessitates the expertise of hundreds of specially trained and dedicated personnel. The Milwaukee Metropolitan Sewerage District (MMSD) manages one of the nation's most sophisticated real-time sewer control systems, which has undergone a remarkable evolution over nearly a century [71]. Initially, the system operated manually through gates in the 1930s. Subsequently, it incorporated pump stations, sluice gates, and advanced technologies such as remote sensing, telemetry, and automation from the 1980s onwards. Since 2000, MMSD has further refined these technologies to enhance system performance and bolster its capabilities in stormwater management. Notably, the district has forged collaborative partnerships with the Department of Transportation in recent years to further enhance its operational capabilities.

Engineers from the Metropolitan Sewer District (MMSD) play a pivotal role in safeguarding water resources and fostering sustainability through innovative wastewater and stormwater management practices. They are responsible for designing and operating advanced systems, including one of the nation's most prominent real-time sewer control networks. Furthermore, they implement green infrastructure solutions to mitigate pollution and mitigate stormwater overflows. Their backgrounds in civil and environmental engineering enable them to contribute to public health, environmental protection, and climate resilience. Their professional trajectories present opportunities for technical advancement, interdisciplinary collaboration, and a profound impact on the community and ecosystem.

### 3.3 Interview Instruments

The development of the research questions was guided by prior literature on engineering career trajectories, including the work of Marie Paretti and colleagues, who emphasize the role of workplace context, identity, and communication in shaping engineers' professional paths [29], [72], [73]. These insights highlighted the importance of exploring both technical and socio-cultural dimensions of engineering practice.

Building on these insights, the initial focus of this study was further refined through ongoing discussion with my advisor, Dr. Sarah Blackowski. Drawing on her expertise in workforce development and engineering education, we closely examined the specific context of mid-career engineers working in a Midwestern Municipal Water Facility. Through these discussions, we collaboratively formulated research questions that aimed to uncover the key supports and challenges these professionals face, as well as how their career experiences evolve over time. To guide the interviews, we organized the questions into four sections: Past Experiences, which

explored participants' educational backgrounds and early career paths; Present Experiences, which focused on their current responsibilities, workplace challenges, and available supports; Future Experiences, which addressed their professional goals, leadership development, and anticipated opportunities; and Context and Demographic Questions, which gathered information to better understand each participant's broader professional and personal context. A selection of these interview questions is presented in Figure 3.

<p><b>Past Experiences</b></p> <ul style="list-style-type: none"> <li>• Please discuss your college experience. <ul style="list-style-type: none"> <li>❖ Impactful experiences in your field?</li> <li>❖ Career development experiences?</li> </ul> </li> <li>• How do you think your college experience affected your choice of career?</li> <li>• How has your experience been at MMSD so far?</li> </ul>
<p><b>Present Experiences</b></p> <ul style="list-style-type: none"> <li>• What does a day in your work life look like at MMSD? <ul style="list-style-type: none"> <li>❖ How was this supported by your past experiences?</li> </ul> </li> <li>• What types of things support your success at MMSD? Barriers?</li> <li>• How has the MMSD system change affected you? Positively and negatively? <ul style="list-style-type: none"> <li>❖ How have new technologies affected you?</li> <li>❖ How do you perceive MMSD in comparison to other plants around the country?</li> <li>❖ In terms of sustainability, support, future growth?</li> </ul> </li> </ul>
<p><b>Context &amp; Demographic Questions</b></p> <ul style="list-style-type: none"> <li>• What is your ethnic background? Where are you from?</li> <li>• How old are you? How long have you been in this career?</li> </ul>
<p><b>Future Experiences</b></p> <ul style="list-style-type: none"> <li>• What are your career goals for the future? <ul style="list-style-type: none"> <li>❖ 5 years? 10?</li> <li>❖ How have your past experiences and MMSD affected your career goals?</li> </ul> </li> </ul>

Figure 3: Interview Questions

### 3.4 Participants

14 civil engineers currently working in the Midwest water sector were initially contacted for this study. Participants were stratified based on their years of experience and organizational context to capture a diverse range of professional perspectives. A single geographic region, the Midwest region, was chosen due to its unique geologic context and proximity to a critical freshwater resource, Lake Michigan, which significantly shapes civil engineering practices in the area. Out of the 14 total, 11 engineers responded and participated in the study. Recruitment was conducted via email through the authors' extended professional network. Among the participants, one held a Ph.D., while nine others had dual degrees in Civil and Environmental Engineering and fields such as Public Administration or Law, and one with a combined background in Mechanical and Architectural Engineering. These interviews provided rich insights into the experiences of civil engineers who worked in the water sector. Participants all signed a consent form prior to the interviews, which was reviewed and approved by the University of Wisconsin-Milwaukee's Internal Review Board (IRB). The IRB approval number is IRB#: 25.134.

### 3.5 Qualitative Research:

Qualitative research often focuses on local issues and human relationships, rather than broad topics. Planning, collecting, analyzing, coding, and presenting such data can be challenging, especially for audiences used to quantitative data and huge sample sizes. Context is crucial in qualitative research due to the many interactions that take place across applications and cultures [56]. Qualitative research approaches include phenomenology, ethnography, case study, and narrative research [56], [74]. In this study, we presented a case study as a component of our research. Qualitative research might provide an opportunity to explore new concepts [74].

### 3.6 Analysis

Thematic analysis (TA) identifies, analyzes, and interprets patterns of meaning such as themes in qualitative data. TA differs from other qualitative analytic techniques in that it provides a method or technique without theoretical constraints, rather than a methodology (which is a framework for study) [75]. TA is a structured yet flexible method for coding and identifying themes in qualitative data. Codes mark key features of the data, while themes represent broader patterns centered around a core idea. TA goes beyond summarization, focusing on meaningful insights guided (but not rigidly constrained) by the research question. It emphasizes rigor through processes like a two-stage theme review, ensuring analysis remains grounded in the data [75], [76], [77], [78]. In this research, themes were selected through an iterative process of thematic analysis. After transcribing and coding the interviews, recurring patterns and ideas were grouped into categories with the help of the literature review. A theme was considered to have emerged when it consistently appeared across multiple interviews, captured a meaningful aspect of the research question, and was supported by rich, descriptive data. Reflexive journaling and peer debriefing were also used to ensure the consistency and credibility of theme development.

### 3.7 Limitation

This research focused solely on one specific group within the engineering profession. It did not include data from other roles connected to the water industry, such as architects, field surveyors, contractors, HR personnel, or other non-technical professionals. The study was also geographically limited to professionals based in Milwaukee, which may not fully reflect the experiences of engineers in other parts of the Midwest or the United States. Additionally, the sample size was constrained to 11 participants due to time and resource limitations. While the interviews provided rich qualitative data, they primarily focused on participants' support and

challenges, with limited exploration of their personal philosophies or broader perceptions of their roles within the industry. These limitations suggest the need for expanded research that includes a more diverse participant pool, wider geographic scope, and a broader range of inquiry topics.

