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Towards the Adoption of Construction 4.0 Technology: Exploring the Role of Organizational Citizenship Behavior

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Abstract

Organizational Citizenship Behavior (OCB) is an individual's contribution to exceeding the demands of the role in the workplace. The construction industry is on the brink of a paradigm shift with the emergence of Construction 4.0 (C4.0) technologies. A strategic roadmap outlined in the Construction 4.0 Strategic Plan (2021-2025) identifies twelve pivotal technologies poised to revolutionize construction processes. However, the acceptance and deployment of C4.0 technologies among industry players have not been encouraging. This research explores how OCB could influence the adoption of C4.0 technologies in the construction industry. Within this context, the Technology Acceptance Model (TAM) provides a theoretical lens to elucidate user acceptance dynamics. Based on the Social Exchange Theory, this study examines the relationship between the five dimensions of OCB: altruism, conscientiousness, sportsmanship, civic virtue, and courtesy, with the technology acceptance measures, which consist of perceived usefulness (PU) and perceived ease of use (PEOU). The objectives of this paper are to 1) identify key OCB indicators relevant to C4.0 adoption and 2) identify the relationship between OCB and C4.0. Data will be collected from Grade 7 contractors in Malaysia through quantitative methods to validate the hypothesized relationships. Civic virtue, courtesy and conscientiouosness were the top 3 key ocb indicator relevant to C4.0 adoption. Altruism shows significant relationship with PU, meanwhile civic virtue show signficant relatioship with PEOU. The results demonstrate that Civic Virtue, Courtesy, and Conscientiousness emerge as the top three key OCB indicators critical to adopting Construction 4.0 technology. Notably, Altruism shows a significant positive relationship with the technology's PU, while Civic Virtue is strongly associated with PEOU. These findings underscore the importance of specific OCB behaviors in facilitating the effective integration of C4.0 within organizations. Ultimately, this research endeavours to fill a crucial gap in the literature by elucidating the role of OCB in influencing attitudes and behaviours toward C4.0 technology adoption in the construction industry.

1. Introduction

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Nowadays, the term Industrial Revolution (IR) has become one of the central topics among industries, particularly the construction industry (Ibrahim *et al*., 2019). It has brought about disruptive changes in technological advancement, notably in the construction process (Oke *et al*., 2024). The conceptual framework proposed by Osunsanmi *et al*. (2020) defines C4.0 as the integration of innovative site practices, simulation, and virtualization, aimed at enhancing the performance of construction companies.

In the construction industry, the impacts suggest that the adoption of intelligent and digital technologies significantly enhances project performance and productivity by reducing construction time, lowering costs, minimizing defects or clashes, and improving construction quality, including safety and client satisfaction. Additionally, these technologies, such as BIM, optimize the project management lifecycle (Ibrahim *et al*., 2019). New technologies, methodologies, and digital solutions bring significant challenges and solutions for every stakeholder (Nagy *et al*., 2021). While organisations, projects (Du *et al*., 2018), and governments (Maskuriy *et al*., 2019) face several challenges, new stakeholders (Lavikka *et al*., 2018) have realised the opportunity of C4.0 in the construction industry. The construction industry can delay the change but cannot prevent it.

The implementation of IR4.0 represents not only a technological transformation but also a cultural change. (De Soto *et al*., 2022). Aligned with the ongoing industrial revolution, organisations must transform their working culture to embrace technology, thereby effectively bolstering company performance. Previous research conducted by Allen and Rush (1998), Tai *et al*. (2012) and Winer (2001) has proved that the role of OCB is significant and positively linked with increased and effective employee performance. According to Yang *et al*., (2021), OCB is an individual's contribution to exceeding the demands of the role in the workplace. Kark (2004) discovered that organizations with high performance, employees are more aware of citizenship behaviors, unlike employees who work in organizational units with low performance. It can therefore be realized that effective employee performance increases when there is collaborative involvement in OCB amongst team members.

Several studies across sectors have demonstrated the positive impact of OCB on organizational success, including improvements of productivity, resource utilization, group coordination, performance enhancement, and adaptability to environmental changes (Tambe, 2014). Significant results have been observed in sectors such as scientific research, manufacturing, community service, construction, hospitality, healthcare, high tech, and business, where dimensions of OCB, such as altruism, conscientiousness, civic virtue, sportsmanship, and courtesy, play vital roles in increasing the firm performance.

The digital transformation requires organisational changes (Newman *et al*., 2021). However, the innovation culture within the construction industry remains relatively low (Klinc & Turk, 2019). Research has confirmed that historical assumptions and the lack of innovative thinking inhibit transformation. The research results also pointed out that, in parallel with workflows, cooperation within the organisation is a problem, which is further worsened by the lack of trust and lack of shared individual standards and the lack of trust (Nagy *et al*., 2021). It is essential to understand how these technologies interact and influence the planning, design, construction, and operation procedures for buildings and infrastructure works (Souza & Debs, 2023).

Recognizing the difficulty in adopting and learning new technologies, construction industry stakeholders need to prepare the current workforce in C 4.0 paradigms by emphasizing the need for OCB among employees to create an environment conducive to technological advancements and ensure a harmonious relationship between industry professionals and the broader societal framework. Based on the case study in China, where spontaneous OCB played a crucial role in successfully completing emergency hospital megaprojects during COVID-19 (W. Wang *et al*., 2021), this research shifts focus to the competitive environment in Malaysia marked by the implementation of C4.0. In relation to that, this study aims to examine the importance of OCB indicators and its relationship with PU and PEOU. The result will contribute to enhancing the adoption of technology in Malaysian construction organisations.

