

## Research Article

# Mediating Effect of Construction Industry Development on Workforce Diversity and Technology Adoption: Evidence from Iraq

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| Article Info                  | Abstract                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
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| Article History               | Infrastructure projects in Iraq encounter multiple challenges, including inefficient workforce diversity (WD) management, shortages in technical skills, and technological gaps, which can directly affect productivity and project success. Under such circumstances, examining the way WD influences technology adoption (TA) and the mediating role of construction industry development (CID) becomes particularly noticeable. Therefore, this study aimed to elucidate these relationships and provide practical insights into improving project performance. Using an exploratory mixed-method approach, qualitative data were collected through semi-structured interviews with industry experts and then analyzed using thematic analysis. The findings of this stage revealed that the cultural, linguistic, and professional dimensions of CID can simultaneously present opportunities for innovation and challenges for coordination and management. In the quantitative phase, structural equation modeling was employed to test the research hypotheses. The results confirmed that CID strengthens the relationship between WD and TA, suggesting that this mediating variable can provide a platform for improving diversity management and facilitating TA. Accordingly, policymakers and project managers must adopt comprehensive strategies to enhance workforce capabilities and institutional infrastructure, thereby promoting productivity and sustainability in infrastructure projects. |
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| Construction Industry         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Karbala International Airport |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Diversity                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Project Management            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Mixed Method                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Structural Equation Modeling  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |



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## 1. Introduction

As the backbone of economic and social development, the construction industry now stands at the forefront of confronting multifaceted global crises, ranging from climate change and resource scarcity to mounting pressures for infrastructure upgrades [1]. In this context, the acceleration of globalization and the penetration of transformative technologies have disrupted traditional industry paradigms, rendering a fundamental rethinking of human resource management (HRM) models, production capacity enhancement, and intelligent technology integration a strategic necessity [2].

Among the variables influencing the competitiveness of the construction industry, workforce diversity (WD) has emerged as a prominent factor encompassing a wide range of individual and collective differences, including age, gender, experience, nationality, and culture [3, 4]. Some studies have shown that well-managed diversity can foster creativity, improve decision-making quality, and facilitate the adoption of modern technologies [5, 6]. However, this relationship is often nonlinear, multicausal, and highly dependent on the organizational context [7], thereby raising new questions about the conditions and mechanisms through which diversity truly influences technology-driven project performance.

Despite the growing significance of modern technologies, such as building information modeling (BIM), automated systems, and intelligent sensors, the construction industry continues to face substantial lags in technology adoption (TA) in many countries, particularly Iraq. This lag stems from a combination of structural and behavioral factors, including insufficient digital infrastructure, limited investment in research and development, cultural resistance to change, and weak integration of human skills with technological capabilities [8, 9]. In addition, the outcome of this gap is reduced productivity, diminished competitiveness, and slower modernization of infrastructure projects, which, in turn, act as additional barriers to thoroughly leveraging the potential benefits of WD.

Construction industry development (CID) is one potential mechanism that can shape the link between WD and TA. CID is a dynamic process that not only provides the technical and managerial infrastructure necessary for effectively utilizing human diversity but also establishes institutional foundations for embedding innovation and fostering knowledge synergies [10-13].

Despite the growing evidence on the benefits and challenges of diversity management [14-16], a clear gap remains in the academic literature. To the best of our knowledge, no study has yet systematically examined how CID might function as a mediating variable that shapes the strength and direction of WD's impact on TA [17]. On the other hand, the bulk of existing studies have focused on organizational, economic, and cultural barriers, with comparatively less attention paid to the structural and institutional capacities of the industry to facilitate this process [7, 8].

This theoretical gap becomes even more critical in contexts such as Iraq, where the construction industry encounters a combination of underdeveloped infrastructure, slow technology absorption, and inefficiencies in HRM systems [8, 18]. In such circumstances, understanding whether and how industry development can serve as a key mechanism for activating the positive effects of diversity on TA is not merely an academic question but also a practical imperative for policymakers and infrastructure project managers.

Accordingly, this study seeks to address the following fundamental research question:

*Can CID function as a mediating variable that strengthens and explains the relationship between WD and TA in the infrastructure projects of Iraq?*

## 2. Literature Review

### 2.1. Workforce Diversity in the Construction Industry

Workforce Diversity, as a significant dimension of human capital, has increasingly attracted the attention of researchers and practitioners in the construction industry over recent decades [19]. This concept encompasses various dimensions, including age, gender, ethnicity, experience, education, nationality, and cognitive styles [3, 15]. When effectively managed, diverse teams can lead to improved decision-making, enhanced creativity, reduced conflicts, and increased productivity in projects [4, 5].

For instance, the study by Yan et al. on the Australian construction industry revealed that diversity in age and experience has a direct effect on labor productivity [20]. By leveraging diversity and inclusion, the construction industry could minimize the growing shortage of skilled labor it has been facing, thereby enhancing its capacity for innovation and productivity [3].

In addition, systematic reviews by Almeida et al. and Özbilgin et al. elaborated on the managerial dimensions of diversity in organizations. They addressed the challenges of implementing inclusion policies in traditional industries [21, 22].

However, the significance of WD is not limited solely to performance outcomes. Recent literature highlights that diversity can specifically act as a catalyst for TA. On the one hand, cognitive and cultural diversity can foster multiple perspectives while reducing decision-making biases; thus, they play a critical role in assessing technological risks and selecting innovative tools [16, 23]. On the other hand, the presence of employees from diverse backgrounds increases the likelihood of having individuals with digital literacy or prior experience with advanced technologies, thereby decreasing organizational resistance to TA [6, 24]. Recent research has further indicated that organizations with higher levels of diversity tend to demonstrate a stronger inclination toward utilizing innovative and digital technologies, as they are more exposed to environmental pressures for innovation and change [14]. In other words, diversity serves as a socio-cognitive platform that enhances an organization's capacity for technological learning and innovation absorption [25].

Nonetheless, WD still faces several obstacles, including unconscious biases, patriarchal organizational structures, and cultural misalignments in multinational projects [16, 20]. These challenges underscore the need to explore the relationship between diversity and other performance-related variables (e.g., TA) in greater depth.

### 2.2. Technology Adoption in Construction Projects

Technology Adoption is considered a critical factor in improving efficiency, safety, and innovation in construction projects [9, 12]. Despite the numerous advantages of advanced technologies (e.g., industrialized construction, smart sensors, and information management systems), the level of TA remains

low in many countries [2, 13].

According to the findings of Chen et al., in recent years, the growing inclination toward the use of modern construction methods and advanced technologies has driven organizations in the sector to adopt innovative approaches aimed at enhancing performance. A systematic review of 175 articles (2001–2020) conducted in accordance with the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses identified 26 distinct technologies categorized into five main groups (i.e., data collection, analysis, visualization, communication, and automated design and construction). Among them, digital technologies—particularly in the areas of data collection and visualization—have been recognized as key drivers of innovation, offering numerous benefits (e.g., increased productivity, improved safety, enhanced quality, and strengthened sustainability). BIM emerged as the most frequently identified technology, often integrated with complementary tools, such as drones, geographic information systems, light detection and ranging, and multidimensional modeling. The study emphasizes the necessity for a comprehensive cultural transformation, a reevaluation of business models, and structural reforms in various areas, including legislation, education, contracting, and procurement systems [12].