### 3.8 Research Quality

Qualitative research aims to comprehend the "why" and "how" of human behavior by deeply examining lived experiences, in contrast to quantitative research, which places more emphasis on measuring variables and statistical analysis [79], [80]. Recognizing qualitative research as a skill necessitates creativity and adherence to three fundamental principles: transparency, thoroughness in methodology, and a solid foundation in evidence. The way that researchers define and conduct their investigations is frequently influenced by their personal worldviews or belief systems [74]. Researchers can collect rich, contextual data using techniques like focus groups, participant observations, and in-depth interviews that can provide complex insights on psychological, social, and cultural phenomena [79], [81], [82], [83]. This qualitative study upheld high standards of research quality and ethics through several deliberate practices. Informed consent was obtained from all participants, who were clearly informed that their involvement was voluntary and that they could withdraw at any time without penalty. To protect confidentiality, identifying information was removed, and data was securely stored. Two researchers collaboratively managed participant engagement and data handling to ensure consistency and reduce bias. Thematic coding was cross-checked and refined through peer discussion to enhance reliability. Throughout, participant voices were represented with care and respect, ensuring the findings authentically reflected their lived experiences. These measures supported the credibility, trustworthiness, and ethical integrity of the research. The study

included 11 participants, which is appropriate for qualitative research focused on depth rather than breadth. A key component of qualitative research is data saturation, which is the moment at which more data collection stops producing fresh ideas, themes, or classifications that are pertinent to the study issue [79]. Saturation prioritizes the depth and complexity of interpretation, going beyond theme identification to guarantee a profound and nuanced comprehension of participants' experiences [79], [84], [85]. Code saturation refers to the level of analytical granularity at which no further codes are needed to completely characterize the data [79], [86], [87], [88]. Saturation was reached when no new themes or insights emerged from additional interviews, indicating that the core experiences and perspectives relevant to the research question had been adequately captured. The amount of data that qualitative researchers collect may be influenced by a number of circumstances, and it is quantified not just by the quantity of interviews conducted but also, where appropriate, by the presence of participant observation [89]. A small number of participants can be highly valuable, especially when studying hidden or hard-to-reach groups like elites or subcultures. In such cases, even 6 to 12 participants may provide meaningful insights, as access to these populations is often limited [89]. This sample size aligns with established qualitative research standards, where 6–12 participants are often sufficient to achieve data saturation and ensure analytic depth, particularly within a focused group sharing similar roles or experiences.

### 3.9 Research Question

The combination of this data collection and analysis allowed me to work on answering the following research question with this thesis:

***What supports and challenges exist for local, Midwestern water-sector engineers in their careers?***

This is an important endeavor because, as discussed in the literature review, much of the research exploring the engineering career has been done with undergraduate students, graduate students, and early-career engineers.

## 4 Results and Discussion

Our civilization is shaped by engineering in many ways, since it cultivates innovation and technical applications that promote social and economic advancement [37]. For engineers, technical proficiency must be complemented by professional skills [90], [91]. These include proficiency in communication, teamwork, planning, organizing, information and communication technology (ICT), lifelong learning, initiative, and entrepreneurship. Effective communication is widely regarded as the most crucial and essential of these professional abilities [91], [92]. In order to effectively finish complicated technological tasks, engineers must be able to communicate ideas and problems in a clear and concise manner to prevent misunderstandings and mistakes [91], [93]. Organizations need employees who are committed to achieving high technical and professional skill levels, adopting new technologies, being self-motivated, and actively participating in their job if they are to adjust to this quickly changing environment [52].

In the following section, I discuss each overall theme I found during my thematic analysis of the semi-structured interviews. The quotes are used to demonstrate the importance of each of the themes. Quotes are taken from the original participants' words and may have slight grammatical errors due to their spoken-word nature. The findings from the interviews provide valuable insights into the supports and challenges experienced by professionals in the water sector. Several key themes emerged from the narratives, reflecting both the challenges and opportunities encountered throughout their career development. Effective communication and a supportive environment were frequently highlighted as essential for professional growth and collaboration within multidisciplinary teams. Participants also emphasized the importance of internship and consultancy experiences, which played a critical role in shaping their practical understanding and exposure to real-world engineering scenarios. Moreover, the increasing presence and impact of digital transformation within the sector were noted, underscoring the demand for adaptability and continuous learning. Sub-Themes of self-improvement surfaced as participants reflected on their proactive efforts to enhance their skills and remain relevant in an evolving industry. At the same time, gender discrimination emerged as a significant barrier, with several participants recounting experiences that underscored persistent inequalities. The following sections present illustrative quotes that exemplify these themes and deepen our understanding of the lived experiences of engineering professionals in the water sector.

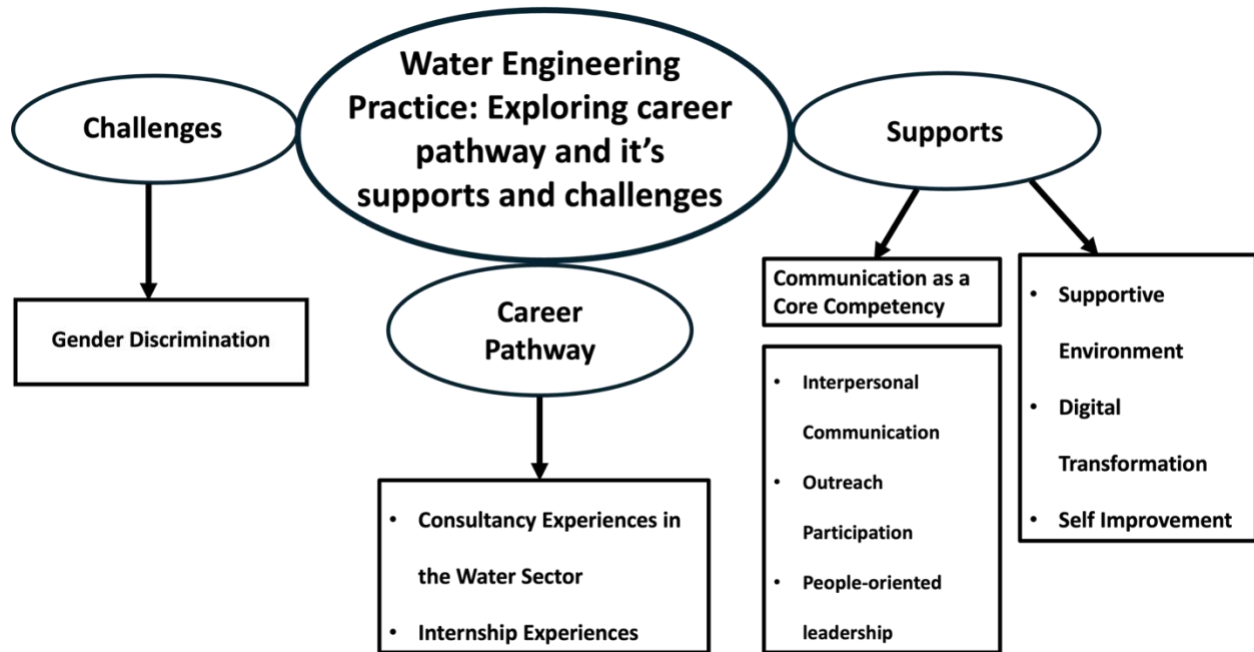


Figure 4: Results from the interviews for Exploring Challenge, Supports, and Career Pathways in the Water Engineering Practices

#### 4.1 Communication

Effective communication is paramount to engineering practice. Despite its emphasis in engineering education, it remains a significant challenge in the workplace readiness of newly graduated engineers [72]. Research studies and reports from government and business sectors consistently indicate that communication is a persistent weakness in the job readiness of recent engineering graduates across multiple decades [72].