2. Literature Review

2.1 Introduction of Construction 4.0

C4.0 is a concept that emerged from integrating digital technologies based on the principles of IR4.0 in the global construction industry (Turner *et al*., 2021). Initially, it was introduced with a focus on dam construction (Li and Shi, 2015), but its scope expanded to digitising the entire construction sector (Schober, 2015). Definitions of C4.0 vary, encompassing ideas such as finding complementarity between technological approaches, establishing digital construction sites, and implementing Industry 4.0 in construction. Common elements include using technologies like IoT, Big Data, and AI. The overarching goal is to transform the traditionally fragmented construction industry into an integrated one by reshaping processes, organizational structures, and project management. C4.0 brings benefits such as reduced costs, time savings, improved performance, and enhanced collaboration (Moshood *et al*., 2020) through increased supply chain integration. Overall, the adoption of C4.0 can potentially revolutionize the construction sector globally.

2.2 Construction 4.0 Technology

C4.0 technology represents a transformative framework characterized by advancements in industrial production and construction, the integration of cyber-physical systems, and the proliferation of digital technologies (Ratana *et al*., 2023). Key digital technologies in C4.0 include Building Information Modeling (BIM), Common Data Environment (CDE), unmanned aerial systems, cloud-based project management solutions, Augmented Reality/Virtual Reality (AR/VR) technologies, artificial intelligence, cybersecurity measures, big data analytics, blockchain technology, and laser scanning. In the realm of cyber-physical systems, components include robotics and automation, sensor technologies, Internet of Things (IoT) devices, wearable sensors for workers, actuators, additive manufacturing capabilities, offsite and onsite construction methodologies, and equipment embedded with sensors (Ratana *et al*., 2023).

C4.0 signifies more than technological upgrades; it represents a paradigm shift embracing innovation and heightened productivity (Böck, 2015). Derived from the foundations of IR4.0, C4.0 is tailored to the construction sector, embracing technological advancements that revolutionize work methods about processes, materials, and markets. The conceptual framework of C4.0 is categorized into two main pillars: the digitization of the construction industry and the industrialization of construction processes (Craveiro *et al*., 2019).

Adopting C4.0 technologies such as BIM, IoT, 3D printing, big data analytics, artificial intelligence, robotics, AR/VR, blockchain, and cloud-based collaboration solutions promises numerous benefits (Roslan *et al*., 2022). These technologies enhance productivity, cost savings, risk reduction, safety, project efficiency, and decision-making capabilities across various aspects of construction projects. They enable real-time monitoring, data-driven decision-making, automation of tasks, improved collaboration, and streamlined processes, leading to enhanced project outcomes and competitiveness in the industry.

2.3 Construction 4.0 Technology Adoption

The Construction Industry Development Board (CIDB) emphasizes that the evolution of the construction sector relies significantly on adopting new technologies and innovative methodologies. Embracing these advancements will transform how buildings and infrastructure projects are delivered, prioritizing superior performance and aiming to enhance overall quality of life. As projects become more complex and interconnected, there is a growing demand for the construction industry to adopt new technologies and creative processes to ensure efficient value delivery (CIDB, 2020).

2.3.1 Critical Success Factor of Construction 4.0

Based on studies by Moeuf *et al*. (2020), Kumar *et al*. (2023), and Pozzi *et al*. (2023), the adoption of C4.0 technologies within the construction industry hinges on several critical success factors (CSFs) that facilitate successful implementation initiatives. These factors include aligning C4.0 initiatives with organizational strategy, ensuring organizational adaptability and agility to embrace new technologies swiftly, integrating change management practices to navigate the transformative nature of C4.0 adoption, fostering employee engagement and continuous learning programs to equip the workforce with necessary skills, implementing effective communication channels to facilitate interdisciplinary collaboration, nurturing a positive organizational culture conducive to change adoption, integrating diverse technology platforms for improved sustainability and supply chain efficiency, and implementing a robust Knowledge Management System to facilitate knowledge creation, exchange, and innovation. (Kumar *et al*.,2023; Chiarini and Kumar, 2021; Sony and Naik, 2020; Luthra & Mangla, 2018; Zhou *et al*., 2017). Together, these CSFs contribute to the seamless integration and effective utilization of C4.0 technologies, enabling organizations to enhance productivity, efficiency, and competitiveness in the construction industry landscape.

2.4 Challenges Behind Construction 4.0

Integrating new technologies like C4.0 in the construction industry brings significant potential benefits, yet its full adoption faces several challenges. Despite recognizing its advantages, including improved planning, design, construction, and operations, the industry has not fully embraced C4.0 technology. Previous studies by Edwards *et al*. (2017), Osunsanmi *et al*. (2020), Al-Saeed *et al*. (2019), and Suferi and Rahman (2021) have identified various challenges associated with C4.0 adoption. These challenges range from organizational resistance to change and inadequate infrastructure to technological complexities and workforce skill gaps. Overcoming these hurdles is crucial to realizing the transformative potential of C4.0 technology in the construction sector.

2.4.1 Resistance to Changes

Resistance to change poses a significant challenge in adopting new technologies, particularly in conservative industries like construction. Employees often resist embracing new tools and workflows due to concerns about their proficiency with emerging technologies such as IoT and fears of job displacement caused by increased automation and autonomy (De Vass *et al*., 2021). Addressing worries related to data transparency, reliance on technical support systems, and safety during human-machine interactions is crucial to building trust in technology adoption (Müller *et al*., 2018). Trust plays a pivotal role in successfully implementing new technologies, as user anxieties can hinder adoption decisions (Heinssen *et al*., 1987; Bozionelos, 2004). In industries like construction, which are conservative in embracing change, the transition to IR 4.0 requires substantial changes in both social and technical systems. Employees play a central role in driving the success of IR 4.0 despite the radical shift it entails from traditional work practices, highlighting the need for them to adapt to a new way of working (Müller *et al*., 2018).