On the economic front, Bigdellou and Chen reported that high initial investment costs and uncertainty about the return on investment are significant barriers to the adoption of new technologies [7]. Likewise, Yousif et al. explored the digitalization of the construction industry and noted that, despite project managers' interest in innovation, inadequate infrastructure, insufficient training, and lack of supportive regulations constitute serious obstacles to TA [8]. These findings underscore the importance of organizational and contextual factors (e.g., industrial development) in facilitating the TA process.

Amid these discussions, growing evidence suggests that WD can serve as a facilitating factor in TA. For instance, Khan et al. demonstrated that combining WD with a culture of organizational learning has a positive impact on technological innovation and organizational performance [6]. Similarly, Odazie et al. emphasized that management approaches grounded in inclusion and diversity provide more effective pathways for deploying advanced technologies in construction organizations [23]. Therefore, TA is not only influenced by economic and institutional conditions but also significantly by the social and cognitive capital derived from WD.

### **2.3. Importance of Construction Industry Development**

Construction Industry Development is a multidimensional process that involves process improvement, innovation integration, human resource enhancement, and the adoption of advanced technology [13]. It is noteworthy that this development not only improves technical infrastructure but also enhances managerial capacity and workforce competencies [26].

Rosa et al. found that innovation in processes and products, mediated by organizational innovation, could significantly improve the performance of the construction industry in Spain [11]. Likewise, Aghimien

et al. (in their study on the impacts of the Fourth Industrial Revolution) underlined the role of technological and digital advancements in redefining the requirements for industrial development [27].

In the context of developing countries, CID can serve as a suitable platform for linking WD to innovation and technology. Opportunities for leveraging diverse employee capabilities can be expanded by improving formal structures, education and empowerment systems, and participatory policies [17].

According to the literature review, although considerable research exists on WD and TA, the structural relationship between these two variables, particularly considering the mediating role of CID, has received limited comprehensive attention. Hence, this study aims to fill this gap by using a mixed-method approach to analyze the mediating mechanisms of industrial development in the interaction between WD and TA in infrastructure projects.

Despite the growing body of research on the TA in the construction industry, a review of the literature reveals that most previous studies have primarily focused on the technical and functional dimensions of these technologies [16, 17]. On the other hand, institutional, social, and contextual dimensions, particularly in developing countries and unique environments such as Iraq, have received comparatively less attention. Furthermore, most existing investigations have concentrated on limited case studies or small statistical samples, which pose challenges to the generalizability of their results [23, 24]. Moreover, the literature has rarely examined the role of political factors and weak regulatory institutions as key barrier factors that exert a direct and decisive influence on the process of adopting modern technologies within the construction industry of Iraq [8].

Accordingly, the primary research gap in this field stems from the absence of a comprehensive and context-specific analysis that simultaneously addresses the technical, institutional, and social dimensions within the framework of the construction projects in Iraq. The present study has been specifically designed to fill this gap by integrating empirical and analytical approaches to provide a clearer understanding of the multilayered and complex barriers to the adoption of modern technologies in Iraq's construction sector.

### 3. Methodology

This study employed a sequential exploratory mixed-methods approach (qualitative and quantitative) to provide an in-depth understanding of the relationship between WD and TA in infrastructure projects, while considering the mediating role of CID [28].

First, qualitative data were gathered through conducting semi-structured interviews with 20 experts, including site engineers, project managers, and senior professionals involved in the construction of the Karbala International Airport (Table 1). Due to its multinational structure, high cultural diversity, and use of advanced technologies, this project provided a suitable context for exploring human interactions, industry development dynamics, and TA processes. This research aimed to identify perceptions,

experiences, opportunities, and challenges associated with the influence of WD on technology adoption, as well as the facilitating role of development in the construction industry.

A snowball sampling method was employed, and interviews continued until theoretical saturation was reached [29]. The interview protocol was structured around four core themes: (1) experiences with WD, (2) the role of CID, (3) TA challenges and drivers, and (4) interactions among these components.

The required data were analyzed using Braun and Clarke's thematic analysis framework [29], supported by MAXQDA 24 software. This process led to the identification of three main themes: (a) WD, (b) CID, and (c) TA. Notably, CID emerged as a key intervening factor in the TA process. Additionally, member checking and peer debriefing were employed to enhance the trustworthiness of the findings.

These insights formed the basis for designing the initial conceptual model and the instrument for the quantitative phase.

**Table 1.** Demographic characteristics of the interviewees.

| Row | Interviewee Position            | Work Experience | Education Level   | Nationality | Sector             |
|-----|---------------------------------|-----------------|-------------------|-------------|--------------------|
| 1   | Project consultant manager      | 35              | Master's degree   | Iraqi       | Consulting company |
| 2   | Construction manager            | 10              | Master's degree   | Turkish     |                    |
| 3   | Planning engineer               | 7               | Bachelor's degree | Pakistan    |                    |
| 4   | Consulting engineer             | 30              | Bachelor's degree | Portugal    |                    |
| 5   | Project management office       | 3               | Bachelor's degree | Iraqi       |                    |
| 6   | Supervising engineer            | 10              | Master's degree   | Iraqi       |                    |
| 7   | Consulting engineer             | 10              | Master's degree   | Iraqi       |                    |
| 8   | Project management office       | 2               | Bachelor's degree | Iraqi       |                    |
| 9   | Project management office       | 12              | Bachelor's degree | Iraqi       |                    |
| 10  | Project contractor manager      | 20              | Master's degree   | Iraqi       |                    |
| 11  | Assistant engineer              | 1               | Bachelor's degree | Iraqi       | Contractor company |
| 12  | Project management office       | 5               | Bachelor's degree | Iraqi       |                    |
| 13  | Project implementation engineer | 4               | Master's degree   | Iraqi       |                    |
| 14  | Project implementation engineer | 15              | Master's degree   | Iraqi       |                    |
| 15  | Project implementation engineer | 6               | Bachelor's degree | Iraqi       |                    |
| 16  | Project implementation engineer | 4               | Master's degree   | Iraqi       |                    |
| 17  | Project implementation engineer | 5               | Bachelor's degree | Iraqi       |                    |
| 18  | Project client manager          | 10              | Master's degree   | Iraqi       | Employer company   |
| 19  | Project management office       | 7               | Bachelor's degree | Iraqi       |                    |
| 20  | Project management office       | 2               | Bachelor's degree | Iraqi       |                    |

In the second phase, a structured questionnaire was developed based on the qualitative findings and designed using a five-point Likert-type scale. The face validity and content validity of this questionnaire

were reviewed and refined with inputs from experts in project management and human resources.

Then, the questionnaires were distributed to projects either implemented by international companies or managed by Iraqi firms employing foreign experts and engineers alongside local specialists. The target population consisted of engineers, project managers, consultants, and academic faculty members with experience in international construction projects. A total of 700 questionnaires were distributed and collected online. The quantitative data were analyzed using structural equation modeling (SEM) with specialized software to examine the mediating role of CID in the relationship between WD and TA.