A major theme in the interviews was participants having experiences via their work departments. In the following quote, Madison talks about her experience at her job's outreach group. Six participants shared a similar experience in their jobs.

*Madison said: "We need better communication. We have a great outreach group, and they do amazing work, but you know there's these people there, you know, they're doing the best they can. You know, how do we create our own identity in the world of who we are and what we do? So I think. That to me, that's where we're we're falling short."*

Madison shares that she thinks engineers are lacking in their identity within the department and group. This is important in developing social learners. Madison's quote highlights a key issue: while outreach efforts are well-intentioned and active, there is often a disconnect in how engineers define and present themselves to the outside world. She raises an important question about professional identity: how do engineers, both as individuals and as teams, effectively

communicate who they are and the value they bring? This disconnect can hinder the effectiveness of outreach and limit its potential to inspire, educate, or build trust with the public.

Furthermore, Bradley reflects on how his department encouraged early involvement with the local community, emphasizing how structured outreach experiences shaped his perspective on engineering beyond its technical aspects.

*Bradly said: "I guess from an early perspective to sort of force us to go out, out, out there and to get involved in the local community. I thought that was really nice."*

Bradley's statement highlights the positive impact of early outreach efforts on engineers' engagement with the world around them. These experiences foster not only technical expertise but also socially aware individuals who prioritize community connections. Six participants shared similar sentiments, suggesting that this is not an isolated occurrence. While departmental outreach programs are valuable, they often lack cohesion and clarity. Both of the participants' suggestion emphasizes the need for more intentional communication and identity-building initiatives. These efforts are not only essential for public engagement but also shape social learners, engineers who recognize the significance of human connection, communication, and community in their professional development.

Lisbon's quote accurately reflects a widely recognized understanding among engineers: technical expertise alone is insufficient for success. He emphasizes the significance of

interpersonal and management skills, particularly for individuals aspiring to leadership or consulting positions. His honest response, “I admit I have not really developed any of that,” emphasizes the disparity between the traditional engineering curriculum and the demands of contemporary professional environments. At least seven participants shared the consensus that interpersonal and management skills are essential for success in a water industry career. To advance to a higher position within the industry, effective communication skills, in addition to technical expertise, are crucial.

*Lisbon said: “Rather than the technical side of things, I mean you should know the technical side, but you also have to have all of those interpersonal management skills. You know, which I have not. I admit I have not really developed any of that. But people that rise in the organizations typically, you know, will develop that now in consulting, you know, bringing in the work, having clients.”*

The growing demand for engineers to develop communication and leadership skills alongside their technical expertise is highlighted by his reflection. This emphasizes the significance of communication, client relations, and team management in engineering careers, which are essential for professional advancement. Without these skills, technical knowledge alone cannot lead to the highest positions in the industry.

Furthermore, while enquiring deeply into her success in the industry, Jackie emphasizes the utmost importance of interpersonal communication in leadership roles. She emphasizes that

transitioning into management necessitates a broader skill set beyond technical expertise. Additionally, she highlights the necessity of being an effective communicator and collaborator in the water industry career, which aligns with Lisbon's quote.

Jackie said: *"But what I've done all before has made me a very good communicator, a collaborator, and I have".*

This statement emphasizes the utmost importance of intercommunication skills, particularly those related to being people-oriented and outgoing, in achieving effective leadership and career advancement within engineering disciplines.

Furthermore, John highlights the role of intercommunication in the workplace, emphasizing how meaningful interactions help break down assumptions and foster understanding among peers.

John said: *"And what that was like and, you know, the difficulties he had with that, but just, you know, really getting to know the people we work with and I've always been interested in that and kind of talked to people about that, but I think a lot of people are scared to, you know, they want to make an assumption about somebody based on where they're from or what they looks like or you know something like that. And they're making a lot of efforts to expose us to all these different things."*

John's reflection shows the significance of effective intercommunication beyond technical terminology. It emphasizes the importance of empathy, openness, and a willingness to engage with diverse perspectives to create robust and inclusive work environments. John's insights reveal a broader initiative within engineering spaces to dismantle stereotypes and promote inclusivity, fostering deeper interpersonal connections and empathy among professionals.

Supportive managers also played a role in helping engineers develop communication skills. When asked about support and experiences, Saleen's reflection emphasizes the critical role that effective communication and supportive management play in engineering work, especially when navigating emotionally charged situations. She emphasizes the significance of having professionals in human resources and public relations as intermediaries between engineers and the public. This separation serves as a protective measure, safeguarding technical professionals from direct confrontations and enabling them to concentrate on problem-solving.

*Saleen shared: "The communities that have HR and public relations folks are fantastic because there's a buffer then between the person who's all worked up about whatever. The thing is going to the professional who is trying to solve the problem. So, I spent most of my time in that role, diffusing people's anger. Actively being an engineer, versus actively managing projects, actively trying to improve the community."*

Her experience underscores the dual responsibility that engineers often bear not only executing technical tasks but also acting as communicators and mediators within their communities. When departments or organizations provide supportive roles such as Human Resources (HR) and Public Relations (PR), it enables engineers to concentrate more effectively on both technical and community-oriented endeavors. Saleen's example demonstrates how supportive structures and effective communication practices can alleviate emotional burdens, reduce conflicts, and foster more sustainable working environments.

Leslie emphasizes the significance of communication as a defining characteristic for individuals assuming leadership positions within engineering organizations. Her analysis underlines the concept that effective leadership in engineering exhilarates technical proficiency, necessitating an approachable, communicative, and people-oriented performance.

*Leslie said: "If you want to go into management, I think you have to be a little more oriented, people-oriented, you know, outgoing."*

This perspective underscores the significance of supportive managers who prioritize open communication and cultivate robust relationships with their teams. Characteristics such as "people-oriented" and "outgoing" reflect a manager's willingness to actively listen, engage, and create a positive work environment where team members feel valued and supported. Leslie's insight further emphasizes that effective communication is not merely a soft skill but a fundamental aspect of leadership, particularly in fostering empathy and building trust within engineering teams.

Alan stated the profound impact that supportive managers have had on his professional journey, particularly emphasizing the significance of robust communication. His reflection underscores the transformative potential of effective leadership, which is grounded in clear communication and exemplary management skills. This leadership approach can significantly enhance the work environment for engineers.

*Alan said: "That was very good and that's really made a big difference. You know, for me it's just have people that were good communicators and managers."*

Alan's words demonstrate that effective managers are not solely focused on task completion but also on fostering communication and understanding within their teams. By being approachable and skilled communicators, leaders can create a work environment where engineers feel valued, guided, and supported in their roles.

Across participant reflections, it is evident that supportive managers play a pivotal role in fostering positive and effective engineering environments. Whether through effective communication, people-oriented leadership, or implementing strategies to mitigate workplace stress, supportive managers contribute to the development of trust, collaboration, and professional growth. Participants such as Alan and Leslie underscored that exemplary managers possess not only technical expertise but also approachability, communicative skills, and a genuine commitment to the well-being of their teams. Ultimately, the presence of supportive leadership

empowers engineers to thrive not only as technical experts but also as socially engaged professionals who feel valued and understood within their work environments.