2.4.2 Lack of industry 4.0 skills and know-how

The lack of IR 4.0 skills and know-how presents a significant challenge for organizations that leverage advanced technologies effectively. Managing complex systems like IoT and data analytics requires professionals proficient in predictive analytics and content analysis (Kamble *et al*., 2019; Haddud *et al*., 2017; Janssen *et al*., 2019), but many organizations struggle with knowledge gaps at both management and employee levels (Birkel & Hartmann, 2019; Abazi, 2016). Soft skills such as communication, teamwork, problem-solving, decision-making, and critical thinking (Bolpagni *et al*., 2022; De Soto *et al*.,2022; K. Yang *et al*., 2022; Adepoju & Aigbavboa, 2021) are also crucial for navigating C4.0. The value derived from IR4.0 technologies relies heavily on skilled professionals who can utilize these tools to enhance operations and decision-making processes. However, many workers lack the necessary knowledge and skills for Industry 4.0, hindering productivity and efficiency (Ing *et al*., 2019). Embracing Industry 4.0 demands a fundamental mindset shift among workers and requires them to adapt to new technologies and work processes (Maskuriy *et al*., 2019; Klinc & Turk, 2019).

2.5 Social Exchange Theory (SET)

SET has been used as an underpinning theory to explain the relationship between OCB and C4.0 adoption of construction organisations. SET emphasizes interdependent interactions and reciprocal relationships within organizations (Liaquat & Mehmood, 2017), creating a sense of obligation and reciprocity among employees. It plays a pivotal role in understanding various organizational relationships, influencing employee behaviours, and fostering organizational commitment. In the context of C4.0 technology adoption, SET integrated with OCB provides a nuanced understanding of underlying processes. This integration reveals that employees engaging in OCB, such as knowledge sharing and collaborative support, create an environment where reciprocal relationships thrive (Tomlinson & Fai, 2013), influencing the overall technology adoption experience. The balance of commitment between employees and organizations is crucial in adopting C4.0, where OCB exemplifies commitment and creates a positive atmosphere for the adoption of technology (Oparaocha, 2016). SET's application extends to open innovation environments, where OCB contributes to a culture of active participation in technology adoption, aligning with the principles of open innovation. Overall, integrating SET and OCB offers a robust theoretical framework for comprehending the intricate interplay between individual and success factors in successfully adopting advanced C4.0 technologies.

2.6 Technology Acceptance Model (TAM)

This study uses TAM to measure the adoption level of C4.0. TAM introduced by Davis in 1985, remains a foundational framework for understanding user acceptance of new technology, emphasizing perceived usefulness (PU) and perceived ease of use (PEOU) as critical determinants of acceptance (Davis *et al*., 1989). In the context of C4.0, TAM provides a robust foundation for predicting users' attitudes towards technological innovations, particularly regarding advanced digital systems and automation in the construction industry. PU denotes users' beliefs regarding a system's ability to enhance productivity and efficiency, while PEOU reflects users' ability to use technology without significant difficulty (Davis *et al*., 1989). Positive expectations and extrinsic motivation influence users' intention to use technology, while ease of use becomes paramount in the adoption of C4.0. Integrating OCB into TAM extends its applicability by considering positive workplace behaviours and organizational culture, which significantly influence employees' perceptions of technology. This extended model offers valuable insights into individual and organizational factors impacting the adoption of C4.0 technology in organizations, making it a valuable measure for assessing technology adoption in the construction industry.

2.7 Organizational Citizenship Behavior (OCB)

OCB initially described by Organ (1988), refers to discretionary behavior by employees that is not explicitly rewarded but contributes to the effective functioning of the organization. It indirectly supports the organization's social system and is associated with outcomes like job satisfaction, trust, commitment, and mood (Bateman & Organ, 1983; Podsakoff *et al*., 1990). OCB is viewed as advantageous and essential for organizational operations, as it reduces the need for formal control mechanisms and enhances available resources (Organ, 1988). OCB is characterized by dimensions such as altruism, conscientiousness, sportsmanship, courtesy, and civic virtue, as proposed by various researchers, including Smith *et al*. (1983), Organ (1988), Van Dyne *et al*. (1994), and Podsakoff Mackenzie (1994). Among these dimensions, altruism involves helping others in the organization (Organ, 1997), conscientiousness entails exceeding minimum role requirements (MacKenzie *et al*., 1993), sportsmanship reflects enduring workplace challenges without complaint (Organ, 1990), courtesy prevents interpersonal problems (Organ, 1990), and civic virtue involves active participation in organizational processes and events (Podsakoff *et al*., 1990). These dimensions collectively contribute to organizational effectiveness and employee morale. Table 1 indicates studies proven the relationship between OCB dimensions and performance (either firm or employee) in various sectors.

Table 1 *OCB influencing performance*

Resources	Sector	OCB	Performance	Result
Annamalah *et al*. (2022)	Manufacturing	Altruism, Conscientiousness, Civic Virtue, Sportsmanship, Courtesy	Open Innovation	Significant
Widarko & Anwarodin, (2022)	Community Service	Altruism, Conscientiousness, Civic Virtue, Sportsmanship, Courtesy	Civil servant Performance	Significant
Kissi *et al*., (2019)	Construction	Altruism, Conscientiousness, Civic Virtue, Sportsmanship, Courtesy	Employee performance	Significant
Taşkiran &İyigün, (2019)	Hospitality	Sportsmanship	Entrepreneurial Orientation	Significant
Haider *et al*., (2017)	Healthcare	Altruism, Conscientiousness, Civic Virtue, Sportsmanship, Courtesy	Innovation Implementation	Significant
Basu *et al*., (2017)	Healthcare	Altruism, Conscientiousness, Civic Virtue, Sportsmanship, Courtesy	Job performance	Significant
Naqshbandi *et al*. (2016)	High tech	Sportsmanship	Open Innovation	Significant

2.7.1 OCB in Construction 4.0

This research strategically employs OCB as a lens to explore its influence on adopting C4.0 within organizational settings. OCB, characterized by voluntary and discretionary actions that support organizational goals, aligns well intending to foster a culture of embracing advanced technologies like C4.0. The construction industry, undergoing a transformative shift with the integration of technologies such as BIM, IoT, robotics, and AI, requires a collaborative and forward-thinking organizational culture. Each dimension of OCB plays a distinct role in shaping employee behaviour towards C4.0 adoption. Altruism promotes voluntary assistance and knowledge sharing, conscientiousness ensures adherence to new processes, sportsmanship encourages a positive attitude towards challenges, civic virtue fosters responsibility and participation, and courtesy enhances interpersonal relations (Hartl & Heß, 2017). These dimensions collectively contribute to shaping a positive workplace culture that embraces and maximises the benefits of advanced construction technologies. The research aims to highlight the pivotal role of OCB in facilitating the adoption and integration of C4.0 technologies within organizations.