Overall, the combination of in-depth qualitative analysis with quantitative causal testing facilitated the identification of key influencing factors and enabled the development of a testable theoretical model, thereby enhancing the generalizability of our findings.

#### 4. Results

Braun and Clarke's thematic analysis framework [29], facilitated by the MAXQDA 24 software (version), was utilized to analyze the qualitative data obtained from the interviews. This approach enabled the systematic organization of data and provided a profound and theoretical understanding of the phenomenon under investigation.

The analysis process included six main steps:

1. Becoming familiar with the data: To ensure that the researcher has obtained a comprehensive understanding of the content and is prepared for coding, all interview transcripts were read and reviewed multiple times.
2. Generating initial codes: Meaningful statements and phrases were extracted, resulting in over 100 initial codes that provided the foundation for subsequent analyses.
3. Searching for themes: Similar codes were grouped into categories, forming the basis for preliminary themes.
4. Reviewing themes: Preliminary themes were compared against the raw data and aligned with the research objectives to ensure their validity and coherence.
5. Defining and naming themes: Each theme was assigned a descriptive label that accurately reflected its content and conceptual boundaries.
6. Producing the report: The final themes were described and interpreted using illustrative quotations from participants, and the results of the thematic analysis were systematically reported [29].

This analytical process facilitated the identification of conceptual patterns and the relationships among WD, CID, and TA (Table 2). In addition, the findings of the thematic analysis formed the basis for developing an integrated causal model, providing a foundation for empirical testing and future research in the field of HRM and technology in infrastructure projects (Figure 1).

**Table 2.** Thematic categories, sub-themes, and their descriptions in data analysis.

| Main Theme | Related Sub-Themes                                                                                                                                                       | Theme Description                                                                                                                                                                  |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| WD         | Level of diversity acceptance<br>Demographic diversity<br>Professional and skill diversity<br>Cultural and linguistic diversity<br>Thinking styles and work perspectives | This category refers to the diversity of human resource characteristics within construction projects, which can influence collaboration, creativity, and communication challenges. |
| CID        | Modernization of construction technologies<br>Improvement of managerial systems<br>Enhancement of resource productivity<br>Alignment with market and key stakeholders    | This category addresses the level of advancement, infrastructure, and the construction industry's readiness to adapt to new technologies and enhance overall project performance.  |
| TA         | Organizational readiness for TA<br>Individual characteristics of the workforce<br>Organizational culture and psychology<br>Technological training and learning           | This category pertains to factors affecting the speed and quality of new TA in projects, encompassing both individual and organizational levels.                                   |

Note. WD: Workforce diversity; CID: Construction industry development; TA: Technology adoption.

Based on the findings obtained from thematic analysis and the classification of conceptual categories, a theoretical model was developed to explain the causal relationships among three key constructs (i.e., WD, CID, and TA) within the context of infrastructure projects in Iraq. This model, grounded in concepts derived from qualitative interviews, provides a conceptual framework for understanding how dynamic workforce and industrial factors impact technological innovation in the construction industry.

In this model, WD is conceptualized as the independent variable. It encompasses multiple dimensions, including demographic differences (e.g., gender, age, and ethnicity), professional and skill diversity, cultural and linguistic variation, cognitive styles, and the overall level of tolerance and acceptance of differences. These aspects may serve as sources of creativity and innovation while also presenting challenges related to team cohesion and operational coordination.

Furthermore, CID acts as the mediating variable and plays a critical role in the model. This construct is defined through the modernization of construction technologies (1), improvement of managerial systems (2), optimization of resource utilization (3), and enhanced engagement with stakeholders (4). The level of development within the construction industry can either facilitate or hinder the influence of WD on TA. It is worth noting that the capacity to leverage a diverse workforce for innovative outcomes is significantly greater in more advanced industrial environments.

Finally, TA is positioned as the dependent variable. It includes elements such as organizational readiness, individual workforce characteristics, change-oriented organizational culture, and capabilities for technological learning. The findings suggest that the successful adoption of emerging technologies requires a synergistic interplay between human capacities and industrial infrastructure.

This conceptual model provides a solid foundation for conducting quantitative research, thereby enabling the testing of causal hypotheses among key variables. From a policy perspective, the proposed

model can further inform the design of managerial interventions aimed at optimizing the performance of construction projects in Iraq, particularly in contexts where WD is increasing and the industry is under pressure to adapt to technological change rapidly.

