EPiC Series in Built Environment
Volume 7, 2026, Pages 704–712
Proceedings of Associated Schools of Construction 62nd Annual International Conference

Barriers to Technology Integration in the Construction Workforce

Rachel Mosier[1], Tulio Sulbaran[2], Sanjeev Adhikari[3], Sandeep Langar[2]
[1]Oklahoma State University, [2]The University of Texas at San Antonio, [3]Kennesaw State University

Emerging technologies are at the forefront of the ever-changing modern business environment, impacting industries in the US, including construction. Although the construction industry has made significant strides in adopting innovation over the last two decades, it has historically lagged in adopting technological innovations. This is because technological innovation adoption is not a straightforward process, and numerous barriers can affect it. Some of these barriers include the environments in which potential adopters operate, implementation costs, and the geographical locations in which construction businesses might operate. This study explores barriers to integrated technology adoption and implementation in the construction industry in states with poverty rates above the national average. An online survey was used to collect data, and descriptive statistics were used to analyze it. The study population included construction workers in three states with significant persistent poverty, measured by the percentage of counties with persistent poverty. The results indicate that a dual bottleneck fundamentally stalls technology adoption in construction: the initial cost burden and the internal inability to effectively utilize the investment. These findings from this study support the possible roles of vendors and academic institutions in helping the construction industry overcome barriers to integrating technology into its operations.

Keywords: Barriers, Construction Workforce, Innovative technology adoption, Construction Innovation

Introduction and Background

The construction industry significantly contributes to the US GDP (Goolsbee & Syverson, 2023) and continues to grow, even though recent growth has been sluggish (AIA, 2025). In addition, the industry faces other significant challenges, such as reduced productivity compared to other industries over the decades (BLS 2025; Goolsbee & Syverson 2023), historical resistance to change, the lack of standardized manufacturing techniques such as Six Sigma or LEAN (Hossain et al. 2019), fragmented nature of the construction industry (Elkhayat et al. 2024), and others. Furthermore, historically, the construction industry has been perceived as resistant or “slow” to adopting technological innovations (Bigdellou & Chen, 2025; Davis & Songer, 2009).

At the same time, there are indications that in the last two decades, the US Architecture, Engineering, and Construction (AEC) industry has adopted technological innovations (Albeaino & Gheisari 2021;

Fountain & Langar 2018; Langar & Pearce 2017). In the US, AEC companies are also utilizing both traditional methods (Langar & Bhansali, 2018) and non-traditional methods (such as outsourcing) (Fountain & Langar 2018) to leverage technological innovations to mitigate some of the industry's challenges. Along with mitigating some of the challenges, adoption of technological innovations such as 3D Printing, Building Information Modeling, Drones, Robotics, and others by AEC firms can facilitate improved productivity, visualization (Bigdellou & Chen 2025), reduced errors/rework resulting in delays (Sacks et al. 2018), improved productivity (Sacks et al. 2018), inspection and monitoring (Anwar & Azhar 2024) safety (Fasoyinu et al. 2025; Webb & Langar 2019), and others. Given the numerous benefits that can be accrued from technological innovation adoption, one significant challenge is that it is not a straightforward process (Rogers, 2003), including in the construction industry (Elkhayat et al. 2024).

According to Rogers (2003), there are prior conditions that must be met for innovation to be adopted, including 1) Previous Practice, 2) Felt needs/problems, 3) Innovativeness, and 4) Norms of the social systems. Further, there must be knowledge and persuasion before a decision occurs to support implementation. Knowledge characteristics include 1) socioeconomic characteristics, 2) personality variables, and 3) communication behavior (Rogers 2003). Perceived characteristics of the innovation required for persuasion include 1) Relative Advantage, 2) Compatibility, 3) Complexity, 4) Trialability, and 5) Observability (Rogers 2003). The required characteristics for innovation were compared with the existing literature on barriers in the construction industry.