When asked about what types of supportive environments were provided to them at their department, participants talked about being good communicators and having good relationships with other professionals. Red emphasized the significance of comprehending workplace dynamics and processes, highlighting how this knowledge facilitates the establishment and maintenance of robust relationships with construction teams or any other team outside the office.

Red said: *“You know how things can be done in order to maintain a good relationship with people on these construction teams, you know so.”*

Both Red and Alan’s quotes demonstrate common sentiments across our participants. Red talks about how they develop a better understanding of the process they do at work, which helps them have a better relationship with the construction teams. Alan shares that they notice and appreciate when people they work with are good communicators and managers. Together, these insights collectively demonstrate that supportive work environments are not solely shaped by internal culture but also by the capacity to establish and maintain meaningful connections with collaborators and professionals beyond the office premises. Professional connections are crucial for success in engineering [94]. Developing professional relationships within the engineering industry has become an integral aspect of the profession.

Communication is critical to all administrative activities because it provides the foundation for understanding, trust, and connection between people[95]. It allows people to exchange knowledge, influence others, and develop meaningful connections. Effective communicators communicate with others in a skillful and responsible manner, preserving both personal integrity and strong social relationships[95]. Participants emphasized the significance of collaboration, effective communication, and mutual understanding with external professionals, including construction crews, consultants, and clients. These external partnerships contributed to more successful and fulfilling work experiences by fostering a broader sense of connection, expanding professional networks, and often facilitating the seamless integration of technical planning with practical implementation. Ultimately, establishing robust industry relationships enhances teamwork, promotes continuous learning, and reinforces the social dimension of engineering work, complementing technical expertise and fostering a well-rounded professional development.

## 4.2 Supportive Environment

Employee engagement fosters a sense of unity and collaboration within the organization[96]. Employee well-being significantly contributes to job performance. Furthermore, when an organization prioritizes the well-being of its workforce, it effectively mitigates toxic workplace environments and fosters long-term sustainability in overall performance [96]. A toxic workplace environment refers to the negative dynamics and interactions that exist between employees and their work setting [96], [97].

Out of the 11 participants, 10 shared how the supportive environment aided them in their careers, while four participants discussed how a toxic environment can create obstacles for them. Rose reflected on the challenges she faced during the early stages of her career, describing the experience as a continuous struggle where progress felt like an uphill battle. Since transitioning to her current role, she has experienced a supportive and positive work environment, significantly improving her professional journey and sense of stability.

*Rose said: "So much of my early career just felt like I was being knocked down over and over and over again that I was fighting an uphill battle, and I've had none of that since I've started here."*

Rose's experience demonstrates how transitioning into a supportive work environment can substantially enhance job satisfaction and career stability.

Madison shared her perspective on how confidence grows with the right workplace environment. She emphasized that feeling understood and supported at work has allowed her to be more authentic, enhancing her confidence over time.

Madison said: *“I'd say my confidence has continued to evolve. I felt like I was pretty confident coming in, but even more so, you know, the more you're supported and you understood, the more you can be yourself.”*

Madison emphasizes that a supportive work environment fosters authenticity and enhances self-confidence.

Red discussed his approach to workplace collaboration and responsibility. He believes in taking initiative regardless of defined roles, focusing on teamwork and shared success rather than rigid job boundaries.

Red said: *“You know, rearrange some things, even though it's coming from a different division or something than a lot of people, or some people sometimes are like. Nope, Nope. That's somebody else's job. You know, it's to me, it's we're all here to get a job done. It doesn't matter if it's my job or somebody else's. The point is to get the job done. So let's get it done.”*

Red's approach shows the symbiotic nature of a collaborative mindset and shared responsibility within a nurturing environment. In environments where teamwork is prioritized over rigid role boundaries, employees are more willing to step up and help, even outside of their immediate duties. This not only boosts productivity but also nurtures a sense of unity and collective ownership, where the success of one is seen as the success of all.

Lisbon talked about the importance of daily communication and emotional support in leadership. She finds value in working with like-minded colleagues and believes that consistent check-ins and genuine interactions contribute to a healthy and motivated work environment.

Lisbon said: *“Just a lot of time with staff just checking in on their work and how they're doing, and supporting them anyway. You can. So responding to emails, talking to you know. People and you know that it's really good to go to work every day with like-minded people.”*

Lisbon emphasizes the emotional and interpersonal dimensions of leadership within a supportive environment. Her approach to regular check-ins and genuine engagement with her team demonstrates how compassionate leadership contributes to a healthy workplace culture. Working with like-minded, supportive colleagues creates a sense of belonging and motivation, reinforcing the idea that emotional support is just as important as operational support in sustaining employee engagement.

Madison described how personal connections and professional support have shaped her career path. She highlighted the power of networking and mentorship, emphasizing that relationships, mutual support, and being open to opportunities have been crucial to her long-term success.

Madison said: *"I've had a lot of support from bosses over the years. When I was actually that friend of mine in my classes at [Midwest R-1 Category University], she told me about an internship here at [Upper Midwest Water Treatment Plant] when we were going to school together, and she said you should apply because she was already working there. She was going back for a degree as an adult. And we weren't quite the same age, but close. And she told me about that. And I am forever grateful that she told me about that because that cut me in here and, well, obviously I had to, you know, put my own time and effort into maintaining the. Job here, but she helped me with that. And then when I was here, I got another job. In between being the intern and coming back and working full time. Time because I made a connection with someone here whose daughter worked somewhere else, and he passed my resume on to her. And then she helped me get the job there. And then when that place closed up, she found a place for me to apply at the next job. So it so it's always been networking has has been more impactful for me than a time thing that happened that it's it's. I guess like like we were saying, support. Who you surround yourself with, who you get to know, how you put yourself out there and let them see who you are and what your capabilities are, really helps get you somewhere and be open to anything. So. So then, to continue that story a little bit. So once I was at that next job that she had helped me find. The same friend."*

Madison's story illustrates how professional support systems and networking opportunities drive long-term career advancement. This narrative reveals how sustained mentorship, peer support, and networking opportunities shape long-term career pathways. Madison's success is not solely due to individual effort, but also to the people who recognized her potential and opened doors for her. Her story affirms that supportive environments often extend beyond the immediate workplace and into professional networks that provide critical opportunities, guidance, and encouragement.

Jackie underscored the importance of interdepartmental support and teamwork. She believes that by uplifting others, everyone contributes to collective success, fostering a culture of collaboration and shared accountability.

*Jackie said: "We're doing the work together. If one of our departments can't do what they need to do, then we're all going to fail. So if we can boost them up in whatever way we can, we do and it makes all of us look good."*

Jackie's approach exemplifies the importance of interdepartmental support in achieving collective success. By fostering a culture where departments actively assist each other, she highlights how collaboration improves not just outcomes, but also relationships and morale. Her statement shows that in a healthy work environment, success is viewed through a collective lens; when one team thrives, the whole organization benefits.

These reflections highlight the profound impact of supportive environments, collaboration, and interpersonal relationships in shaping meaningful career experiences. Whether through overcoming early career challenges, building confidence through

understanding, or stepping beyond defined roles to ensure collective success, each voice emphasizes the value of mutual support and shared purpose. Networking, mentorship, and a willingness to uplift others not only foster individual growth but also strengthen team cohesion and organizational resilience. Ultimately, these stories illustrate that a positive, collaborative workplace culture is essential for both personal fulfillment and professional achievement.