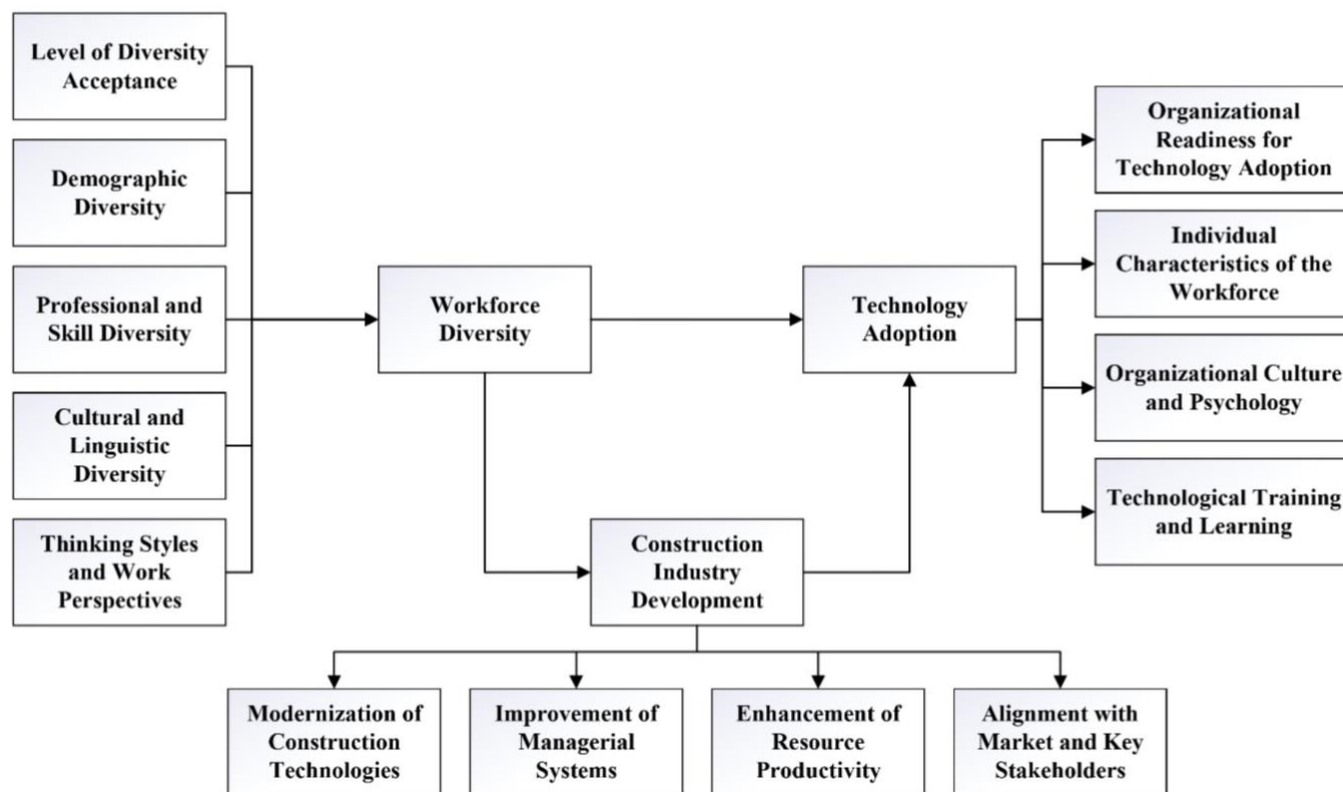


**Figure 1.** Conceptual model of the research. Source: Author of the present study.

Based on the suggested theoretical model, which includes three core variables (i.e., WD, CID, and TA), with CID acting as a mediating variable between the independent and dependent variables, research hypotheses can be formulated as follows:

*Hypothesis 1:* WD positively influences CID in infrastructure projects.

By providing a diverse range of skills, perspectives, and problem-solving approaches, WD enhances organizational innovation, which in turn positively impacts CID outcomes. Empirical evidence suggests that diverse teams demonstrate higher innovative performance and can generate creative solutions in projects [4].

*Hypothesis 2:* CID positively affects TA in infrastructure projects.

CID facilitates TA by providing necessary organizational processes, knowledge infrastructure, and openness to change. According to previous research, innovation and development in projects create the conditions and capabilities required for the successful implementation of new technologies [26].

*Hypothesis 3:* WD positively impacts TA in infrastructure projects.

By offering diverse technical expertise, cultural perspectives, and experiences, WD promotes

knowledge sharing and collaborative problem-solving, directly contributing to TA. These characteristics enable teams to recognize the value of new technologies and implement them effectively [30].

*Hypothesis 4:* CID mediates the effect of WD on TA in infrastructure projects.

Previous studies have supported the mediating role of CID in the relationship between WD and TA. Diverse teams enhance innovation, which in turn facilitates technology adoption through providing creative solutions and effective implementation strategies [31].

To develop the data collection instrument for this study, a systematic and scholarly process was undertaken under the guidance of two faculty members. The questionnaire was designed based on the key dimensions of the theoretical model, with particular attention given to ensuring conceptual clarity, structural coherence, and appropriateness for the characteristics of the target population. Then, the initial version of the questionnaire was reviewed and revised by the academic advisors to ensure the content validity and comprehensive coverage of the study variables.

During the implementation phase, the final version of the questionnaire was distributed to over 700 professionals active in the three main sectors of the construction industry (i.e., contractors, clients, and consultants) through both in-person and online methods. Efforts were made to include participants with diverse roles and responsibilities in order to obtain a comprehensive and multidimensional understanding of the industry context.

A total of 329 completed questionnaires were returned, representing a response rate of 47%. Such a participation rate in academic research is generally considered an indicator of the instrument's validity and the respondents' interest in the research topic. According to previous studies, response rates of 50% or higher are deemed acceptable for face-to-face surveys, and those of 44.1% or higher are considered acceptable for online surveys [32, 33]. The demographic information of the respondents (i.e., age, education, area of expertise, work experience, and sector of activity) is presented in Table 3.

In the quantitative data analysis, SmartPLS software (version 3) was employed to perform SEM. This method was chosen due to its capability to simultaneously analyze complex relationships among variables and multiple indicators per construct, thus enabling a more comprehensive interpretation of the data.

Convergent validity was assessed using average variance extracted and composite reliability. According to established standards, composite reliability values above 0.70 and average variance extracted values above 0.50 indicate acceptable convergent validity [34]. All constructs met these criteria (Table 4). Additionally, Cronbach's alpha coefficients for all constructs exceeded 0.70, reflecting acceptable internal consistency of the measurement instrument.

To further assess reliability, factor loadings were examined using the partial least squares (PLS) approach. Loadings above 0.40 were considered acceptable. The results (Table 4) indicated that the research instrument possesses sound psychometric properties.

**Table 3.** Demographic characteristics of respondents.

| Characteristic           | Category                  | Frequency (%) |
|--------------------------|---------------------------|---------------|
| <b>Age</b>               | < 30 years                | 107 (32.5)    |
|                          | 30-40 years               | 128 (38.9)    |
|                          | > 41 years                | 94 (28.6)     |
| <b>Total</b>             |                           | 329 (100)     |
| <b>Education level</b>   | Bachelor's degree         | 166 (50.5)    |
|                          | Master's degree           | 101 (30.7)    |
|                          | PhD                       | 62 (18.8)     |
| <b>Total</b>             |                           | 329 (100)     |
| <b>Specialization</b>    | Civil engineering         | 112 (34)      |
|                          | Architectural engineering | 47 (14.3)     |
|                          | Electrical engineering    | 87 (26.4)     |
|                          | Mechanical engineering    | 68 (20.7)     |
|                          | Other specializations     | 15 (4.6)      |
| <b>Total</b>             |                           | 329 (100)     |
| <b>Experience</b>        | < 5 years                 | 54 (16.4)     |
|                          | 5-10 years                | 82 (24.9)     |
|                          | 11-20 years               | 98 (29.8)     |
|                          | > 20 years                | 95 (28.9)     |
| <b>Total</b>             |                           | 329 (100)     |
| <b>Field of activity</b> | University professor      | 62 (18.8)     |
|                          | Execution sector          | 148 (45)      |
|                          | Employer sector           | 58 (17.6)     |
|                          | Consultant sector         | 61 (18.5)     |
| <b>Total</b>             |                           | 329 (100)     |

**Table 4.** The values of AVE, CR, and Cronbach's Alpha for the primary constructs of the study.

| Categories                                               | Cronbach's Alpha | rho_A | CR    | AVE   |
|----------------------------------------------------------|------------------|-------|-------|-------|
| Alignment with Market and Key Stakeholders (AMKS)        | 0.812            | 0.825 | 0.914 | 0.841 |
| Construction Industry Development (CID)                  | 0.908            | 0.910 | 0.926 | 0.609 |
| Cultural and Linguistic Diversity (CLD)                  | 0.778            | 0.781 | 0.900 | 0.818 |
| Demographic Diversity (DD)                               | 0.863            | 0.865 | 0.936 | 0.880 |
| Enhancement of Resource Productivity (ERP)               | 0.830            | 0.831 | 0.922 | 0.855 |
| Improvement of Managerial Systems (IMS)                  | 0.876            | 0.876 | 0.941 | 0.889 |
| Individual Characteristics of the Workforce (ICW)        | 0.861            | 0.869 | 0.935 | 0.877 |
| Level of Diversity Acceptance (LDA)                      | 0.732            | 0.737 | 0.882 | 0.789 |
| Modernization of Construction Technologies (MCT)         | 0.741            | 0.741 | 0.885 | 0.794 |
| Organizational Culture and Psychology (OCP)              | 0.742            | 0.742 | 0.886 | 0.795 |
| Organizational Readiness for _Technology Adoption (ORTA) | 0.819            | 0.821 | 0.917 | 0.847 |
| Professional and Skill Diversity (PSD)                   | 0.881            | 0.881 | 0.944 | 0.894 |
| Technological Training and Learning (TTL)                | 0.732            | 0.732 | 0.882 | 0.789 |
| Technology Adoption (TA)                                 | 0.890            | 0.897 | 0.912 | 0.567 |
| Thinking Styles and Work Perspectives (TSWP)             | 0.742            | 0.743 | 0.886 | 0.795 |
| Workforce Diversity (WD)                                 | 0.914            | 0.915 | 0.928 | 0.564 |

Note. AVE: Average variance extracted; CR: Composite reliability.