Existing barriers to implementation of technology in the construction workforce were identified; which include: 1) High implementation costs (Criminale & Langar 2017, Gajjar & Burgett 2020, Esfahani et al. 2025); 2) Lack of skilled personnel and Lack of personnel time (Sveiby 2007, Ogunseiju et al, 2021, and Dogra & Sparkling 2020); 3)Training, Learning Curve (Criminale& Langar 2017, Ogunseiju et al, 2021, Esfahani et al. 2025); 4) Lack of strategic alignment including owner and stakeholder (Architects, Sub-contractor, and Engineer) support (Karbasiahvazi et al. 2022, Brockmann 2025), 5) Cybersecurity concerns (Oke et al. 2025); 6) Software challenges (Harode & Thabet 2023);7) Limited infrastructure within company (Esfahani et al. 2025, Oke et al. 2025); 8) Lack of interest within the company and Resistance to change (Adekunle et al. 2021); 9) Limited communication (Winkler 2024), 10) Cultural issues (Lavy et al., 2010); 11) Unclear benefits; 12) Lack of non-financial resources (Oke et al. 2025), and 13) Limited financial support from the government (Oke et al. 2025).

These barriers were used to identify constraints on integrated technology adoption and implementation within the construction industry, particularly among construction professionals operating in states with poverty rates above the national average, which collectively account for a significant portion of persistently poor counties nationwide.

Methodology

The research employed an online survey to assess barriers to integrated technology adoption and implementation in the US construction industry. Of the various tools available to host an online survey, Qualtrics was purposively selected as: i) the use of the platform in AEC industry research (Kereri et al., 2021); ii) the Research Team had extensive experience with the use of the platform in previous research. The developed instrument consisted of closed- and open-ended questions grouped into three sections: (i) Demographic Information; (ii) Technology Adoption and Literacy Skills; and (iii) Support for the Implementation of Construction Technologies. Given that the paper's scope is barriers to technology integration, the paper includes only information relevant to that section, along with demographic information. Existing barriers to technology implementation for this research were identified as 1) High implementation costs, 2) Lack of skilled personnel, 3) Lack of personnel time, 4) Training, 5) Learning Curve, 6) Lack of strategic alignment, 7) Owner support, 8) Stakeholder (Architects, Sub-contractor, and Engineer) support, 9) Cyber security concerns, 10) Software challenges, 11) Limited infrastructure within company, 12) Lack of interest within the company, 13) Resistance to change, 14) Limited communication, 15) Cultural issues, 16) Unclear benefits, 17) Lack of non-financial resources, and 18) Limited financial support from the government.

The online survey target population consisted of construction workers in three states with counties with significant, persistent poverty. For the purposes of this study, Persistent Poverty has been defined as areas with "a *poverty rate of 20.0% or higher during the three decades from 1989 to 2015-2019*" (USCB, 2023). Georgia, Oklahoma, and Texas were selected because, together, they account for approximately 42.5% of the counties identified nationwide as Persistent Poverty Counties (PPCs) (USEDA, 2023). In addition, these states had significantly higher poverty rates than the national average of 10.6% (USCB, 2025), with Georgia at about 12.9% (University of Georgia, 2025), Oklahoma at about 14.9% (Oklahoma Policy Institute, 2025), and Texas at about 14% (Texas Demographic Center, 2025). Following the identification of the target population, the universities involved in the survey distribution sought institutional approval (Institutional Review Board) to conduct the study. After obtaining approval for the survey instrument, the online instrument was disseminated through collaborations with regional trade organizations in the three states (Georgia, Oklahoma, and Texas) and through interpersonal networks, such as the Industry Advisory Board, LinkedIn, and direct emails to industry professionals in the three states. The survey data were collected and downloaded for descriptive statistical analysis, and the results have been presented in the subsequent section.

Results

A total of 34 participants responded to the study. The participants were not required to answer all questions; therefore, the number of responses per question varied. A total of 29 participants responded to the question "Do you work in the construction industry?". The majority of respondents, 79% (23 participants), indicated that they work in the Construction Industry. The remaining participants either responded that "Prefer not to Answer" or "No". The majority of the respondents (79%) identified themselves as "Male," and the remaining as "Female." When asked about their "*Job Location*," 28 of 34 respondents responded. The majority of respondents, 41% (12 participants), reported "*Working (mostly) at the office*," the second most common answer, with 24% (7 participants) reported "*Work on the jobsite and the office*," as depicted in Figure 1. From the perspective of respondent experience in the construction industry, 19 of 34 respondents answered the question. The majority of respondents (32%) reported having more than 20 years of experience, as shown in Figure 2. These responses indicate a good representation of both people who work at the office (perhaps with administrative responsibilities) and those who work at job sites (perhaps with field- and project-specific responsibilities).