### 4.3 Consultancy Experiences in the Water Sector

Engineering consulting (EC) firms in the construction sector are experience-based and knowledge-intensive organizations [98]. Their operations are heavily reliant on the accumulation and application of knowledge gained from past projects. Therefore, these firms necessitate effective mechanisms and tools to capture, retain, and facilitate the reuse of organizational knowledge as a strategic asset [98]. Engineering consulting can be a valuable asset in the water sector, effectively mitigating concerns for both public and private stakeholders. It facilitates the seamless integration of private initiatives with public responsibilities, ensuring a harmonious balance in water management [99].

In the water sector, engineering consultancy roles often serve as critical bridges between design, construction, and long-term infrastructure management. Eight out of eleven participants shared their experiences with consulting firms and their impact on their professional careers. They shared that even joining as an entry level at a consultancy can help professionals to grow in their career. They also highlighted how professionals in this field not only possess technical expertise but also gain valuable insights through diverse roles, whether as consultants, contractors, or clients. Through real-world experiences, individuals in this sector learn to navigate complex relationships, manage shifting responsibilities, and understand the intricacies of project delivery. The following quotes from professionals highlight the valuable lessons gained from different perspectives within engineering consulting.

Leslie shared that she spent the first 11 years of her career in private consulting, specifically in the field of land development. Her work spanned multiple disciplines, including transportation

and geotechnical engineering, reflecting the diverse and interdisciplinary nature of consulting roles in infrastructure projects.

*Leslie said: “No, I worked in private consulting in land development. For the first eleven years of my career. So land development is transportation geotechnical.”*

Leslie’s career exemplifies the diverse and interdisciplinary foundation provided by consulting. Her exposure to various engineering disciplines within land development underscores the broad skill set and adaptability acquired through consultancy roles during the early stages of a professional career.

Bradly emphasizes the importance of embracing all career experiences even those that may not initially feel ideal. His viewpoint highlights how early-career or less-than-perfect roles still provide exposure to workflows, industry standards, and self-awareness that can influence long-term career direction.

*Bradly said: “Even if you are taking a position that you're not in love with. That experience can help you understand where you want to go next and what you want to do and, you can do terrible things for a long time. Even if it's not a good fit because you're going to learn about yourself, you're going to learn about the industry. Your knowledge is power.”*

Bradly’s perspective highlights the long-term value of all professional experiences, even those that may seem misaligned. Early roles, regardless of fit, contribute essential industry insight and personal growth that shape future career paths in consulting and beyond.

John, who worked with a contractor before entering consultancy, explains how that experience helped him understand the construction side of engineering. His experience revealed that many engineers enter projects with a confrontational mindset toward contractors, often assuming they are primarily profit-driven and prone to cutting corners. However, John's direct involvement taught him the value of cooperation and the importance of recognizing the "grey areas" that exist within technical specifications and site-based decision-making. His insights emphasize that mutual respect, clear communication, and a balanced approach between contractors and consultants are essential to achieving successful project outcomes for all stakeholders.

*John said: "When I worked for the contractor that helped me learn the contractor, some people have very confrontational. Some engineers have very confrontational relationship with the contractor that they think the contractor's always trying to screw them. They're always trying to cut corners. The contractors just trying to make money. And so you have to be fair with them and be realistic of what? Is it not very not a black and white. There's a grey area in there, and some stuff with specifications, and you have to work with them so that the project's successful for the contractor. And successful for the owner. So that's something my previous experience helped me learn."*

John's extensive experience effectively bridges the gap between consulting and contracting. His insights highlight the significance of empathy, collaboration, and adeptly navigating ambiguous project delivery scenarios. These essential skills not only enhance

communication but also significantly contribute to the successful outcomes of projects within the water sector.

In the interview, Peter explained himself how experience gained on both the consultant and client sides offers valuable insights into the transformative shift in perspective that accompanies career advancement. He highlights the challenges associated with supervising consultants whose work approaches may differ from his own, underscoring the significance of empathy, adaptability, and a comprehensive understanding of the overarching objectives of a project.

*Peter said: "I am the project manager for the supervising those consultants. So it's been. It's been interesting to be on kind of on the client side. You know, before I for 9 years I was working in the consultant side. Doing the actual work for you know clients, but here for 16 years I've been on the client side, so it's sometimes frustrating because the consultants don't always do. The work that you want them to do, you know quite the way you would do it."*

Peter's dual perspective from both consultant and client roles emphasizes the value of understanding differing work styles. His experience underscores the need for adaptability and communication when managing diverse teams to align expectations and meet project goals.

These reflections collectively demonstrate that consultancy experiences in the water sector encompass a multifaceted approach beyond mere technical execution. It requires emotional intelligence, adaptability, and the ability to adopt a comprehensive perspective on projects. This consultancy experience serves as a valuable asset for clients, whether collaborating with

contractors, consulting firms, or as a member of a client's team. Professionals gain valuable insights that not only contribute to the success of projects but also facilitate long-term career development.

#### 4.4 Digital Transformation:

Digital transformation is a technology-driven process that causes significant disruptions within organizations, profoundly influencing how they create value, formulate strategies, and structure their operations [25], [26]. Digital transformation has given rise to innovative business models and brought significant disruptions to global markets and industries [25]. Integrating environmental sustainability principles into operations can increase organizational value and amplify the benefits of digitalization [25], [100]. When asking about the digital transformation, 'How have new technologies affected you?' questions like this participant answers it quite well.

Digital tools are revolutionizing accountability and transparency within workplace systems. As Leslie explained, sophisticated tracking capabilities in contemporary accounting platforms furnish unequivocal records of user engagement, thereby guaranteeing accuracy, mitigating misunderstandings, and optimizing operational efficiency.

Leslie said: *"I mean, it just makes it makes our accounting system so much simpler. It makes I love it because it is the system time stamps everything so and it shows if somebody actually looked at something. So somebody can't say, yeah, I looked at your report, and be like. The system shows you never went in there, like it literally knows if that person logged in and opened the report. So even if they didn't do anything in it, but I can like if they tell me they looked at it, and I'm like, no, you didn't. So nobody says that anymore because they know that it says, you know, like the system says. You can look at the history, and you can see this person went into the document five times."*

Leslie shared a clear example of how digital transformation reshapes organizational processes, particularly in accounting and information management. By implementing a digital system that timestamps every user interaction and logs document access, the organization has significantly improved transparency and accountability. This technological shift reduces ambiguity; no longer can individuals falsely claim they reviewed or engaged with a report when the system can verify otherwise. The ability to see whether a document was opened, how many times, and by whom ensures that responsibility is traceable. This not only simplifies managerial oversight but also creates a culture where individuals are more mindful of their actions, knowing that their digital footprint is visible and auditable.

From a broader organizational perspective, such advancements are critical components of digital transformation. They do more than streamline operations, they redefine how teams communicate, collaborate, and build trust. The digitization of internal processes minimizes misunderstandings, reduces the need for manual follow-ups, and supports evidence-based decision-making. Employees are empowered to work more independently, while leadership can focus on strategy rather than micromanagement. Ultimately, by integrating accountability into the digital infrastructure, organizations enhance their agility, efficiency, and alignment with contemporary standards of operational excellence and sustainability.

Flexible and hybrid work arrangements have become indispensable in promoting a healthy work-life balance. As Bradley shared, the flexibility to work remotely when necessary, particularly for family obligations, provides a degree of adaptability that was not always feasible in conventional work environments.