The Fornell and Larcker [35] matrix was used to examine divergent validity (Table 5).

**Table 5.** Divergent validity results.

|      | AMKS  | CID   | CLD   | DD    | ERP   | IMS   | ICW   | LDA   | MCT   | OCP   | ORTA  | PSD   | TTL   | TA    | TSWP  | WD    |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| AMKS | 0.917 |       |       |       |       |       |       |       |       |       |       |       |       |       |       | 0.751 |
| CID  | 0.812 | 0.781 |       |       |       |       |       |       |       |       |       |       |       |       |       | 0.892 |
| CLD  | 0.548 | 0.629 | 0.904 |       |       |       |       |       |       |       |       |       |       |       |       | 0.837 |
| DD   | 0.508 | 0.653 | 0.457 | 0.938 |       |       |       |       |       |       |       |       |       |       |       | 0.855 |
| ERP  | 0.608 | 0.831 | 0.579 | 0.635 | 0.924 |       |       |       |       |       |       |       |       |       |       | 0.806 |
| IMS  | 0.592 | 0.887 | 0.523 | 0.551 | 0.620 | 0.943 |       |       |       |       |       |       |       |       |       | 0.713 |
| ICW  | 0.494 | 0.665 | 0.496 | 0.479 | 0.667 | 0.551 | 0.937 |       |       |       |       |       |       |       |       | 0.612 |
| LDA  | 0.593 | 0.697 | 0.563 | 0.710 | 0.642 | 0.582 | 0.556 | 0.888 |       |       |       |       |       |       |       | 0.570 |
| MCT  | 0.581 | 0.865 | 0.485 | 0.515 | 0.583 | 0.785 | 0.542 | 0.544 | 0.891 |       |       |       |       |       |       | 0.818 |
| OCP  | 0.591 | 0.685 | 0.524 | 0.580 | 0.596 | 0.578 | 0.560 | 0.603 | 0.558 | 0.892 |       |       |       |       |       | 0.729 |
| ORTA | 0.563 | 0.702 | 0.587 | 0.596 | 0.713 | 0.569 | 0.661 | 0.650 | 0.533 | 0.607 | 0.920 |       |       |       |       | 0.662 |
| PSD  | 0.513 | 0.638 | 0.479 | 0.660 | 0.586 | 0.538 | 0.451 | 0.625 | 0.525 | 0.539 | 0.533 | 0.945 |       |       |       | 0.627 |
| TTL  | 0.595 | 0.697 | 0.564 | 0.705 | 0.642 | 0.582 | 0.557 | 1.000 | 0.543 | 0.605 | 0.649 | 0.623 | 0.888 |       |       | 0.856 |
| TA   | 0.653 | 0.804 | 0.637 | 0.652 | 0.769 | 0.668 | 0.835 | 0.704 | 0.638 | 0.853 | 0.856 | 0.612 | 0.704 | 0.753 |       | 0.606 |
| TSWP | 0.568 | 0.732 | 0.708 | 0.559 | 0.643 | 0.624 | 0.600 | 0.620 | 0.649 | 0.588 | 0.638 | 0.570 | 0.619 | 0.713 | 0.892 | 0.837 |
| WD   | 0.663 | 0.815 | 0.768 | 0.831 | 0.751 | 0.686 | 0.627 | 0.856 | 0.662 | 0.690 | 0.729 | 0.818 | 0.855 | 0.806 | 0.713 | 0.751 |

Note. AMKS: Alignment with market and key stakeholders; CID: Construction industry development; CLD: Cultural and linguistic diversity; DD: Demographic diversity; ERP: Enhancement of resource productivity; IMS: Improvement of managerial systems; ICW: Individual characteristics of the workforce; LDA: Level of diversity acceptance; MCT: Modernization of construction technologies; OCP: Organizational culture and psychology; ORTA: Organizational readiness for technology adoption; PSD: Professional and skill diversity; TTL: Technological training and learning; TA: Technology adoption; TSWP: Thinking styles and work perspectives; WD: Workforce diversity.

Based on the obtained data (Table 5), the values along the main diagonal of the matrix were higher than the off-diagonal values, indicating that each latent construct has the strongest correlation with its own indicators and significantly lower correlations with the indicators of other constructs. As a result, the model demonstrated satisfactory discriminant validity.

The PLS-SEM approach was employed, given the nature of the data and the presence of a mediating variable in the conceptual model. The analysis was conducted using SmartPLS (version 3), which is well-suited for examining complex relationships among variables and analyzing the effects of mediating constructs (Figure 2 and Figure 3).