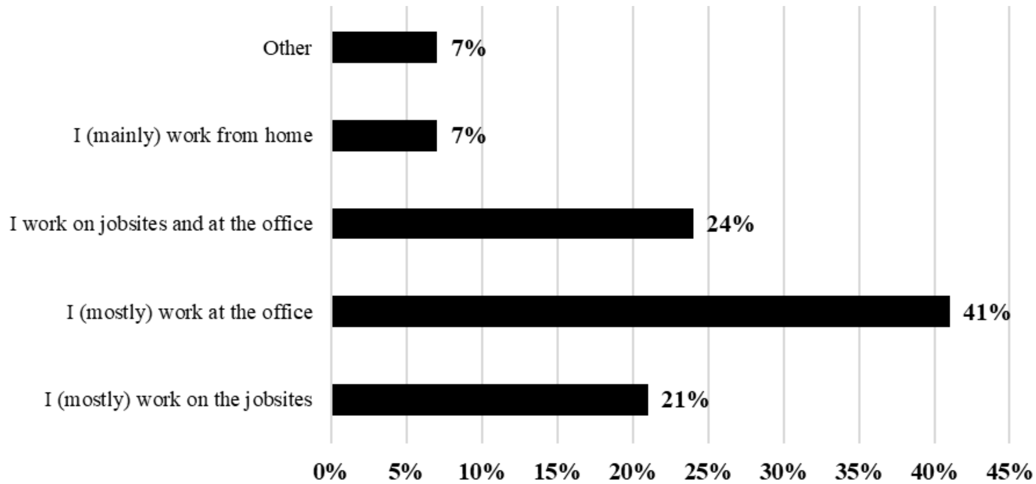

Figure 1: Respondent job location

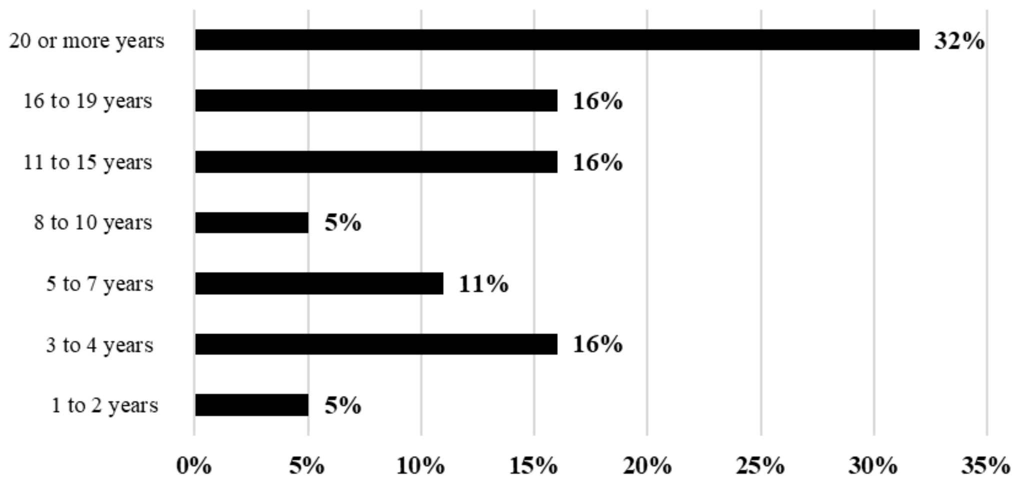

Figure 2: Respondent experience in the construction industry

When asked about the main barriers to implementing construction technologies in their company, 20 of the 34 participants responded (Figure 3). Each participant could select all 18 applicable barriers identified in the research methodology section. The responses indicate that the top three barriers identified by the respondents were as follows:

a. *High implementation costs*, cited by 70% of respondents (14 participants).
b. *Lack of skilled personnel*, identified by 60% of the respondents (12 participants).
c. *Training* was indicated by 60% of the respondents (12 participants)

The next three barriers indicated by the participants, yet still highly significant, included:

d. *Resistance to change*, reported by half of the respondents (10 participants).
e. *Owner support* included by 35% of the respondents (7 participants)
f. *Learning curve* mentioned by 30% of the respondents (6 participants)

It is worth noting that three of the top six barriers (b, c, and f) relate to workforce training for implementing construction technologies.