2.8 Proposed Conceptual Framework and Hypothesis Formulation

The proposed conceptual framework aims to examine the influence of five dimensions of OCB—altruism, conscientiousness, sportsmanship, civic virtue, and courtesy on the adoption of C4.0 technology. These OCB dimensions serve as independent variables, while the dependent variable is technology adoption, measured through PEOU and PU.

The integration of OCB and technology adoption allows for an exploration of how positive workplace behaviours impact the adoption of advanced technologies, considering critical success factors in the context of C4.0 technology adoption. Soft skills such as communication, teamwork, problem-solving, decision-making, and critical thinking which are addressed in OCB dimensions are identified as relevant factors contributing to successful technology adoption in the Construction 4.0 literature (Bolpagni *et al.*, 2022; De Soto *et al.*,2022; K. Yang *et al.*, 2022; Adepoju and Aigbavboa, 2021). Figure 1 shows the research framework on the OCB and C 4.0 adoptation.

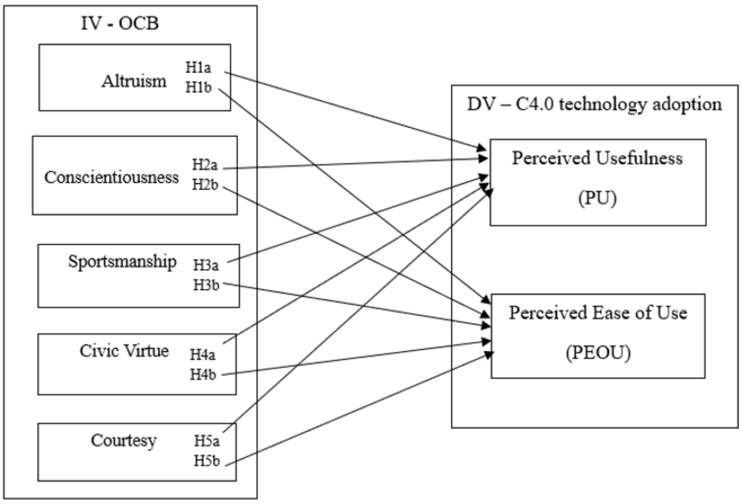

Fig. 1 *A research framework on OCB and C4.0 technology adoption*

2.8.1 Altruism and PEOU and PU

Altruism among employees in the context of C4.0 technology adoption is crucial for fostering a supportive and collaborative organizational culture. Altruistic behaviours, such as assisting colleagues, sharing knowledge, and promoting teamwork, contribute significantly to the successful integration of new technologies. Research by Stewart & Gosain (2006) suggests that altruistic behaviour increases when employees work together towards common goals.

Altruism not only accelerates the learning process for co-innovators but also fosters a culture of efficiency and innovation within the organization. Podsakoff and MacKenzie (1997) demonstrate the positive impact of altruism on productivity and product quality. Moreover, altruistic behaviours contribute to conflict resolution and promote dedication to the organization's well-being.

The hypotheses posit that altruistic behaviours positively influence the PEOU and PU of C4.0 technologies. Employees who demonstrate altruistic behaviours create a supportive environment conducive to technology adoption, making it easier for their peers to seek assistance and guidance.

H1a: There is a positive and significant relationship between altruistic behavior and PU in technology adoption.
H1b: There is a positive and significant relationship between altruistic behavior and PEOU in technology adoption

2.8.2 Conscientiousness and PEOU and PU

Conscientious individuals play a significant role in shaping the perception and adoption of technology within organizations, particularly in the context of C4.0 technology adoption. They perceive technology as a valuable tool that enhances productivity and enables them to fulfil their responsibilities more effectively (Naqshbandi *et al.*, 2016). Conscientious employees recognize the ability of technology to streamline tasks and support their work responsibilities, contributing to the overall perceived usefulness of the technology.

Research indicates that conscientious employees go beyond basic requirements and invest extra time and effort in adopting technology within the organization. Their proactive engagement creates favourable conditions for open innovation, and they exhibit diligence in adhering to security protocols, contributing significantly to cybersecurity efforts, which are critical in C4.0 implementations (Naqshbandi *et al*. ,2016).

Conscientiousness is associated with beliefs that technology will facilitate effective job performance and is linked to behavioural intentions to use software technology (Devaraj *et al*., 2008). Professionals scoring high on conscientiousness tend to be achievement-oriented and are more likely to accept and use better technologies (Lakhal and Khechine, 2017). Conscientious individuals are more likely to perceive technology as useful and easy to use, contributing to their willingness to accept, implement, and promote digital transformation within the organization.

H2a: There is a positive and significant relationship between conscientiousness and PU of technology.
H2b: There is a positive and significant relationship between conscientiousness and PEOU of technology.

2.8.3 Sportsmanship and PEOU and PU

Sportsmanship, characterized by a positive and cooperative attitude among employees, is identified as a significant factor positively correlated with the PU of technology within organizational settings. Employees who exhibit sportsmanship contribute to the organization's adaptive capacity in the context of technology adoption, fostering an environment conducive to successful integration (Podsakoff and MacKenzie,1997).

Sportsmanship also encourages employees to view challenges and failures as integral to the learning process, fostering an innovative culture within the organization. Tolerating setbacks becomes crucial for embracing the exploratory nature of adopting new technologies (K. Yang *et al*., 2022).

Moreover, sportsmanship contributes to enhanced problem resolution, organizational policy formulation, and task design in the context of technology adoption. Highly engaged employees play a vital role in the efficacy of the technology adoption process, impacting the overall competency and effectiveness of the workforce during the adoption journey Sandrin *et al*. (2018). Employees demonstrating sportsmanship are more likely to perceive technology as useful and easy to use, contributing to the successful adoption and integration of technology within the organization.

