



Research on the Reform of University Digital Intelligence Talent Training Against the Background of Building Digitalization

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Abstract. In the digital age, the fundamental goal of civil engineering program reform is to cultivate versatile professionals who possess both specialized domain knowledge and digital technology application skills. This paper offers insights for universities to develop digital-intelligence talent in civil engineering from three perspectives. Integrating digital technologies into teaching and securing support from software/hardware educational resources serve as primary pathways and robust safeguards for program upgrading and transformation. Establishing strategic partnerships between universities and enterprises constitutes the core approach to cultivating digital-savvy talent. Advancing digital-intelligence course development, enhancing faculty digital application capabilities, and establishing faculty digital competency assessment mechanisms represent key tasks for elevating educators' digital literacy.

Keywords: Digital Talent, Digital Twin Technology, BIM, Digital Literacy

1 Introduction

In the digital age, the new advantage in educational development lies in its deep integration with information technology. Higher education institutions should seize the opportunities presented by artificial intelligence, actively participate in and lead the transformation of intelligent education, thereby accelerating reforms in talent cultivation models. Traditional civil engineering programs, due to their inherently limited connection with digital technologies, exhibit significant shortcomings in their conventional talent cultivation approaches—particularly in fostering innovative thinking, integrating interdisciplinary knowledge, and rapidly adapting to new technological changes—making urgent reform imperative. through the impasse in talent cultivation? Clearly, enhancing the alignment of talent development with industrial and regional economic growth is the key to overcoming this challenge. China's urban development has now entered a critical phase, shifting from large-scale incremental construction to upgrading and renovating existing infrastructure. The transformed civil engineering discipline will emerge as an interdisciplinary field integrating traditional civil engineering techniques,

civil information engineering technologies, and mechanized automation control technologies. Civil engineering professionals cultivated by universities should be digital-intelligence talents bridging traditional infrastructure with emerging fields. Thus, digital-intelligence civil engineering professionals are interdisciplinary talents possessing expertise in civil engineering, digital technologies, and artificial intelligence, along with cross-disciplinary application capabilities. As the primary battleground for talent cultivation, universities should develop digital-intelligence talents during the civil engineering industry's transformation through pathways such as program upgrading, industry-education integration, and enhancing faculty digital literacy, as illustrated in Figure 1.

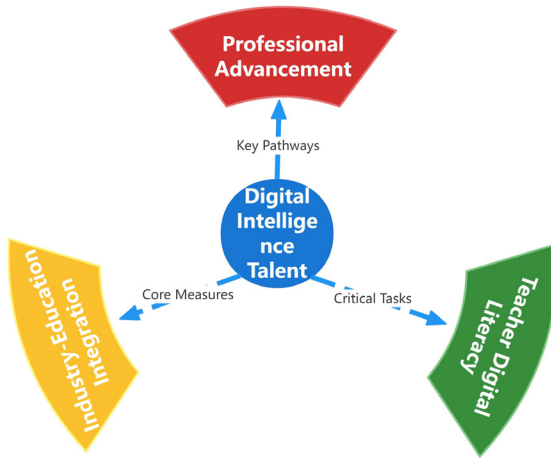


Fig. 1. Primary Pathways for Cultivating Digital Talent in Civil Engineering.

2 Professional Transformation is a Key Initiative in Cultivating Digital and Intelligent Talent for Civil Engineering

Revisions to talent development programs during professional transformation should prioritize industry relevance and focus on digital intelligence, cultivating interdisciplinary professionals with applied capabilities. The restructuring of the curriculum system should emphasize interdisciplinary integration, which can occur either within natural sciences or across different disciplines. For example, the integration of civil engineering and computer science gives rise to smart construction; the combination of civil engineering and transportation engineering leads to intelligent transportation; and the intersection of civil engineering with management science, artificial intelligence, and new energy science creates new interdisciplinary fields. Curriculum reform must simultaneously address the relationship between the reform of “existing” courses and “new” courses. Existing courses should be upgraded by integrating digital technology knowledge into their original content. New courses should reflect interdisciplinary ap-

proaches and regional economic needs, adding subjects like BIM, GIS, artificial intelligence, big data applications, prefabricated construction, drones, computer vision, and image processing technology. Through the reform of both existing and new courses, a “Digital Intelligence+” curriculum system will be established, laying a solid foundation for cultivating digital intelligence professionals. Top-level design serves as the guiding principle for cultivating digital-intelligence talent in higher education. Universities should develop and implement action plans based on strategic frameworks for digital-intelligence talent development, addressing critical tasks like digital infrastructure construction, faculty training, and digital curriculum systems to ensure continuous talent cultivation^[1]. The status of digital curriculum reform in civil engineering programs across universities is summarized in Table 1.