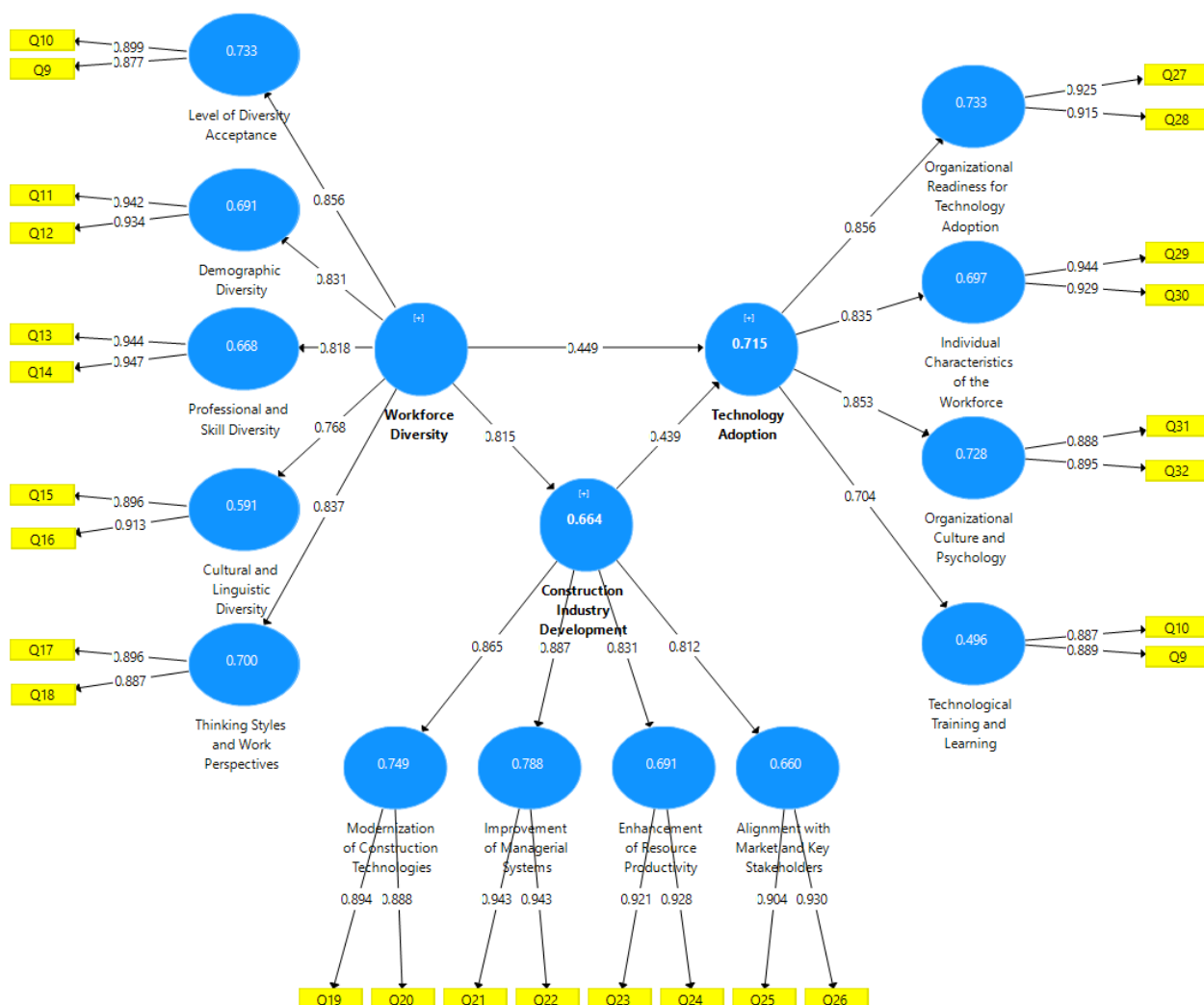


**Figure 2.** The research model with standardized factor loadings and path coefficients.

In this study, the conceptual model consisted of WD, CID, and TA as independent, mediating, and dependent variables, respectively. The model was evaluated using PLS-SEM.

First, the overall model fit was assessed using the coefficient of determination ( $R^2$ ). The  $R^2$  value for CID was 0.664, indicating that WD explains 66.4% of the variance in CID. Similarly, the corresponding value was 0.715 for TA, suggesting that the combination of WD and CID justifies 71.5% of the variance in TA. These values demonstrate a high predictive power and a good model fit.

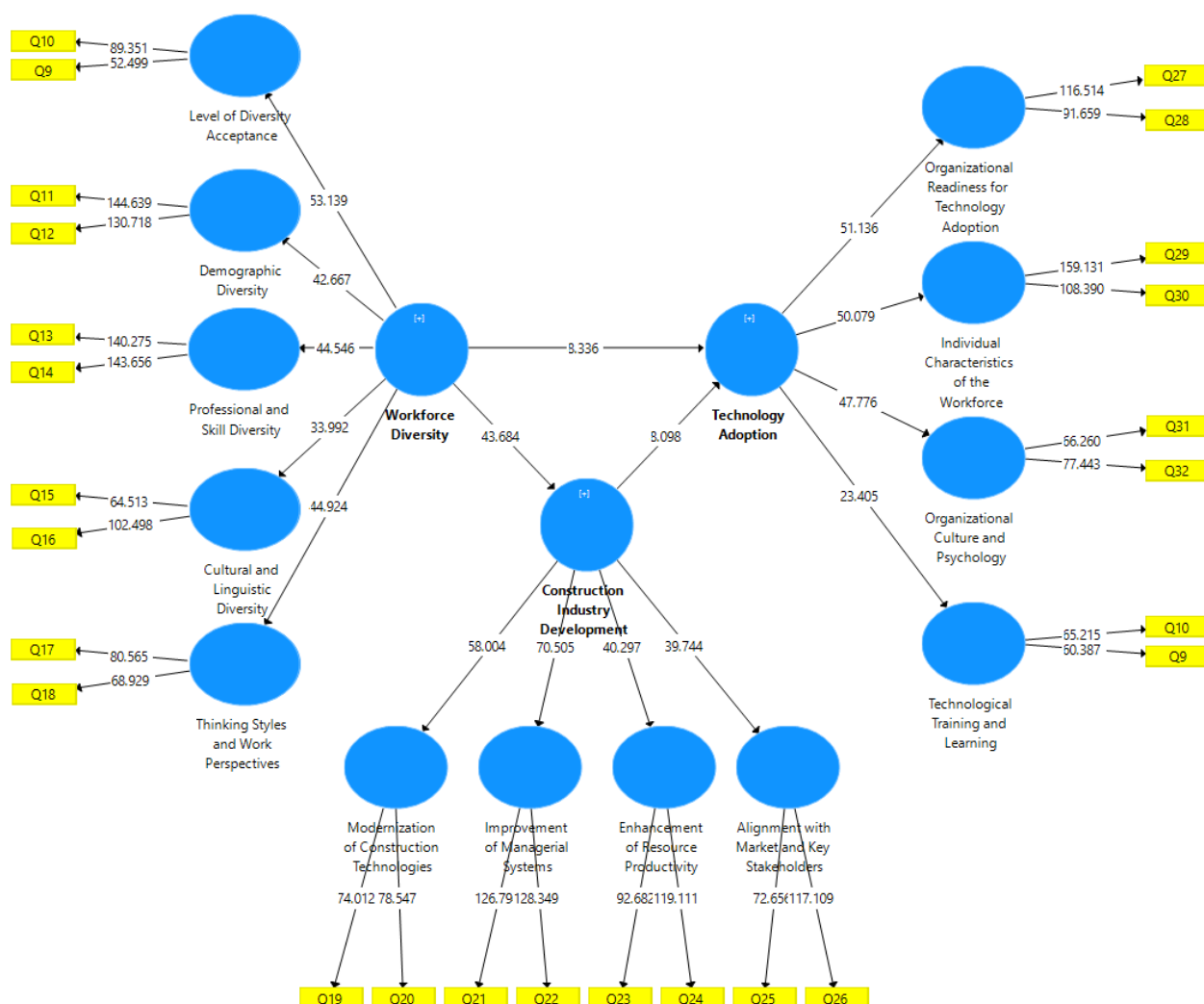


**Figure 3.** The research model with T-values.

Path analysis revealed that the direct effect coefficient of WD on TA was 0.449, representing the positive and significant direct impact of WD on TA. Moreover, the direct effect of WD on CID was 0.815, signifying the highly strong influence of WD on CID. The path coefficient from CID to TA was 0.439, highlighting the important role of industry development in enhancing the level of TA. In general, all path coefficients were statistically significant.

The indirect effects analysis confirmed that CID plays a notable mediating role in the relationship between WD and TA. The indirect effect of this path was estimated at 0.357, and the total effect was 0.806, implying a substantial increase in the impact of WD on TA through the CID.