H3a: There is a positive and significant relationship between sportsmanship and PU of technology.
H3b: There is a positive and significant relationship between sportsmanship and PEOU of technology.

2.8.4 Civic Virtue and PEOU and PU

Civic virtue, characterized by proactive engagement in process improvement efforts. Employees demonstrating civic virtue actively participate in business processes and stay informed about industry changes, fostering a culture of continuous improvement (Organ,1988; Yoon, 2009).

Their voluntary participation in decision-making processes fosters cooperation, power-sharing, and positive interactions among employees, enhancing overall effectiveness and efficiency Hwang and Choi (2017). Civic virtue also aligns with the need for employees to be actively involved in training and education initiatives for C4.0 technologies, contributing to the organization's competency.

Civic virtue is associated with employees' perception of technology's ease of use, as competent employees contribute to the organization's overall competency. Active participation in training initiatives reinforces the perception of technology as easy to use, thus enhancing the adoption of C4.0 technologies. As outlined by Maduka *et al*. (2018), employees' competency in utilizing a system or technology directly influences their perception of its usefulness.

Fostering a culture of civic virtue among employees is expected to lead to higher levels of PU and PEOU of technology, thereby enhancing the adoption of C4.0 technology within the organization.

H4a: There is a positive and significant relationship between civic virtue and PU of technology.
H4b: There is a positive and significant relationship between civic virtue and PEOU of technology.

2.8.5 Courtesy and PEOU and PU

Courtesy behaviours, characterized by politeness and respect in employee interactions, are positively correlated with the perceived ease of technology adoption within organizations (Naqshbandi *et al*., 2016). Courtesy serves as a powerful mechanism for fostering a positive and cooperative work environment, enhancing various aspects that facilitate the ease of technology adoption.

Courtesy facilitates coordinating activities among team members and across work groups, reducing the likelihood of problems and promoting efficient problem resolution (Podsakoff and MacKenzie, 1997). In the context of technology platform integration, courtesy plays a pivotal role in ensuring smooth integration through positive interactions among employees.

Effective communication, closely linked to courtesy, is a crucial success factor in digital transformation and the adoption of C4.0 (Yoon,2009). Clear and respectful communication, facilitated by courtesy, fosters a positive atmosphere conducive to learning and collaboration during the technology adoption process.

Courtesy contributes to a collaborative environment, enhancing teamwork and facilitating successful collaboration in adopting new technologies, particularly in the interdisciplinary nature of Construction 4.0. Furthermore, courtesy plays a crucial role in conflict resolution, fostering a positive and harmonious work environment. Employees demonstrating courtesy behaviors are expected to perceive technology as easier to use, contributing to a smoother technology adoption process and reinforcing a positive work environment.

H5a: There is a positive and significant relationship between courtesy and PU of technology.
H5b: There is a positive and significant relationship between courtesy and PEOU of technology.

3. Methodology

3.1 Research Design

The flow of the research process has been summarised in Figure 2 below:

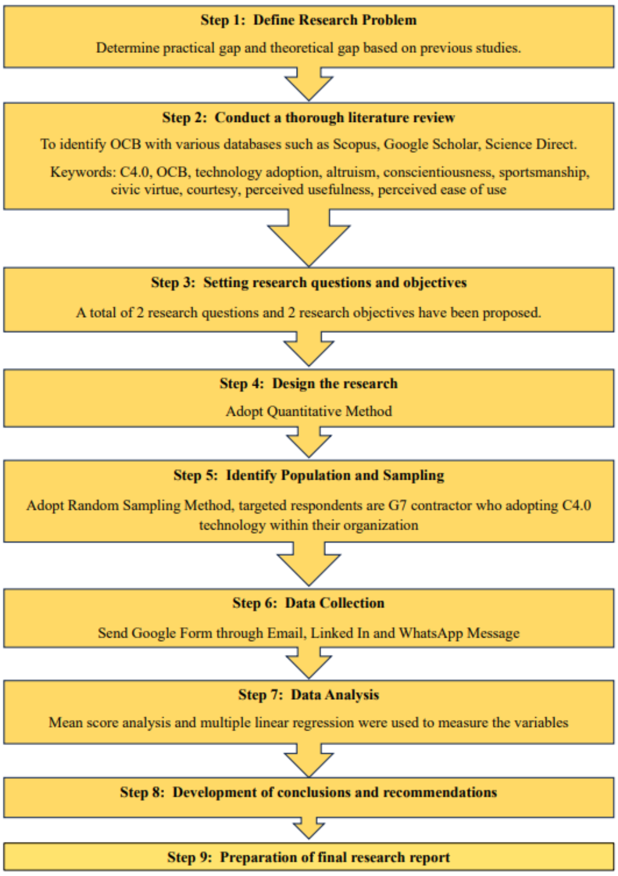

Fig. 2 *Steps in carrying out the research*

3.2 Research Method

The research method chosen for this study is quantitative research, which involves collecting, analysing, and interpreting numerical data derived from observations (Taherdoost, 2022). Quantitative research employs structured questionnaires with closed-ended questions, often using Likert scale multiple-choice questions. Closed-ended questions offer explicit options for respondents to select from, typically ranging from a 5-point scale. This method allows researchers to gather quantitative data from respondents, providing insights into the phenomena under investigation. Quantitative research focuses on numerical values to explain and describe observed phenomena, contrasting with qualitative research, which aims to collect and analyze textual data using interpretive methods (Taherdoost, 2022).

3.3 Population and Sampling

In this study, a probability sampling method, specifically random sampling, was adopted. This deliberate selection process targeted Grade 7 construction professionals actively involved in adopting C4.0 within Malaysian construction firms. By focusing on these professionals, who are both employees and contributors to C4.0 implementation, valuable insights into their behaviours within organizational contexts were sought. The entire population in this research consists of all construction firms in Malaysia adopting C4.0 technology, with the sample being a subset, specifically Grade 7 contractors. The list of contractor organisations was based on the CIDB database of registered contractors 2023.