Table 1. Digital Course Reform in Civil Engineering Programs at Universities.

Country	School	Measure
China	Southeast University	Launching micro-specializations in cutting-edge fields through a “theoretical lectures + virtual simulation + enterprise project training” model, focusing on holistic skill development
China	Henan Polytechnic University	Integrating digital twin modeling, engineering big data mining, and machine learning algorithms to build a virtual simulation course cluster
China	Guangzhou City University of Technology	Offering drone surveying and mapping training
China	Qingdao University of Technology	Developing a civil engineering large-scale model to build AI-Launching courses in digital construction and construction robotics
Singapore	National University of Singapore	Launching courses in digital construction and construction robotics
Switzerland	ETH Zurich	Integrate data science and systems analysis into engineering project courses

Taking the application of digital twin technology in the preservation of ancient wooden arch covered bridges as an example integrated into micro-courses^[2]. The wooden arch covered bridges of Fujian and Zhejiang provinces boast a long history, with most having been destroyed by fire. The Mesi Wooden Arch Covered Bridge in Minqing County, Fuzhou City—a provincial-level key cultural relic under protection—presents significant challenges for preservation due to the lack of detailed blueprint documentation. The School of Civil Engineering at Fuzhou University constructed a digital twin of the wooden arch covered bridge using 3D scanning-BIM parametric digital reconstruction technology to study fire spread patterns under various conditions. Fire load is measured in terms of heat, calculated using the formula:

$$Q=\rho Vq \quad (1)$$

In the formula: ρ is the material density ($\text{kg}\cdot\text{m}^{-3}$), V is the material volume (m^3), and q is the unit calorific value of the material (MJ/kg).

$$D^* = \left(\frac{Q}{\rho_\infty C_p T_\infty \sqrt{g}} \right)^{\frac{1}{5}} \quad (2)$$

In the equation: Q represents the total heat release rate of the fire source, set at 2000 kW; ρ_∞ represents air density, set at 1.2 kg/m³; C_p denotes the specific heat capacity at constant pressure, set at 1 kJ/(kg·K); T_∞ indicates ambient temperature, set at 293 K; g represents gravitational acceleration, set at 9.8 m/s². Calculated result: $D^* = 1.27$ m. By employing a BIM-FDS interactive simulation method based on digital twins, an accurate fire information model was constructed. Six simulated scenarios with different fire source locations—including bridgehead and bridge center—were analyzed. The fire spread patterns for these six typical locations were examined, encompassing macro-level and quantitative analyses of heat release rate, fire propagation phenomena, temperature, visibility, and harmful gas concentrations. Results indicate that fires originating beneath the bridge pose the highest risk. Finally, fire prevention strategies are proposed, including upper and lower fire zones, wood flame retardancy, and sprinkler systems.

Overall, in terms of curriculum reform, innovative teaching approaches such as restructuring course content, enhancing the application of digital tools in engineering practice, developing virtual simulation-based experimental teaching projects, and establishing digital-intelligence courses have been implemented. These initiatives cultivate students' interest and ability in interdisciplinary learning [3], thereby driving the high-quality development of digital-intelligence talent cultivation.

3 Deepening the Integration of Industry and Education is the Core Pathway for Cultivating Digital and Intelligent Talent in Civil Engineering

Driven by the national strategy for educational digitization, university-industry collaboration focuses on the deep integration of digital technologies with teaching and learning. Higher education institutions should effectively leverage enterprises' rich industrial experience and technological advantages, utilizing large-scale AI models to overcome constraints in civil engineering education imposed by resources, methodologies, tools, and facilities. This approach integrates construction scenarios, cutting-edge technologies, and operational processes into teaching and learning, driving convergence through intelligent solutions.