An examination of the dimensions of each construct demonstrated the following results:

- For WD, the highest loading was found for “level of diversity acceptance” (factor loading = 0.856), followed by “thinking styles and work perspectives” and “demographic diversity”.
- Within CID, dimensions with the highest loading were “improvement of managerial systems” (factor loading = 0.887), “modernization of construction technologies”, and “enhancement of resource productivity”, respectively.

- In the TA construct, “organizational readiness for technology adoption” had the highest loading (factor loading = 0.856), followed by “organizational culture and psychology” and “individual characteristics of the workforce”.

These findings indicate that in infrastructure projects, CID can amplify the positive effects of WD on TA. In other words, leveraging the potential of a diverse workforce when coupled with process improvements, managerial system upgrades, technology modernization, and technological infrastructure establishment can considerably facilitate TA.

Therefore, policies and strategies that simultaneously focus on effective diversity management and capacity building in CID, as two key pillars, will pave the way for digital transformation in Iraq's infrastructure projects.

Based on the data (Figure 2 and 3), all factor loadings between the items and their corresponding latent variables exceeded 0.70, and t-values were greater than 1.96. The results revealed statistically significant relationships between the items and their respective constructs, representing a high level of validity.

**Table 6.** Results of structural and general model fit criteria.

|             | Original<br>Sample (O) | Sample Mean<br>(M) | Standard Deviation<br>(STDEV) | T Statistics<br>(O/STDEV) | P Values |
|-------------|------------------------|--------------------|-------------------------------|---------------------------|----------|
| CID -> AMKS | 0.812                  | 0.814              | 0.020                         | 41.034                    | 0.000    |
| CID -> ERP  | 0.831                  | 0.830              | 0.020                         | 41.540                    | 0.000    |
| CID -> IMS  | 0.887                  | 0.888              | 0.013                         | 69.166                    | 0.000    |
| CID -> MCT  | 0.865                  | 0.866              | 0.015                         | 58.978                    | 0.000    |
| CID -> TA   | 0.439                  | 0.445              | 0.052                         | 8.394                     | 0.000    |
| TA -> ICW   | 0.835                  | 0.837              | 0.016                         | 50.684                    | 0.000    |
| TA -> OCP   | 0.853                  | 0.854              | 0.018                         | 47.571                    | 0.000    |
| TA -> ORTA  | 0.856                  | 0.856              | 0.017                         | 50.548                    | 0.000    |
| TA -> TTL   | 0.704                  | 0.705              | 0.029                         | 24.402                    | 0.000    |
| WD -> CID   | 0.815                  | 0.815              | 0.020                         | 41.029                    | 0.000    |
| WD -> CLD   | 0.768                  | 0.768              | 0.024                         | 32.503                    | 0.000    |
| WD -> DD    | 0.831                  | 0.830              | 0.019                         | 44.201                    | 0.000    |
| WD -> LDA   | 0.856                  | 0.856              | 0.016                         | 54.642                    | 0.000    |
| WD -> PSD   | 0.818                  | 0.819              | 0.019                         | 43.953                    | 0.000    |
| WD -> TA    | 0.449                  | 0.444              | 0.051                         | 8.860                     | 0.000    |
| WD -> TSWP  | 0.837                  | 0.836              | 0.018                         | 46.467                    | 0.000    |

Note. AMKS: Alignment with market and key stakeholders; ERP: Enhancement of resource productivity; IMS: Improvement of managerial systems; MCT: Modernization of construction technologies; TA: Technology adoption; ICW: Individual characteristics of the workforce; OCP: Organizational culture and psychology; ORTA: Organizational readiness for technology adoption; TTL: Technological training and learning; CID: Construction industry development; CLD: Cultural and linguistic diversity; DD: Demographic diversity; LDA: Level of diversity acceptance; PSD: Professional and skill diversity; TSWP: Thinking styles and work perspectives; WD: Workforce diversity.

Moreover, the findings of the SEM confirmed the significance of the relationships among the key components of the proposed conceptual model in the context of WD in TA in the Iraqi construction industry (Table 6). The path analysis, conducted using t-statistics and p-values, supports the research hypotheses and clarifies the strength of the relationships among the variables. An analytical interpretation of the observed relationships is provided in the following section.

## 5. Discussion

Based on the testing conceptual model, the findings of this study offer an analytical perspective on the impact of WD on the TA, taking into account the mediating role of CID in Iraq. According to the results, WD, particularly in terms of cultural, gender, and age differences, could act as a significant driver of transformation and development within the construction industry, thereby creating the necessary foundation for the acceptance and utilization of new technologies. However, the effect of these variables was constrained by structural, institutional, and cultural barriers inherent to the Iraqi context, underscoring the need for a comparative analysis of the findings.

In the first stage, the findings indicated that WD, as the independent variable, holds substantial potential for enhancing the CID. Among the indicators of this component, the “level of diversity acceptance” demonstrated the highest factor loading, reflecting the decisive role of organizational and employee attitudes toward differences, whether in gender, ethnicity, language, age, or cultural background, in either enabling or inhibiting the positive impacts of diversity. In other words, the mere presence of a diverse workforce does not automatically guarantee improved performance or innovation [4]; rather, the degree to which such diversity is embraced within the organizational culture and workplace interactions serves as the critical factor in realizing its potential benefits [36].

These findings align with those of Cox and Blake, emphasizing the importance of “managing perceptions and attitudes toward diversity” as a prerequisite for leveraging its advantages [37]. Our results are also consistent with those of the study by Shore et al., which confirms that organizations adopting an active inclusionary approach experience markedly stronger positive effects of diversity on innovation and job satisfaction [38].

However, in the context of Iraq, evidence suggests that the level of acceptance of diversity faces significant obstacles. Weaknesses in inclusive human resource policies, the absence of intercultural training, and the persistence of ethnically or religiously preferential attitudes have limited and at times strained intergroup interactions, even within a demographically diverse workforce [8]. This situation mirrors the findings of Owusu-Boadi et al. in African countries with unsystematic human resource structures, where the lack of supportive policies and deficiencies in diversity management not only impede the benefits of diversity. However, it may also increase conflicts, thereby reducing productivity [16].

In the second stage, the obtained data revealed that CID, as the mediating variable, plays a pivotal role in bridging the relationship between WD and TA. This development is a multidimensional construct that encompasses the modernization of construction technologies, enhancement of resource productivity, alignment with market and key stakeholders, and improvement of managerial systems. Among these dimensions, the improvement of managerial systems exhibited the highest factor loading. This finding highlights that the quality and efficiency of managerial systems are at the core of the industry development process [39]. It should be noted that the other dimensions of development (e.g., technology, human resource quality, or equipment) cannot perfectly flourish without such systems.

The findings further confirmed that, in construction projects, enhancing managerial systems through improvements in decision-making processes, mechanization of monitoring, increased transparency, and standardization of procedures has substantially strengthened the link between WD and the adoption of modern technologies [5, 6]. This result aligns with the findings of Othman and Ibrahim Fouda, as well as Baker et al., demonstrating that the presence of mature and integrated managerial systems is the most critical factor in improving productivity, reducing risk, and facilitating the adoption of technological innovations [24, 25].