3.4 Questionnaire Development

A set of questions has been created by adopting and adapting from the previous studies.

1. Section A- Respondents Profile Information
   - This section gathers demographic details such as gender, age, educational qualification, position, and years of experience in the construction industry.
2. Section B- Assessment of OCB
   - This section uses a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) to evaluate the extent of respondents' engagement in OCB. This assessment aims to identify key dimensions of OCB indicators relevant to Construction 4.0 (C4.0) technology adoption, drawing from previous studies by Dinka (2018), and Basu *et al*. (2017).
3. Section C- Perception of Technology Adoption
   - This section focuses on two key dimensions, PEOU and PU, as factors underlying technology adoption. PU and PEOU were measured using a four-item scale developed by Venkatesh and Davis (2000) and Höyng & Lau (2023) for the specific digital labour context. Respondents are asked to rate their perceptions of technology adoption on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), providing insights into their attitudes towards C4.0 technology adoption.

3.5 Data Collection

To gather data, the following procedure was undertaken: First, a list of G7 contractors was identified from the Construction Industry Development Board (CIDB) database, a reliable source of information about construction firms in Malaysia. Second, emails containing the electronic survey method and links to the web-based questionnaire were sent to these contractors.

Additionally, an online survey was conducted using Google Forms to facilitate data collection. The survey link was distributed through popular platforms such as WhatsApp, LinkedIn, Facebook, and email. This multi-platform distribution strategy aimed to reach a diverse and representative sample of G7 contractors engaged in C4.0 adoption. The increasing global access to the internet has made online surveys a preferred method for collecting quantitative data from large and geographically dispersed populations. The online survey's user-friendly interface and accessibility enhanced the efficiency of data collection from a wide range of respondents (Regmi *et al*., 2017). Completion of survey questionnaires online is often preferred by respondents, who can answer at their convenience and at their own pace, which may increase response rates (Callegaro *et al*., 2015). According to Fosnacht *et al*., (2017), the rate of return for a survey is usually 20-25%. 200 respondents will be approached based on a 30-response rate, which is considered high.

3.6 Data Analysis

Quantitative data analysis involves systematically examining, interpreting, and drawing meaningful conclusions from numerical data using statistical methods and computational techniques. In this study, data collected from the survey were analyzed using IBM SPSS Statistics Version 20.

Before the main analysis, a mean score analysis was conducted to determine the importance of each variable relative to the others. Variables with mean scores greater than or equal to the hypothesized mean of 3.0 were considered significant based on one-sample t-test analysis at a 95% confidence level.

To validate the hypotheses, multiple regression was employed to determine the direct impact of the five independent variables (Altruism, Conscientiousness, Sportsmanship, Civic Virtue, Courtesy) on the adoption of C4.0 technology. This regression analysis helps in understanding how the independent variables influence the adoption of C4.0 technology.

4. Results

4.1 Demographic Background

A survey was distributed to 200 G7 contractors via email and LinkedIn, achieving a 30.00% response rate with 60 responses collected over one month (April 15, 2024 - May 15, 2024). The survey's demographic analysis revealed a predominant male representation (93.3%). The majority occupy general employee positions (58.33%). In terms of experience, 46.67% have 1-5 years of working experience. Building Information Modelling (BIM) was the most widely used construction technology (78.1%), followed by Prefabrication & Modular Construction (40.6%) and Internet of Things (IoT) (31.3%).

Table 2 *General Information of Respondents*

Aspect	Categories	n	%
Gender	Male	56	93.3
	Female	4	6.7
Job Position	Middle Managers and above	25	41.7
	General Employee	35	58.3
Years of experience	< 1 year	2	3.3
	1 – 5 years	28	46.7
	6 – 10 years	17	28.3
	Above 10 years	13	21. 7
Type of Construction Technology Used	BIM	50	78.1
	Prefabrication & Modular Construction	26	40.6
	IoT	20	31.3
	Cloud & real-time collaboration	19	29.7
	Advanced Building Material	17	26.9
	Artificial Intelligence	13	20.3
	AR & VR	9	14.1
	Big Data & Predictive Analysis	6	9.4
	3D Scanning & Photogrammetry	5	7.8
	3D Printing & Additive Manufacturing	4	6.3
	Autonomous Construction	4	6.3
	Blockchain	1	1.6

4.2 Reliability Test

The reliability of the questionnaire, which uses a Likert scale, was assessed using SPSS software. A reliability test, specifically Cronbach's alpha, was conducted to validate the accuracy of the data collection method. Cronbach's alpha ranges from 0 to 1, with values above 0.6 considered indicative of reliable instruments (Mubarak, 2017). Seven reliability tests were performed using SPSS, and all variables exhibited Cronbach's alpha values exceeding 0.6, confirming the questionnaire's reliability. Specifically, the OCB indicators showed strong reliability with the following alpha values: Altruism (0.760), Conscientiousness (0.735), Sportsmanship (0.864), Civic Virtue (0.711), and Courtesy (0.800). For the Technology Adoption constructs, Perceived Usefulness (PU) had a Cronbach's alpha of 0.837, and Perceived Ease of Use (PEOU) had 0.817, both indicating high reliability. These results affirm that the measures are consistent and reliable, providing a robust foundation for further analysis.

Table 3 *Reliability Test Results*

Variable	Cronbach's Alpha	Reliability
OCB Indicator – Altruism	0.760	Reliable
OCB Indicator – Conscientiousness	0.735	Reliable
OCB Indicator – Sportsmanship	0.864	Reliable
OCB Indicator – Civic Virtue	0.711	Reliable
OCB Indicator – Courtesy	0.800	Reliable
Technology Adoption – PU	0.837	Reliable
Technology Adoption – PEOU	0.817	Reliable

4.3 Ranking of Key OCB Indicator relevant to Construction 4.0 adoption

The questionnaire survey for this research included sixteen Likert-scale questions on key OCB indicators. Analysis of the mean values for these indicators revealed that Civic Virtue had the highest mean score (4.106), reflecting frequent and consistent behaviors. Courtesy followed with a mean of 4.094, indicating high frequency but slightly more variability. Conscientiousness ranked third with a mean of 4.078 and a standard deviation of 0.570. Altruism was fourth with a mean of 3.879 and a standard deviation of 0.565. Sportsmanship had the lowest mean score (3.372) and the highest variability (SD = 0.819), suggesting it is the least frequently exhibited and most variable behavior among participants. The following section will provide a detailed ranking of each indicator.