3.1 Collaboration at the Strategic Planning Level for Cultivating Digital and Intelligent Talent

Universities and enterprises jointly establish industry-academia colleges for talent cultivation from a strategic development perspective. Building upon this foundation, they co-establish professional advisory committees to jointly review and formulate digital

and intelligent talent development plans, determine curriculum frameworks and learning objectives, ensuring university talent cultivation aligns with corporate talent requirements.

3.2 Collaboration in the Realm of Digital Technology Teaching Resources

The establishment of joint industry-academia training bases offers a direct solution to the lag in higher education resources relative to technological advancement. Enterprises provide cutting-edge software platforms (such as BIM, digital twins, and project management systems), while universities contribute facilities and management services to establish smart construction training centers, joint laboratories, and innovation hubs. These collaborative facilities collectively support teaching, research, and corporate employee training. In recent years, multiple universities have deepened collaborations with enterprises to integrate digital twin technology, align with real-world engineering data, and develop large-scale models—all driving pedagogical innovation. Digital twins serve as dynamic digital representations of physical components, mimicking their real-world behavior^[4]. The application of digital twin technology has opened new dimensions for architectural education^[5,6,7]. Integrating digital twin technology into teaching enables students to directly confront and solve real-world production challenges. This approach bridges the gap between education and industry practice, transcends temporal and spatial constraints, enhances comprehension of abstract concepts, strengthens practical skills, and cultivates versatile intelligent professionals who align with industry trends in digital construction and smart building management. The application of digital twin technology in civil engineering programs across universities is summarized in Table 2.

Table 2. The Application of Digital Twin Technology in Higher Education Institutions Worldwide.

Country	School	Application Cases
China	Henan Polytechnic University	Building Virtual Simulation Environments
China	Beijing University of Civil Engineering and Architecture	Integrating Real Project Data
China	Tongji University	Developing Specialized Large Models
Denmark	Technical University of Denmark	Developing Multimodal Multi-User Virtual Learning Environments
the United Kingdom	University of Cambridge	Impact of Digital Twins on Engineering Project Delivery

Deep collaboration between universities and enterprises in digital technology is the core pathway for cultivating digital and intelligent talent in civil engineering. Enterprises provide resource support for the sustainable development of universities, while universities supply the talent engine for enterprises' intelligent transformation, jointly driving the digital transformation of the civil engineering industry.

4 Enhancing Teachers' Digital Literacy is a Key Task in Cultivating Digital and Intelligent Talent for Civil Engineering

Teacher digital literacy refers to the awareness, capabilities, and responsibilities teachers possess to appropriately utilize digital technologies for acquiring, processing, applying, managing, and evaluating digital information and resources; identifying, analyzing, and resolving educational challenges; and optimizing, innovating, and transforming teaching practices^[8]. As a vital component of modern education, teacher digital literacy training becomes increasingly critical in future learning environments. It directly impacts teaching quality and students' preparedness for the digital world, representing one of the key challenges higher education institutions must address during their digital transformation^[9].

4.1 Advance the Development of Digital and Intelligent Courses to Enhance Teachers' Digital Application Capabilities

The development of digital and intelligent courses in the architecture program is being advanced in a phased and tiered manner, closely aligned with industry trends and the program's ongoing transformation. Through digital innovation workshops, hands-on training, and project simulations, faculty receive specialized, stage-based training. This approach enhances their digital teaching capabilities—from integrating digital technologies into instruction using intelligent platforms to build rich online resources, to mastering core digital tools essential for the discipline.

4.2 Establish a Digital Competency Assessment Mechanism for Teachers to Advance the Enhancement of Their Digital Literacy

The assessment of teachers' digital literacy is a crucial component in cultivating digital talent and advancing educational digital transformation. Universities have established research centers for digital and intelligent education to develop training systems for teachers' digital and intelligent literacy, establish evaluation standards for teachers' digital literacy, and comprehensively explore digital and intelligent education assessment^[10]. Measurement scales and items have been developed around dimensions including digital concepts and awareness, digital technology knowledge and skills, digital application and evaluation, digital security and responsibility, and digital professional development^[11]. This further advances the professional growth and competency enhancement of university faculty within digital teaching environments. Simultaneously, it provides data support and policy recommendations to educational decision-makers regarding digital skills cultivation, enabling the formulation of intervention plans in this domain to facilitate improvements in teachers' digital technology application and instructional innovation. The European Commission has defined the digital competencies teachers should possess in contemporary society, encompassing six domains detailed in Table 3 and Figure 2. Some member states have integrated the European Digital

Competence Framework for Education (DigCompEdu) into teacher training programs. For instance, in Germany's Saarland state, digital literacy has been incorporated into teacher training curricula. In Spain, the CRUE network of higher education institutions plans to implement it as part of continuing education activities for academic staff.