On the other side of the spectrum, the perceived three lowest barriers to implementing technology were:

a. Limited financial support from the government, indicated by only 10% of the respondents (2 participants)
b. Cultural issues were the second lowest barrier cited by only 10% of the respondents (2 participants)
c. Limited communication was the least of the barriers, with only 5% of the respondents (1 participant)

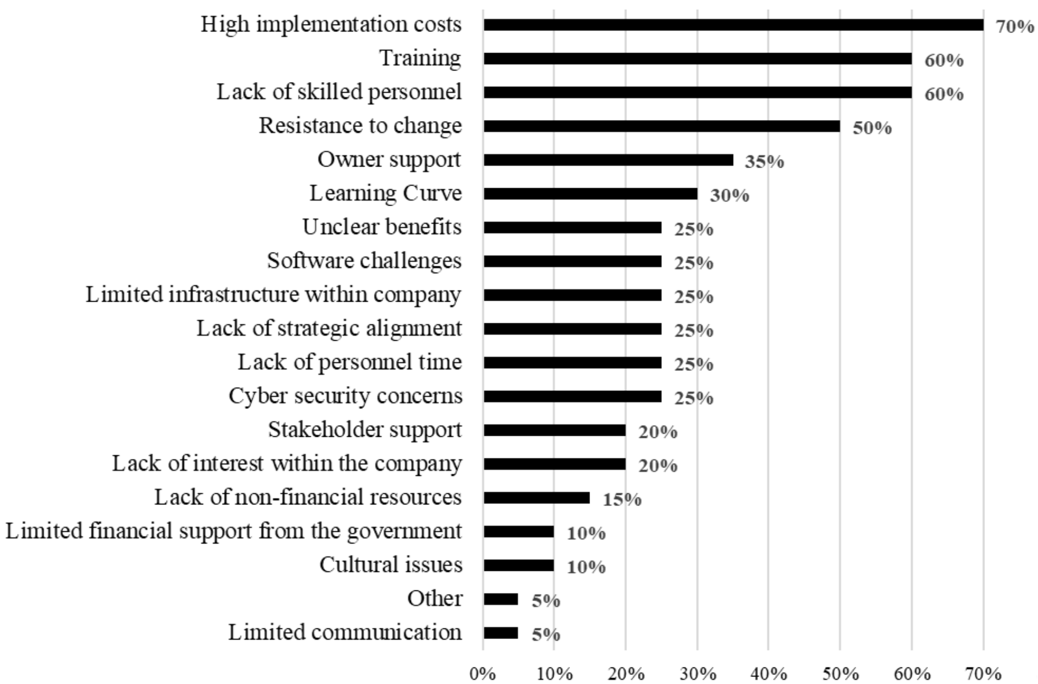

Figure 3. Barriers to Implementing Construction Technologies (n=20)

Discussion

The results of the data analysis highlight two significant implications for the adoption and implementation of construction technology. The first implication is that adopting new construction technologies faces a significant dual challenge: cost and workforce capability, as supported by some existing literature (Criminale & Langar, 2017).

The top barriers include high implementation costs (70%), lack of skilled personnel (60%), and training (60%), which demonstrate that construction companies are simultaneously challenged by the high investment costs required and by the internal personnel capacity to utilize and benefit from these construction technologies. These findings are critical, especially for construction companies operating in economically disadvantaged areas, which face tighter budgetary constraints and limited access to labor and training, thereby significantly hampering the holistic adoption of innovative technologies. Viewing this finding through the perspective of Rogers' Theory, such complex conditions will limit the adoption of innovative technologies in economically disadvantaged areas, as Trialability and Observability may be constrained, which can also affect understanding of the Relative Advantage of such innovations.

In addition, given that the sample is a good representation of both people who work at the office and at construction sites, these concerns are commonly shared among construction individuals with administrative responsibilities (at the office) as well as personnel in the field and with project-specific responsibilities (at job sites). This implies that technology vendors must focus on providing a clear, quantifiable Return on Investment (ROI) and offering more accessible, cost-effective deployment models, particularly for firms facing tight budgetary constraints. This would fit with offering a clear Relative Advantage to construction professionals, especially when operating in economically disadvantaged areas. Without addressing the high initial cost, scaling up personnel training becomes an unnecessary expense that management will be reluctant to bear. Similarly, academic institutions could help overcome the barrier by providing information and training the construction companies' workforce.