Table 4 *Key OCB Indicator relevant to Construction 4.0 adoption*

Key OCB Indicators	Mean	SD	Rank
Civic Virtue	4.106	.493	1
Courtesy	4.094	.598	2
Conscientiousness	4.078	.570	3
Altruism	3.879	.565	4
Sportsmanship	3.372	.819	5

4.4 Correlation Analysis

Relationship between OCB and adoption of Construction 4.0 technology

The correlation analysis reveals that Altruism, Conscientiousness, Civic Virtue, and Courtesy significantly and positively impact both PU and PEOU of construction technology. Altruism (r = 0.586 for PU, r = 0.593 for PEOU) and Civic Virtue (r = 0.458 for PU, r = 0.616 for PEOU) show powerful correlations. Conscientiousness and Courtesy also demonstrate notable positive correlations with both PU and PEOU. Sportsmanship, however, only significantly correlates with PU (r = 0.383) and not with PEOU, suggesting its limited influence on PEOU. These findings underscore the importance of these OCB dimensions in enhancing construction technology's perceived effectiveness and usability.

Table 5 *Mean, standard deviation and Pearson correlation matrix for continuous variables (n=60)*

Variable	Mean	SD	1	2	3	4	5	6	7
1.Altruism	3.879	.565	1						
2.Conscientiousness	4.078	.570	.587**	1					
3.Sportsmanship	3.372	.819	.261*	.171	1				
4.Civic Virtue	4.106	.493	.752**	.593**	.078	1			
5.Courtesy	4.094	.598	.553**	.486**	.169	.655**	1		
6.PU	4.150	.674	.586**	.315*	.383**	.458**	.364**		-
7.PEOU	3.791	.692	.593**	.482**	.219	.616**	.386**	-	1

** Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

4.5 Multiple Regression Analysis

1)OCB and PU

The multiple regression analysis explores the relationship between various OCB dimensions and the PU of C4.0 technologies. The model indicates that the five OCB dimensions collectively explain 35.5% of the variance in PU, which adjusts to 35.5% when accounting for the number of predictors. Among the dimensions, only Altruism has a statistically significant positive effect on PU (β=0.458, p<0.01), suggesting that higher levels of altruism among employees are linked to greater perceived usefulness of these technologies. The other dimensions—Conscientiousness, Sportsmanship, Civic Virtue, and Courtesy—do not significantly affect PU. This implies that, while the overall model moderately explains PU, only altruism significantly enhances the perceived utility of Construction 4.0 technologies, highlighting the importance of fostering altruistic behaviors in the workplace.

Table 6 *Model Summary for OCB and PU*

Model	R	R Square	Adjusted R square	Std.Error of the Estimate
1	.640[a]	.410	.355	.54083

a. Predictors: (Constant), Courtesy, Sportsmanship, Conscientiousness, Altruism, Civic Virtue

Table 7 *Multiple Regression Analysis result for OCB and PU*

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std.Error	Beta	t	Sig
1	(Constant)	.884	.664		1.331	.189
	Altruism	.547	.205	.458	2.675	.010
	Conscientiousness	-.103	.161	-.087	-.641	.525
	Sportsmanship	.218	.092	.265	2.379	.210
	Civic Virtue	.176	.253	.129	.695	.490
	Courtesy	.027	.159	.024	.168	.867

Significant level p≤0.01

2)OCB and PEOU

The multiple regression analysis examines the relationship between various OCB dimensions and the PEOU of C4.0 technologies. The model indicates that the five OCB dimensions collectively explain 39.4% of the variance in PEOU, which adjusts to 39.4% when accounting for the number of predictors. Among the dimensions, only Civic Virtue has a statistically significant positive effect on PEOU (β=0.437, p<0.05), suggesting that higher levels of civic virtue among employees are linked to greater PEOU of these technologies. The other dimensions—Altruism, Conscientiousness, Sportsmanship, and Courtesy—do not significantly affect PEOU, implying that their influence on ease of use is not substantial within this model.

Table 8 *Model Summary for OCB and PEOU*

Model	R	R Square	Adjusted R square	Std.Error of the Estimate
1	.667[a]	.445	.394	.53908

a. Predictors: (Constant), Courtesy, Sportsmanship, Conscientiousness, Altruism, Civic Virtue

Table 9 *Multiple Regression Analysis result for OCB and PEOU*

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std.Error	Beta	t	Sig
1	(Constant)	-.243	.662		-.367	.715
	Altruism	.263	.204	.214	1.289	.203
	Conscientiousness	.150	.160	.124	.939	.352
	Sportsmanship	.105	.091	.124	1.153	.254
	Civic Virtue	.614	.252	.437	2.437	.018
	Courtesy	-.116	.159	-.101	-.732	.467

Significant level $p \leq 0.05$

4.6 Relationship between OCB and Construction 4.0 adoption

The multiple regression analysis reveals that among the OCB dimensions, only Altruism significantly impacts the PU of Construction 4.0 technologies, with a positive effect (B = 0.547, p = 0.010). This suggests that employees who voluntarily assist their colleagues are more likely to find the technology useful. The model explains 35.5% of the variance in PU, highlighting the importance of altruistic behaviors in enhancing technology perception.

Similarly, Civic Virtue significantly impacts PEOU of C4.0 technologies (B = 0.614, p = 0.018). Employees actively involved in organizational affairs find the technology more accessible to use, contributing to a supportive and adaptive work environment. The model accounts for 39.4% of the variance in PEOU, underscoring Civic Virtue's role in facilitating technology adoption.