Table 3. European Digital Competence Framework for Educators^[12,13].

number	Digital capability	Instructions
1	professional engagement	including the use of technology for professional development and collaboration
2	digital resources	focusing on finding, evaluating, and creating digital learning resources
3	teaching and learning	including the use of technology to improve teaching methods and student engagement
4	assessment	including the use of digital tools for formative and summative assessment
5	empowering learners	emphasizing the fostering of digital literacy and critical thinking skills in students
6	facilitating digital citizenship	focusing on the promotion of the responsible and ethical use of technology

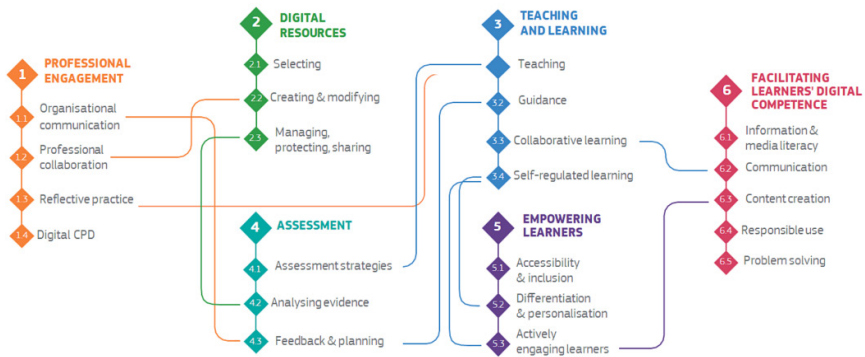


Fig. 2. DigCompEdu framework.^[14]

Ramon Llull University employs the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) based on DigCompEdu to quantitatively assess teachers' digital competence. This approach follows instructional design principles by analyzing the extent of teachers' engagement with digital tools. The evaluation method is applicable to offline, online, and blended teaching environments. Teachers' digital competence assessment results are presented in radar chart format, as shown in Figure 3. These outcomes serve as a reference for teachers seeking to further enhance their digital capabilities.

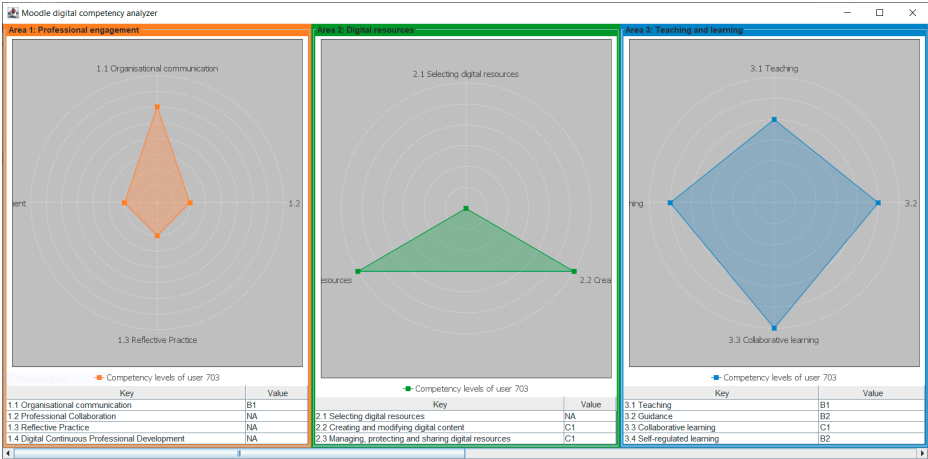


Fig. 3. A radar-chart view of the results of the analysis of a teacher’s digital competence.[15]