The second critical implication is the pronounced need for comprehensive, proactive workforce development on construction technologies. Three of the top six barriers to implementation, which include the lack of skilled personnel, training, and the technological learning curve, are directly related to the workforce development aspect. This cluster of issues, along with resistance to change (50%), suggests that the construction sector is not suffering from a simple lack of interest, as shown by the lowest cited barrier of limited communication (5%), but rather from a technical capability gap. Therefore, a possible solution should not focus solely on purchasing construction technology, but also on harmonized activities that support holistic technological adoption, including the development and implementation of training as a fundamental part of the strategy to overcome barriers. The harmonized activities aligned with the purchase of technologies will aim to facilitate the holistic adoption of technologies to maximize benefits and achieve maturity more quickly. At the same time, the cost of adopting the technology (including harmonized activities) for economically disadvantaged areas can be a challenge. In this regard, academic institutions and non-profit organizations could emerge as integral stakeholders, playing a vital role in assisting construction companies in implementing integrated operational changes, including adoptioning construction technologies. These non-traditional stakeholders could help companies move beyond one-off software tutorials to a progressive workforce development with responsibilities specific to education that explicitly address the new "construction technology competencies." Furthermore, academic institutions and vendors could collaborate to actively communicate the technology's value proposition to construction personnel in the office and on the job site.

Conclusion

A significant body of literature on barriers to technology adoption and implementation exists; it often focuses on specific technologies, such as BIM (Adekunle et al. 2021) or drones (Albeaino & Gheisari 2021). However, this industry-wide online survey focuses on 18 distinct barriers that are not tied to the technology itself. The findings are particularly significant as they reflect insights from construction professionals operating in states with poverty rates exceeding the national average and geographically operating in states that collectively account for approximately 45% of persistently poor counties nationwide. Consistent with prior research identifying workforce shortages as a major limitation in the construction industry (ABC, 2025; BLS, 2025), the results indicate that a lack of skilled personnel remains as one of the primary barriers to technology adoption. These findings suggest that addressing workforce challenges alone is insufficient; instead, a broader set of factors must be considered, including tangible constraints (e.g., implementation costs, training requirements) and intangible factors (e.g., stakeholder support, resistance to change). This holistic perspective is particularly critical for construction firms operating in economically disadvantaged regions.

Limitations and Future Work

One significant limitation of the research is the sample size. At the same time, the initial research findings are in congruence with the literature. Based on this research, the next steps would include training for construction professionals and determining whether workforce training itself will drive change in the adoption and implementation of technologies.

References

Adekunle, S. A., Aigbavboa, C., Ejohwomu, O., Thwala, W. D., & Efiannayi, N. (2021). Key constraints to optimal BIM penetration among Nigerian quantity surveyors. Construction Management 50th Anniversary Conference.

Albeaino, G., & Gheisari, M. (2021). Trends, benefits, and barriers of unmanned aerial systems in the construction industry: A survey study in the United States. Journal of Information Technology in Construction. 26, 84–111. https://doi.org/10.36680/j.itcon.2021.006

American Institute of Architects (AIA). (2025). Architecture Firm Billings Continue to Decline; Broader Economy Remains Generally Positive. March 19, 2025. https://www.aia.org/about-aia/press/architecture-firm-billings-continue-decline-broader-economy-remains-generally Retrieved July 29, 2025.

American Institute of Architects (AIA). (2025). No turnaround in sight for spending on nonresidential buildings. https://www.aia.org/resource-center/july-2025-consensus-construction-forecast

Anwar, R. M. I., & Azhar, S. (2024). Mixed Reality in Building Construction Inspection and Monitoring: A Systematic Review. Virtual Worlds, 3(3), 319–332. https://doi.org/10.3390/virtualworlds3030017

Associated Builders and Contractors (ABC). (2025). Construction Industry Must Attract 439,000 Workers in 2025. < https://www.abc.org/News-Media/News-Releases/abc-construction-industry-must-attract-439000-workers-in-2025> Retrieved July 29, 2025.