These findings emphasize the need to foster altruism and civic virtue in the workplace to enhance the adoption and effective use of C4.0 technologies.

Table 10 *Hypothesis Result*

Hypothesis Testing	Multiple Regression test	Result
H1a	Significant	Accepted
H1b	Insignificant	Rejected
H2a	Insignificant	Rejected
H2b	Insignificant	Rejected
H3a	Insignificant	Rejected
H3b	Insignificant	Rejected
H4a	Insignificant	Rejected
H4b	Significant	Accepted
H5a	Insignificant	Rejected
H5b	Insignificant	Rejected

5. Discussion

This study evaluates five key OCB indicators in the context of C4.0 adoption, identifying Civic Virtue, Courtesy, and Conscientiousness as the most critical. Civic Virtue, emphasising proactive involvement and responsibility, is essential for successful technology integration. Courtesy fosters a harmonious work environment, facilitating effective technology use, while Conscientiousness, involving going beyond role expectations, is crucial for mastering and efficiently using advanced technologies. In contrast, Sportsmanship and Altruism were less impactful, likely due to the specific limitation in C4.0 technologies adoption. Construction organization could be new to technology adoption where the organization has not been fully embraced to the new technology. Thus, fostering Civic Virtue, Courtesy, and Conscientiousness is confirmed to be vital (mean value 4.04.10) for effective Construction 4.0 adoption.

This research identified two most important results. First, the results demonstrate that the first hypothesis H1a was accepted, showing a significant positive relationship between Altruism and PU. Promoting helping behaviour among employees enhances their perception of technology's usefulness, as altruistic behaviours facilitate collaborative problem-solving and knowledge-sharing within the organization. This aligns with prior research, which highlights Altruism's role in creating a supportive work environment that accelerates learning and reinforces the practical value of new technologies (Turnipseed & Rassuli, 2005; Haider *et al*., 2017; Podsakoff *et al*., 1997). In the construction sector, fostering altruistic behaviours can significantly enhance the PU of technology, leading to improved operational efficiency. When employees assist each other, they provide accessible, peer-to-peer support that makes the technology more practical in daily operations. This environment encourages those struggling with technology to seek help, reducing frustration and increasing proficiency. As more employees become comfortable with the technology, productivity improves, reinforcing its usefulness and facilitating successful integration.

While Altruism significantly influences PU, other OCB dimensions—such as Conscientiousness, Sportsmanship, Civic Virtue, and Courtesy did not show a significant impact in this context. This may be due to the inherent complexities of construction technology, where its benefits are often recognized only after users gain sufficient experience with it. Altruistic behaviors play a crucial role in this learning process, making the technology easier to understand and use. Other OCB dimensions might not directly influence PU because they do not immediately address the challenges of technology adoption, though they could still be valuable in the broader context of organizational success, potentially requiring different conditions or timeframes to manifest their impact on PU.

Second, the study reveals that hypothesis H4b was accepted, showing a significant positive relationship between Civic Virtue and PEOU. This finding suggests that employees who are actively involved in organizational affairs and demonstrate responsible behavior tend to find technology easier to use. The positive impact of Civic Virtue on PEOU aligns with prior research, which emphasizes its role in promoting organizational outcomes and facilitating innovation adoption (Podsakoff *et al*., 1997; Yoon, 2009). In the context of C4.0, where swift adaptation and the development of new competencies are crucial, fostering Civic Virtue among employees can accelerate technology adoption and create a supportive work environment conducive to continuous learning and innovation. Employees with high levels of Civic Virtue significantly enhance PEOU by actively participating in organizational initiatives and committing to shared goals. This proactive approach to learning fosters a work environment where the entire workforce becomes proficient with new technologies, ensuring efficient and effective operations without over-reliance on a few individuals.

Conversely, the lack of significant effects for OCB dimensions like Conscientiousness, Sportsmanship, and Courtesy in the regression model may be due to the specialized knowledge and skills required to operate construction technology effectively. While these behaviors are valuable, they may not directly enhance PEOU because they do not inherently drive proactive learning or engagement with new technology. Civic Virtue's significant impact on PEOU could be attributed to the proactive and engaged nature of employees who exhibit this behavior, making them better equipped to navigate complex technologies. Although other OCB dimensions might contribute indirectly by fostering a positive work environment, their impact on PEOU may require additional factors, such as formal training, to be fully realized.

6. Conclusion

This research analyzes the role of OCB in adopting Construction 4.0 technologies in construction firms. Adopting from previous study, the study identifies five key OCB indicators: civic virtue, courtesy, conscientiousness, sportsmanship, and altruism, highlighting civic virtue, courtesy, and conscientiousness as the most crucial for successful technology implementation. The top three important indicators are Civic Virtue, Courtesy, and Conscientiousness. Altruism significantly enhances the PU of technology, while civic virtue significantly improves PEOU. This study contributes to the understanding of OCB and its role in adopting C4.0 technology, extending current knowledge on how specific OCB dimensions influence PU and PEOU of new technologies. The findings offer a nuanced perspective on the relationship between OCB and technology adoption, highlighting significant and insignificant effects.

7. Contribution

This research makes significant practical and theoretical contributions by identifying key OCB indicators related to the adoption of construction technology and exploring their relationships with technology adoption. It reveals that Civic Virtue, Courtesy, and Conscientiousness are crucial behaviors for technology adoption, with altruism significantly correlating with PU and civic virtue with PEOU. These findings help organizations foster behaviors that support technology implementation. The study advances theoretical understanding by providing empirical evidence of the direct influence of specific OCB traits on technology perceptions, filling a gap in existing literature and offering new perspectives for future research. This dual contribution aids organizational leaders in creating environments conducive to technology adoption through targeted OCB development.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Wee Wan Li and Mastura Jaafar;* ***data collection:*** *Wee Wan Li;* ***analysis and interpretation of results:*** *Wee Wan Li;* ***draft manuscript preparation:*** *Wee Wan Li and Mastura Jaafar. All authors reviewed the results and approved the final version of the manuscript.*

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