5 Conclusion

This paper addresses the urgent need for reform in civil engineering to meet the demands of the digital era, proposing pathways for universities to cultivate professionals with digital literacy. Three approaches are established: (1) By restructuring the “Digital Intelligence Plus” curriculum system and leveraging specialized software and hardware infrastructure, digital technologies are integrated into the curriculum to solidify the foundational knowledge and interdisciplinary application capabilities of digital intelligence talent; (2) Deepening collaboration between universities and enterprises in digital teaching resources to bridge the gap between education and production, jointly advancing the digital transformation of the civil engineering industry; (3) Establishing a scientific evaluation mechanism for faculty digital competency through professional development and assessment, systematically enhancing teachers' digital literacy to provide instructional support for cultivating digital-intelligent talent. These strategies form a synergistic mechanism, collectively empowering universities to develop multidisciplinary digital-intelligent professionals in civil engineering who meet the industry's digital transformation demands.

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Disclosure of Interests

We declare that we do not have any commercial or personal interest which may cause a conflict of interest in relation to this study.

References

1. Jiang, X.L., Yuan, J.Y., Yu, W.: Digital Intelligence Empowering New-Quality Talent Cultivation in Vocational Education: Implications, Challenges, and Approaches. *Adult Education* 45(04), 78–84 (2025)
2. Fan, B.H., Song, Z.W., Wang, L.Y., et al.: Fire Protection Strategy for Fujian-Zhejiang Wooden Arch Covered Bridges Based on Digital Reconstruction. *Journal of Southwest Jiaotong University* (2025)
3. Yang, Q., Liu, Z.J., Kong, G.Q., et al.: Research on Higher Engineering Education Strategies in the Context of Interdisciplinary Integration. *Research on Higher Engineering Education* (2025)
4. Lu, Q., Chen, L., Li, S., Pitt, M.: Semi-automatic geometric digital twinning for existing buildings based on images and CAD drawings. *Autom Constr* 115(4), 103183 (2020)
5. Tuhaise, V.V., Tah, J.H.M., Abanda, F.H.: Technologies for digital twin applications in construction. *Autom. Constr* 152 (2023)
6. Hakimi, O., Liu, H., Abudayyeh, O., Houshyar, A., Almatared, M., Alhawiti, A.: Data Fusion for Smart Civil Infrastructure Management: A Conceptual Digital Twin Framework. *Buildings* 13 (2023)
7. Jiang, F., Ma, L., Broyd, T., Chen, K.: Digital Twin and Its Implementations in the Civil Engineering Sector. *Autom. Constr* 130 (2021)
8. Ministry of Education: Notice on Issuing the Education Industry Standard “Teachers' Digital Literacy” (2022). https://www.gov.cn/zhengce/zhengceku/2023-02/21/content_5742422.htm (2023-10-25)
9. Haroud, S., Saqri, N.: Generative AI in Higher Education: Teachers’ and Students’ Perspectives on Support, Replacement, and Digital Literacy. *Education Sciences* 15(4), 396 (2025)
10. Zhang, P.W.: From Knowledge Transmission to Competency Development: Digital Intelligence-Driven Innovation in Higher Education Talent Cultivation Systems. *Chinese Higher Education* (11), 10–13 (2025)
11. Wang, X.J., Zhao, W.P.: Development of Dimensions and Scale for Digital Literacy Among Vocational College Teachers in the Context of Digital Transformation. *Chinese Vocational and Technical Education* (17), 34–45 (2024)
12. Lázaro-Cantabrana, J., Usart-Rodríguez, M., Gisbert-Cervera, M.: Assessing Teacher Digital Competence: The Construction of an Instrument for Measuring the Knowledge of Pre-service Teachers. *J. New Approaches Educ. Res. (NAER J.)* 8, 73–78 (2019)
13. Kiryakova, G., Kozhuharova, D.: The Digital Competences Necessary for the Successful Pedagogical Practice of Teachers in the Digital Age. *Education Sciences* 14(5), 1–19 (2024)
14. Redecker, C.: European Framework for the Digital Competence of Educators: DigCompEdu (No. JRC107466). Joint Research Centre (Seville site); Publications Office of the European Union: Luxembourg (2017)
15. de Torres, E., Canaletta, X., Fonseca, D., et al.: Automated Monitoring of Human–Computer Interaction for Assessing Teachers’ Digital Competence Based on LMS Data Extraction. *Sensors* 24(11) (2024)

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