*Bradly said: "We have hybrid work schedules here. The ability to when I need to. I have some younger kids if I need to stay home because of a sick kid in the past, that's something that's like, well, that's a day lost and I don't the ability to. Do a lot of work from home."*

Bradly shared how hybrid work models, enabled by digital transformation, provide greater flexibility for employees. He highlights that in the past, staying home due to a sick child meant losing a full day of work. Now, thanks to remote work options, they can continue to be productive from home, balancing personal responsibilities with professional duties more effectively.

Red shared experiences how their treatment system works even at night. Digital transformation is reshaping water industry by enabling real-time monitoring and control of operations. As Red explains, modern treatment plants now use online systems to visualize and manage equipment performance remotely.

*Red Said: "Yeah, we do have a monitoring system online monitoring system where we can monitor each equipment and see it on a screen. The entire treatment plan can be seen on a screen. So where various components of the plan can be actually seen digitally on a screen, and like for example, for pumps we have. How many? What's the speed of the pump right now? What speed it is running at?"*

Red highlights the role of digital technologies in enhancing operational efficiency through real-time monitoring systems. He describes an online monitoring system that allows staff to oversee the entire treatment plant digitally, viewing each component on a screen. This includes

detailed information such as the current status and speed of specific equipment like pumps. By having instant access to this data, employees can make timely decisions, quickly detect issues, and optimize performance without needing to be physically present at each machine. This reflects a core aspect of digital transformation, using technology to improve visibility, control, and responsiveness in operations. It not only streamlines processes but also supports predictive maintenance, reduces downtime, and contributes to more efficient and sustainable resource management. During the interview, another significant sub-theme was discussed, and it was self-improvement in the context of digital transformation.

#### 4.4.1 Self-improvement:

The term “performance/competence” encapsulates the belief that an individual possesses the requisite skills and knowledge to effectively perform engineering tasks and comprehend engineering concepts. Self-efficacy beliefs are closely intertwined with this concept [30], [58].

Self-improvement often stems from the ability to adapt, learn independently, and remain curious. Rose’s reflection highlights how education not only provides credentials but also instills essential life skills that support continuous personal growth.

*Rose said: “To back myself up, but also the skills learned from attaining those degrees. So you know, one of the biggest things that is you're probably gathering as you complete your thesis is you have to learn. Teach yourself to learn quickly and pick*

*up things on your own. And. Read a lot, I guess as well and. I think I think that has enabled me to just whatever. Interest I have to pursue it."*

Ultimately, the capacity to teach oneself, stay curious, and pursue personal interests empowers lasting self-development and opens doors to new opportunities.

Embracing change is a fundamental aspect of personal growth. This perspective emphasizes the significance of pursuing advanced education, such as a master's degree, as a proactive strategy to cultivate resilience, adaptability, and future career adaptability.

*Alan said: "I very much enjoy the structure we have now. I would love for it to stay like this forever, where just projects are changing. But that's not realistic. The reality is that there are going to be a series of retirements and with that is going to come change. So part of getting my master's degree is preparing for that change, making sure that I have options that, if I don't particularly like the direction things are going. I can make a change. For me. Or I can stay right here and still be happy with it. Like it just gives that opportunity and that option."*

By investing in personal growth, individuals expand their options, enabling them to embrace change with assurance or preserve their current state on their own terms. This ultimately leads to a more empowered and fulfilling career trajectory. This quote ultimately reflects how self-improvement provides flexibility and choice in terms of digital transformation.

By gaining new qualifications and knowledge, the individual is better equipped to either adapt to changing circumstances or remain content in their current role. This dual possibility fosters a sense of control and optimism about the future, reinforcing that personal growth is essential for both career resilience and satisfaction.

#### 4.5 Internship Experiences:

An internship is a brief period of employment during which a trainee or intern gains practical experience in a particular profession or occupation. Internship programs typically target college students [34]. In addition to contributing to the development of the future workforce, internships enhance industry knowledge, offer career prospects, and introduce innovative ideas to businesses [34]. For engineering graduates, the transition from school to the workplace can be difficult. Unlike the majority of engineering programs, workplace learning incorporates companies, people, cultures, and a variety of non-technical and technical factors [29].

Internships play a pivotal role in shaping career trajectories by offering practical experience and early exposure to a particular field. Red's inaugural internship at a water treatment facility during his studies at a Midwest R-1 university provided valuable insights into the industry and contributed to the consolidation of his career aspirations.

*Red said: "My first internship here in when I was studying at Midwest R-1 category university at Upper Midwest water treatment plants. So when you work in there, and if say I enjoyed working over here. It was like good. I enjoyed the work and that's why I kind of stuck around in this field."*

This positive internship experience not only enhanced Red's practical skills but also nurtured a lasting passion for the field, ultimately influencing his decision to pursue further development within the water treatment industry.

#### 4.6 Gender Discrimination:

It is widely recognized that gender and racial/ethnic disparities become more pronounced at higher levels of the job hierarchy in U.S. engineering professions, progressing from entry-level roles to managerial and leadership positions [101]. Gender discrimination in the workplace persists despite significant advancements over the last 50 years [102], [103]. Women only hold around 37% of leadership positions globally [102].

Gender discrimination remains a significant barrier in many workplaces, particularly those dominated by men. Jackie highlights her previous workplace experiences, how women can be unfairly judged or dismissed based on gender stereotypes, making it difficult for them to assert authority and be taken seriously, regardless of their role or expertise. This quote emphasizes the pervasive issue of gender bias in male-dominated workplaces, where women's authority or expertise is frequently underestimated due to their appearance or adherence to traditional gender roles. Jackie's struggle to be taken seriously while wearing attire that deviates from the norms of the workplace highlights the challenges women face in challenging stereotypes and demonstrating their professional credibility.

*Jackie said: "One time I did have to go out there with skirt on and high heels because I didn't have anything with me. I had to run because they were. They were doing something they shouldn't have been, and I had to stop them. And no one wanted to listen to me because it was all construction workers out there, and they're all men. And who's this girl from the office? She's she must be some secretary or something. Again and. I had to, you know, be loud about it, but direct and and they did listen after a while, but it was. Very uncomfortable".*

This experience highlights broader issues of gender discrimination, where women frequently need to assert themselves more forcefully to secure respect and authority. It underscores the necessity of cultural and structural alterations within workplaces to guarantee that all employees, irrespective of gender, are valued and heard equitably, without the need to contend with biased assumptions.

Despite advances toward workplace equality, many women still encounter situations where their perspectives are overlooked or undervalued. As Madison expresses, this ongoing bias can be both visible and deeply frustrating.

*Madison said: "You know, but there's still times where you see the voices of men being listened to more than the voices of women. And it's really frustrating".*

This quote reflects the ongoing issue of gender bias in many professional settings, where men's opinions are often given more weight than those of women. Despite progress toward equality, the persistence of such disparities continues to limit women's full participation and recognition in the workplace. The expressed frustration highlights the imperative for sustained initiatives to combat gender discrimination, foster equal representation and respect, and establish inclusive settings where the contributions of all individuals are valued irrespective of their gender.

Despite growing awareness and efforts toward equality, sexism and unfair treatment of marginalized groups persist in many workplaces. Lisbon's statement highlights the ongoing

challenges women and other marginalized individuals face, revealing that discrimination remains a significant barrier to true inclusivity.