Nonetheless, the findings showed that improving managerial systems still faces significant challenges in the context of Iraq. Administrative corruption, centralized decision-making at higher levels, lack of informational transparency, and the absence of digital management tools continue to limit the effectiveness of these systems [40]. Similar to the report by Yousif et al., although projects managed by international agencies or organizations with strong governance have achieved notable advances in managerial systems, such practices have yet to become an industry-wide standard in Iraq's construction industry [8].

Finally, the adoption of modern technologies, as the dependent variable in the model, was strongly influenced by the level of industrial development and the effective utilization of human capital. Among the indicators of this construct, organizational readiness for TA recorded the highest factor loading. This indicator measures the extent to which an organization's structural, cultural, and resource capabilities facilitate the integration of new technologies into its processes and projects. More precisely, even when advanced technologies are available, genuine and sustainable adoption will not occur without sufficient organizational readiness.

The data analysis revealed that organizational readiness comprises a set of factors, including the presence of clear technology strategies, adequate digital infrastructure, specialized employee skills, sufficient financial resources, and a positive managerial attitude toward innovation. This finding aligns with the results of Almatari et al. in Malaysia and Rosa et al. in Europe, highlighting that successful TA depends on the level of organizational maturity and structural preparedness [2, 11]. Our result also corroborates the framework proposed by Tornatzky and Fleischer in the Technology-Organization-Environment model,

where organizational readiness is identified as one of the three fundamental pillars of innovation adoption [41].

Our findings indicated that such readiness is primarily observed in projects managed by capable entities, such as religious endowments or companies with international collaborations. These organizations typically possess advanced project management processes, integrated information systems, and continuous training policies. Conversely, many domestic projects lack digital infrastructure, technological planning, or adequate specialized teams, resulting in a situation where their effective and sustained use is not achieved even with access to technologies such as BIM, artificial intelligence, or intelligent monitoring systems [8].

According to the evidence from this study, organizational readiness for TA is not only the most significant indicator within the TA construct but also plays a decisive role in activating the effects of industrial development and WD on innovation. Hence, without such readiness, TA remains a limited and temporary choice, incapable of evolving into a sustainable competitive advantage.

A comparative analysis within the conceptual model revealed that in developing countries like Iraq, the relationship between diversity and technology is not linear or straightforward. Instead, it is interwoven with multilayered interventions, such as industrial development, legal infrastructure, institutional capacity building, and social capital. As noted by Odazie et al., innovative policies are effective in fragile settings only when coupled with industrial empowerment and organizational development [23]. This is particularly evident in the context of Iraq, where the construction industry remains in a transitional phase and requires broader support from policymakers, academia, and international institutions to act as an effective mediator between human resources and technological innovation.

A localized analysis of the Iraqi context revealed that major projects (e.g., Airports, Transport Networks, And Oil and Gas Infrastructure) require a blend of intercultural competencies and advanced technologies. However, as emphasized by Musawi and Naimi, deterrents (e.g., mismanagement, corruption, and the absence of a coherent supply chain) weaken the effectiveness of any innovation [18]. Additionally, the data of our model showed that technology can serve as a positive mediator, amplifying the effect of diversity on project performance. This synergy, as described by Rosa et al., can only be achieved when organizational and procedural innovations are properly implemented [11]. Nonetheless, the lack of digital transformation strategies remains a major barrier to realizing this synergy in Iraq.

A critical assessment of the model's applicability demonstrated a notable gap between the theoretical framework and field realities in Iraq. Cultural resistance to modern approaches, especially within traditionally managed projects, emerges as a key obstacle [24]. Moreover, economic and security challenges have dampened the motivation for technology investment, a constraint also highlighted by Bigdellou and Chen to be common in economically unstable countries [7]. In addition to these challenges, the absence of mandatory policies and inclusion metrics has further hindered the effective implementation of diversity

management practices [5].

From a strategic perspective, our findings can provide practical guidance for infrastructure project managers in Iraq. First, it is essential to develop localized technology strategies tailored to the specific conditions of Iraq; this approach is endorsed by van Wyk et al., who stress the importance of context-sensitive TA [26]. Additionally, enhancing intercultural competencies and promoting a shared language among project personnel are essential prerequisites for effective diversity management [21]. Furthermore, designing performance indicators to measure inclusion and technological productivity can facilitate evidence-based decision-making [15].

Furthermore, the tested model showed that the greatest improvements in project performance occur when both WD and TA are concurrently enhanced, an effect commonly referred to as the “synergy effect” in the literature [23]. However, in Iraq, this effect has only been observed in projects supported by strong institutions and stable funding. For instance, the Karbala Airport development project, which benefited from integrated management and sustained backing, stands out as a successful example of achieving this synergy.

Our findings confirmed that in development-oriented models, WD leads to TA only when CID acts as the connecting bridge, providing the necessary institutional, technical, and human infrastructure for innovation. Diversity remains a latent potential without this structural mediation, and TA becomes an elusive goal. Therefore, future strategies should prioritize the advancement of industry development with an emphasis on human capital and inclusive approaches.

In general, the findings of this study confirmed that while WD and TA can theoretically serve as key drivers for improving infrastructure project performance, their practical realization in Iraq depends on addressing deep-rooted structural, economic, and cultural barriers. Achieving this goal requires coordinated efforts and synergy among the government, private sector, religious institutions, and civil society to establish a stable and coherent platform for leveraging existing potentials.

## 6. Conclusion

This study, adopting an exploratory mixed-method approach, investigated the relationship between WD and TA in infrastructure projects, with a particular emphasis on the mediating role of CID. The qualitative findings indicated that diversity in cultural, linguistic, and professional dimensions can have a dual impact on TA. It was revealed that such diversity functions as a source of innovation and enhanced organizational performance within structured management frameworks; however, in the absence of appropriate institutional mechanisms, it may lead to conflict, misunderstanding, and reduced willingness to embrace technological change.

The quantitative results reinforced this analysis, demonstrating that CID plays a significant mediating role in either facilitating or slowing down the process of TA. Particularly in complex and multinational

projects, key factors (e.g., enhancing technical capacities, standardizing engineering practices, and implementing targeted workforce training) can effectively contribute to greater technological readiness.

A critical reflection on the conditions of the construction industry of Iraq reveals persistent challenges, including weak institutional integration, a lack of comprehensive DM strategies, and a substantial technological gap with global standards. These barriers reduce project productivity and threaten the path toward sustainable development in the sector.

Accordingly, this study emphasizes the need for developing integrated policies across three strategic pillars to enhance TA in infrastructure projects: (1) effective management of WD, (2) development of technological and institutional infrastructure, and (3) reinforcement of professional training and skill development.

### 6.1. Suggestions for Future Research

It is recommended that future studies investigate the role of other variables (e.g., leadership styles, organizational culture, and absorptive capacity) in technology. Moreover, comparative research across countries in the region can help identify successful models for managing the interaction between WD and TA. Eventually, the use of longitudinal data and the integration of advanced analytical methods can provide a more comprehensive understanding of the dynamic nature of these relationships in infrastructure projects.

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