Bigdellou, S., & Chen, Q. (2025). Quantification of economic influences on technology adoption and diffusion in the construction industry. International Journal of Construction Management, 0(0), 1–18. https://doi.org/10.1080/15623599.2025.2530647

Brockmann, C. (2025). Longitudinal Case Study Analysis to Identify an Innovation Process for Contractors in Megaprojects. Proceedings of 61st Annual Associated Schools of Construction International Conference, Southern Alberta Institute of Technology, Calgary, AB, April. Vol. 6 pp. 440-449. https://doi.org/10.29007/wlhx

Davis, K. A., & Songer, A. D. (2009). Resistance to IT Change in the AEC Industry: Are the Stereotypes True? Journal of Construction Engineering and Management, 135(12), 1324–1333. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000108

Dogra, P.& Sparkling, A. (2020). Supervisors' Reliance on Tacit Knowledge and Impediments to Knowledge Sharing in Trades. Proceedings of 56th Annual Associated Schools of Construction International Conference, Liverpool John Moores University, Liverpool, UK, (Virtual) September.

Elkhayat, Y., Adel, K., & Marzouk, M. (2024). Technology adoption in the construction industry (1999–2023): Science mapping and visualization. Automation in Construction, 165, 105491. https://doi.org/10.1016/j.autcon.2024.105491

Esfahani, M. T., Sulbaran, T., & Awolusi, I. (2025). Drivers and Barriers to the Use of Wearable Sensing Devices for Real-Time Safety Risk Assessment in Construction. Proceedings of 61st

Annual Associated Schools of Construction International Conference, Southern Alberta Institute of Technology, Calgary, AB, April. Vol. 6. Pp. 510-519. https://doi.org/10.29007/rlnj

Fasoyinu, A. A., Azhar, S., Sattineni, A., & Toyin, J. O. (2025). Wearable sensing devices for construction safety: Research trends, applications, challenges, and future opportunities. Automation in Construction, 179, 106424. https://doi.org/10.1016/j.autcon.2025.106424

Fountain, J., & Langar, S. (2018). Building Information Modeling (BIM) outsourcing among general contractors. Automation in Construction, 95, 107–117, https://doi.org/10.1016/j.autcon.2018.06.009

Gajjar, D., & Burgett, J. (2020). Evaluating the Use of Unmanned Aerial Systems (UAS) to Perform Low-Slope Roof Inspections. Proceedings of 56th Annual Associated Schools of Construction International Conference, Liverpool John Moores University, Liverpool, UK, (Virtual) September. Volume 1, 2020, Pages 214–222. https://doi.org/10.29007/jknh

Goolsbee, A., & Syverson, C. (2023). The Strange and Awful Path of Productivity in the U.S. Construction Sector (No. w30845). National Bureau of Economic Research. https://doi.org/10.3386/w30845

Harode, A. & Thabet, W. (2023). Extracting BIM data to support a machine learning model for automated clash resolution. Proceedings of 59th Annual Associated Schools of Construction International Conference, Liverpool John Moores University, Liverpool, UK, April 2-6, 2023. EPiC Series in Built Environment. V.4. pp. 381-389. https://doi.org/10.29007/2x41

Hussain, K., He, Z., Ahmad, N., Iqbal, M., & Taskheer Mumtaz, S.M. (2019). Green, lean, Six Sigma barriers at a glance: A case from the construction sector of Pakistan. Building and Environment. 161, (106225), ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2019.106225.

Karbasiahvazi, A., Olbina, A., & Elliott, J. W. (2022). Implementation of Laser Scanning and Photogrammetry in the US Commercial Building Sector. Proceedings of the 58th Annual Associated Schools of Construction International Conference, Georgia Tech. University, Atlanta, GA. EPiC Series in Built Environment.

Kereri, J. O., Friedland, C., Harper, C., & Nahmens, I. (2021). Relationship Embeddedness in Construction Project Teams: The Effect of Social Behaviors on Relational Behaviors. Frontiers in Built Environment. 7:636000.

Langar, S., & Bhansali, S. (2018). Building Information Modeling (BIM) Implementation in the Residential Sector. 3rd BIM Academic Symposium & Job Task Analysis Review- Academic Interoperability Coalition.