*Lisbon Said: “Unfortunately, I think even in even though it's sad to say, you know, being a woman. You know, you're still there. Still things that you know you still hear people being sexist and you still see, you know, marginalized groups not being treated fairly and that just really drives me crazy”.*

Her frustration highlights the pressing necessity of sustained advocacy and systemic transformation to address sexism and guarantee equitable treatment for all, thereby creating workplaces that value diversity and facilitate the flourishing of all individuals.

## 5 Conclusion

Global water scarcity has emerged as one of the 21st century's most significant concerns to human life and societal development [3], [9]. With the continuous rise of the population, the rapid progress of industry and urbanization, and the uncertainties caused by climate change, the contradiction between the supply and demand of water resources is increasing [9], [104]. Engineering fuels contemporary development but also contributes considerably to climate change [105]. As a result, engineering education must emphasize the profession's environmental effects and prepare engineers to design climate-resistant infrastructure [105]. Engineering education is crucial for sustainability since engineers play a significant role in determining our society's growth and development [37].

Civil engineering students and professionals go into many different fields. As a researcher, I am interested in how water engineers are supported in their careers in order to understand how to create better workplaces and engineering education.

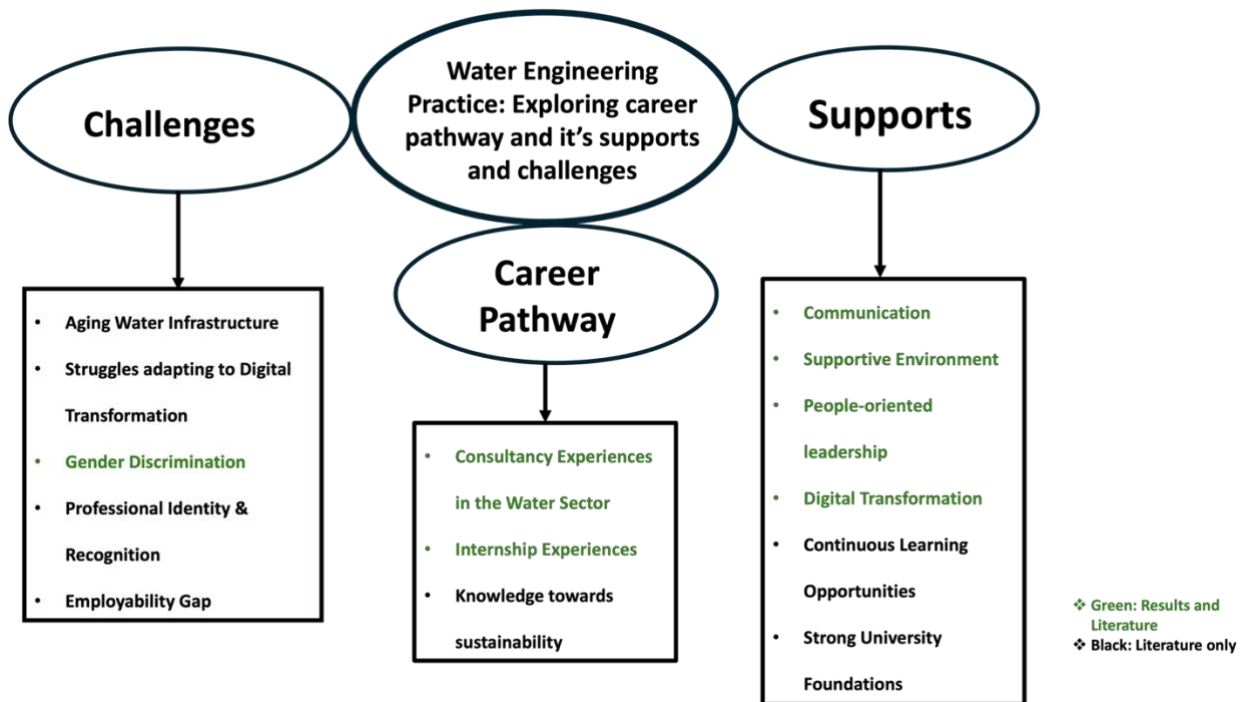


Figure 5: Expected Results from Literature Review for Exploring Challenges, Supports, and Career Pathways in Water Engineering Practice

In this study, I initially expected to uncover significant challenges associated with digital transformation (DT) in the water sector, particularly technical, cultural, or organizational barriers that might hinder progress. However, the findings revealed a different narrative: participants primarily emphasized the benefits of DT, such as increased transparency, operational efficiency, and enhanced flexibility through tools like digital monitoring and hybrid work arrangements. Rather than focusing on obstacles, their experiences highlighted how digital tools support self-improvement, accountability, and adaptability in their daily roles. While I anticipated insights into general workplace barriers, the interviews revealed deeper and more consistent themes around communication, supportive environments, and the impact of early career experiences, such as internships and consultancy roles, on long-term development. Notably, gender discrimination

emerged as a major factor contributing to toxic workplace environments, linking systemic bias with professional stagnation and emotional strain. Overall, while some expectations were met, particularly regarding the importance of internships and support systems, others, such as the presumed difficulties in digital transformation, diverged from participant realities, underscoring a more optimistic and growth-oriented professional landscape than anticipated.

Workplace communication is becoming increasingly important in industrial organizations as economic globalization and organizational structure complexity increase[106]. In the thematic analysis, the first theme identified was communication. The interview insights clearly demonstrate that communication is not merely a supplementary skill but a fundamental competency in sustainable water engineering practice. Participants consistently emphasized that while technical knowledge is foundational, effective interpersonal communication, outreach participation, and people-oriented leadership are the distinguishing characteristics of successful professionals in the field. The recurring theme of supportive managers and workplace environments that prioritize open dialogue, relationship-building, and structured outreach underscores the fact that these factors not only foster individual growth but also contribute to organizational sustainability.

A supportive work environment is an environmental construct that fosters a favorable atmosphere for employees inside an organization[107], [108].The next thematic analysis of this research study was Supportive Environment. The experiences shared by the participants underscore the critical role of a supportive and collaborative work environment in shaping successful and fulfilling careers. From overcoming adversity and building confidence to fostering mentorship and embracing teamwork, each narrative highlights how positive workplace dynamics

contribute to both individual growth and collective achievement. A culture that values emotional support, open communication, and mutual respect not only enhances well-being and job performance but also strengthens organizational resilience and sustainability. The results show that such environments empower individuals to bring their authentic selves to work, strengthen interdepartmental teamwork, and create a shared sense of purpose and accountability. Additionally, stories like Madison's demonstrate the extended value of professional networks and mentorship, highlighting how support systems beyond the immediate workplace can open doors and shape career trajectories. Conversely, participants who experienced toxic work environments described their early careers as marked by struggle and stagnation, underscoring the long-term damage such conditions can cause. These stories collectively affirm that when employees feel supported, understood, and empowered, they are better equipped to thrive and contribute meaningfully to their teams and organizations.