Langar, S., & Pearce, A. R. (2017). Implementation Trends for Rainwater-Harvesting Technologies and Strategies and Their Relationship with Building Information Modeling. Journal of Architectural Engineering, 23(1), 04016016. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000228

Lavy, S., Aggarwal, C., & Porwal, V. (2010). Fatalities of Hispanic Workers: Safety Initiatives Taken by U.S. Construction Companies to Address Linguistic and Cultural Issues. International Journal of Construction Education and Research, 6(:4), 271-284, DOI: 10.1080/15578771.2010.514693

National Association of Homebuilders (NAHB). (2024). Labor Report Shows Dire Need for New Construction Workers. Oct 11, 2024. < https://www.nahb.org/blog/2024/10/hbi-construction-labor-report-fall-2024> Retrieved July 29, 2025.

National Bureau of Economic Research (NBER). (2023). The Strange And Awful Path Of Productivity In The U.S. Construction Sector (No. 30845; NBER Working Paper). University of Chicago.

Ogunseiju, O., Akanmu, A., & Bairaktarova, D. (2021). Sensing Technologies in Construction Engineering and Management Programs: A Comparison of Industry Expectations and Faculty

Perceptions. Proceedings of 57th Annual Associated Schools of Construction International Conference, California State University, Chico, CA (Virtual), April. Vol. 2 pp. 505-513. https://doi.org/10.29007/8srj

Oke, A. E., Aliu, J., and & Onajite, S. A. (2024). Barriers to the adoption of digital technologies for sustainable construction in a developing economy, Architectural Engineering and Design Management, 20 (3), 431-447, DOI: 10.1080/17452007.2023.2187754

Oklahoma Policy Institute. (2025). 2024 Census data: Oklahoma ranks as 8th poorest state. Accessed: January. 12, 2026. Available at: https://okpolicy.org/2024-census-data-oklahoma-ranks-as-8th-poorest-state/

Rogers, E. M. (2003). Diffusion of Innovations. 5th Ed. Rogers EM. New York, NY: Free Press, 2005.

Sacks, R., Eastman, C., Lee, G., & Teicholz, P. (2018). BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers. John Wiley & Sons.

Sage Economics. (2025). Construction Trend Tuesday (#17) Manufacturing Momentum Waves. < https://www.sageecon.com/t/construction-trend-tuesday?utm_source=substack&utm_medium=email> Retrieved July 29, 2025.

Sveiby, K. E. (2007). Disabling the Context for Knowledge Work: The Role of Managers' Behaviours. Management Decision, 45(10), 1636-1655. doi:10.1108/00251740710838004

Texas Demographic Center. (2025). National Poverty in America Awareness Month 2024. January. 12, 2026. Available at:https://demographics.texas.gov/Visualizations/2024/PovertyInTx/

University of Georgia. (2025). Poverty Rate. January. 12, 2026. Available at: https://georgiadata.org/topics/economics/poverty-rate

US Bureau of Labor Statistics (BLS). (2025). Productivity Home Page: U.S. Bureau of Labor Statistics. Bureau of Labor Statistics. https://www.bls.gov/productivity/

US Census Bureau (USCB). (2023). 341 U.S. Counties Experiencing Persistent Poverty. Accessed: Oct. 22, 2024. Available at: https://www.census.gov/library/stories/2023/05/persistent-poverty-areas-with-long-term-high-poverty.html

US Census Bureau (USCB). (2025). Poverty in the United States: 2024. Accessed: January. 12, 2026. Available at: https://www.census.gov/library/publications/2025/demo/p60-287.html

US Economic Development Administration. (USEDA). (2023).FY2023 Persistent Poverty Counties (PPCs). Accessed: January. 12, 2026.

Webb, T., & Langar, S. (2019). Utilizing BIM as a Tool for Managing Construction Site Safety: A Review of Literature. Proceedings of the 55th Associated School of Construction International Conference, Denver, CO, USA, April 10–13, 2019

Winkler, C. (2024). Implementing solar photovoltaic systems in buildings: a case of systemic innovation in the construction sector. Construction Innovation (Emerald Group Publishing Limited), 24(7), 102–123. https://doi.org/10.1108/CI-10-2022-0264