The third thematic analysis is Consultancy Experiences in the Water Sector. Engineering consultancy experiences in the water sector offer more than just technical proficiency; they cultivate a versatile and strategic mindset crucial for long-term success in infrastructure development. As shared by participants, consulting careers expose professionals to a diverse range of disciplines and working environments, providing valuable insights into project delivery from multiple perspectives: consultant, contractor, and client. These roles require not only engineering expertise but also emotional intelligence, adaptability, and strong communication skills to manage complex stakeholder relationships and evolving project challenges. Participants like Leslie and Bradly demonstrate how diverse project exposure and even imperfect job fits serve as stepping stones for long-term growth. Meanwhile, perspectives from John and Peter highlight

the importance of cross-sector experience, bridging roles between consultants, contractors, and clients to foster a more collaborative, empathetic, and outcomes-oriented approach to project delivery. Ultimately, such experiences empower professionals to manage infrastructure projects more comprehensively, foster collaborative partnerships, and contribute significantly to sustainable water management solutions. The ability to draw from a diverse background in consultancy positions individuals as key assets in shaping resilient, efficient, and equitable water infrastructure systems.

Global sustainability and digital transformation are creating complex challenges at the intersection of technical and non-technical fields [109]. As new career paths emerge, graduates must be equipped to work in teams, solve problems, and drive change. Engineering education must adapt by offering programs that also engage non-technical students, addressing the growing demand for skilled professionals [109]. In this thematic analysis, the fourth theme I explored was Digital Transformation. This theme is closely intertwined with the first two themes and also aligns with the concept of self-improvement. The integration of digital technologies into the water sector is fundamentally reshaping the way organizations operate, communicate, and deliver value. As demonstrated through the experiences of Leslie, Bradly, and Red, digital transformation enhances accountability, operational flexibility, and system efficiency. Digital tools that track engagement and timestamp interactions, like those mentioned by Leslie, foster transparency and eliminate ambiguity in workplace communication. Hybrid work arrangements, highlighted by Bradly, show how technology supports employee well-being and work-life balance without compromising productivity. Meanwhile, Red's example of real-time digital monitoring illustrates the transformative impact of automation and data visibility in managing critical infrastructure.

Together, these experiences highlight that digital transformation is not merely about adopting new technologies; it is about redefining workflows, empowering individuals, and creating agile, responsive systems that can adapt to both internal and external challenges. This evolution not only drives operational excellence but also aligns with broader goals of sustainability, accountability, and strategic innovation across the water industry and beyond.

The next sub-theme was Self-Improvement, which is a subpart of the previous theme, Digital Transformation. Professional growth opportunities are significantly influenced by individuals' self-improvement of their learning processes [110]. Self-evaluation, which involves comparing one's performance to a benchmark, is a crucial component of self-monitoring. Individuals who engage in self-reflection meticulously evaluate their motivation, beliefs, plans, learning process, and outcomes. Self-monitoring is a fundamental requirement for professional advancement and development [110]. The participants' reflections emphasize the profound connection between self-improvement and digital transformation within the water sector. Rose's experience demonstrates how the independent learning process, augmented by the demands of higher education, fosters curiosity and self-sufficiency. These skills are important in a rapidly evolving professional environment characterized by continuous technological advancements, necessitating individuals to continuously enhance their knowledge bases. Similarly, Alan's pursuit of a master's degree highlights a proactive response to anticipated industry shifts, highlighting how personal development can serve as a strategic instrument for navigating digital and organizational transformations.

Digital transformation introduces new tools, workflows, and expectations that demand resilience and flexibility from water sector professionals. The results reveal that individuals who

invest in their growth through education and self-directed learning are better positioned to adapt to evolving project demands and organizational structures. Furthermore, they acquire the confidence and autonomy to either embrace change or maintain stability on their own terms. Ultimately, the findings underscore that personal growth rooted in curiosity, adaptability, and education is not only crucial for maintaining pace with digital transformation but also for cultivating fulfilling and future-proof careers.

Targeted internship programs can help fill mission-critical roles in the water sector, where over one-third of the workforce is getting close to retirement age [34], [111]. This research next theme was internship experiences, which is closely related to consultancy experiences. The findings highlight how internship experiences serve as foundational touchpoints in shaping long-term career paths, particularly in specialized sectors like water engineering. Red's early exposure through a hands-on internship not only provided practical skills but also fostered a sense of belonging and interest that guided his career direction. This mirrors insights from the consultancy experiences, where professionals emphasized the importance of early roles, regardless of level, in developing technical knowledge, adaptability, and relational awareness.

Both internship and consultancy experiences offer immersive learning environments that bridge academic theory with real-world problems. They expose individuals to interdisciplinary collaboration, dynamic problem-solving, and professional networks that support growth over time. Ultimately, these early experiences, whether as interns or consultants, lay the groundwork for confident career navigation, reinforcing that practical exposure is critical for developing the skills, perspectives, and passion necessary for sustainable careers in the water sector.

Several initiatives are underway to promote gender equality in the workplace, encompassing strategies such as encouraging women to enter underrepresented fields, providing support for their career advancement, and enhancing employee retention [102]. While these endeavors are often driven by noble intentions, many are lacking an evidence-based approach in their design, implementation, and assessment of effectiveness [102]. The final theme of this research is Gender Discrimination. The participants' experiences reveal a clear link between gender discrimination and the broader issue of toxic workplace environments. For women like Jackie, Madison, and Lisbon, the constant need to prove their credibility, assert authority in the face of dismissal, or witness the unequal treatment of marginalized groups contributes significantly to workplace toxicity. Such environments are not only emotionally exhausting but also undermine psychological safety, team cohesion, and long-term employee retention.

Toxicity in the workplace often stems from entrenched cultural norms that allow biases, such as sexism, to persist unchallenged. When women's voices are routinely undervalued or ignored, and when discriminatory behaviors go unchecked, it signals a systemic failure that affects the well-being and professional growth of all employees, not just those directly targeted. These hostile dynamics can lead to disengagement, decreased morale, and a lack of trust in leadership. Therefore, addressing gender discrimination is not just a matter of fairness; it is essential to transforming toxic work environments into supportive, inclusive spaces. Building equitable workplace cultures requires more than individual resilience; it demands structural change, inclusive leadership, and accountability mechanisms that ensure all employees, regardless of gender or background, feel respected, empowered, and heard.

Finally, this research highlights that sustainable water engineering practice is shaped not only by technical expertise but by a holistic integration of early career experiences, supportive work environments, digital transformation, and inclusive workplace culture. Internship and consultancy experiences serve as foundational touchpoints, offering practical exposure and cultivating adaptability, interdisciplinary collaboration, and long-term engagement in the field. Effective communication and supportive environments were found to be essential for professional growth, fostering resilience, innovation, and team cohesion. As digital transformation redefines workflows through automation, remote collaboration, and data transparency, the ability to self-improve and learn independently becomes increasingly vital. However, persistent gender discrimination continues to undermine these advancements by contributing to toxic workplace cultures, eroding psychological safety and stifling the contributions of marginalized groups. Addressing these systemic issues is essential not just for equity but for organizational sustainability and workforce retention. Ultimately, achieving sustainable practice in water engineering requires a commitment to inclusive leadership, structural change, and continuous personal and professional development, ensuring the sector remains resilient, innovative, and equitable in the face of global water and climate challenges.

## 6 Future Work Recommendation:

- Conduct research on how the US Workforce by Generation works, and Future professionals can learn from the current workforce and how they are likely to perceive and shape future workplace environments.
- Investigate how well current engineering education programs equip students with the skills needed for interdisciplinary, collaborative, and sustainability-focused work.

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