Exploring the Challenges and Opportunities of Implementing Advanced Construction Technologies (ACT) in State University Campus Infrastructure Projects

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ABSTRACT

This study explored the challenges and opportunities in using Advanced Construction Technologies (ACT) in campus infrastructure projects, with a focus on Pampanga State Agricultural University (PSAU). Technologies such as Building Information Modeling (BIM), drones, and Artificial Intelligence (AI) have shown potential to improve efficiency, cost management, and sustainability in construction. Using a structured survey answered by 15 key stakeholders involved in university construction, the study found high awareness but no actual use of these technologies at PSAU. Key barriers include budget constraints, lack of training, and technical skills. Despite these challenges, stakeholders believe that ACT can offer major benefits, including better project efficiency, sustainability, and decision-making. The study suggests steps universities can take to support ACT integration in future infrastructure projects.

INTRODUCTION

Background of Study

The construction industry is one of the leading industries globally. In 2020, the construction industry amounted to 13.8% of the Global Gross Domestic Product (GDP), about 84.5 trillion dollars (FMI and Autodesk, 2020). While it is one of the leading industries, challenges are still inevitable. Nowadays, the continuous improvement of structural facilities also increases the complexity of construction planning and management. In addition, with the rising demand for efficiency, cost-effectiveness, and quality projects, integrating cutting-edge technologies has become essential in addressing the industry's persistent challenges.

The integration of advanced construction technologies (ACT), such as Building Information Modeling (BIM), drones, and Artificial Intelligence (AI), has revolutionized the construction industry in recent years. These technologies pose significant improvements in project management, sustainability, and overall project outcomes. From the study of Azhar (2009), they found that Building Information Modeling (BIM) significantly enhances collaboration and project visualization, which leads to improved profitability, reduced costs, better time management, and improved customer-client relationships. Meanwhile, as a remote sensing platform, unmanned air vehicles or drones have high potential in increasing the efficiency of construction project data acquisition by having a much higher spatial and temporal resolution compared to other techniques (Zhou, 2018). Moreover, the integration of Artificial Intelligence (AI) in construction helps optimize processes and reduce errors (Zhang, 2020).

Despite this potential, the adoption of these technologies in state university campus projects has been relatively slow. According to Goh (2016), state universities often face challenges, including but not limited to bureaucratic red tape, budget constraints, and resistance to change from university stakeholders. Barriers like these can hinder the development of construction processes, like the adoption of more innovative construction technologies.

This study assessed the challenges and opportunities in implementing advanced construction technologies (ACT) in higher education campus projects. Through this assessment, the research provided a comprehensive

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understanding of how ACT can be utilized in the development of state university campus infrastructure projects.

Research Questions

1.1.1. What is the current level of awareness, usage, and challenges associated with the adoption of advanced construction technologies (ACT) in state university infrastructure projects?

1.1.2. What are the perceived benefits of state universities in implementing advanced construction technologies (ACT) in campus infrastructure projects?

1.1.3. What factors influence the adoption of advanced construction technologies (ACT) in campus infrastructure projects?

Scope and Delimitation

This study focused on the analysis of awareness, usage, benefits, challenges, and factors influencing the adoption of advanced construction technologies (ACT) in state university infrastructure projects. In addition, the study relied on questionnaire data from 15 stakeholders representing various groups involved in state university infrastructure projects. This research was confined to Pampanga State Agricultural University (PSAU) and was limited to quantitative data gathered from a structured survey.

This study will not involve in-depth assessments of specific construction technologies. Furthermore, the research will not extend to private universities or large-scale government projects outside the research locale.

REVIEW OF RELATED LITERATURE

Related Literature

Advanced Construction Technologies (ACT)

Advanced Construction Technologies (ACT) encompasses a broad spectrum of modern construction methods and tools such as Building Information Modeling (BIM), drones, modular systems, and artificial intelligence that enhance the efficiency and sustainability of construction projects (Zhou et al., 2020). Globally, the use of ACT has grown in response to the need for resilient, cost-efficient infrastructure. Countries like Singapore and the United Kingdom have pioneered smart construction practices to support sustainable development goals (Ghosh & Arora, 2021).

Benefits of ACT in Institutional Infrastructure Projects

The integration of ACT in institutional infrastructure leads to better space utilization, improved construction timelines, and optimized building performance. Technologies like BIM provide a comprehensive approach to design, construction, and facility management by enabling real-time collaboration among project stakeholders (Alreshidi et al., 2018). In campus projects, modular construction has reduced duration and minimized site disturbances (Wang & Leite, 2016).

Institutional and Policy Barriers in the Philippine Context

In the Philippine setting, infrastructure development in state universities follows the procurement rules of Republic Act No. 9184, which tends to prioritize cost over quality and innovation (Sicat & Cruz, 2023). Budget limitations, lack of institutional policies supporting technology integration, and inadequate technical training among contractors also limit the application of ACT.

Related Studies

Foreign Studies

Al-Hammad's (2020) study entitled “The implementation of Building Information Modeling (BIM) in university campus construction in Saudi Arabia” led to a 25% reduction in design conflicts and improved

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stakeholder communication. The study emphasized the role of digital technologies in enhancing project transparency and efficiency in academic institutions.

Likewise, in the study of Chien et al. (2014), they investigated the application of RFID and IoT in construction project management in Taiwan. Their findings showed that integrating smart technologies enhanced real-time tracking of materials and workers, resulting in more efficient scheduling and reduced labor costs.

Local Studies

In the case study conducted by Dela Cruz and Mariano (2022), the University of the Philippines Diliman implemented partial BIM modeling for a new science building. The research found that while there were initial barriers related to training and software access, the use of BIM significantly improved design coordination and change management.

On the other side, Torres and Valerio (2021) examined a pilot modular classroom construction at a university in Region IV-A. The findings showed time savings and reduced labor requirements, but also noted supply chain issues that hindered continuous ACT application in regional projects.

METHODOLOGY

Research Design

This study employed a quantitative research approach, focusing on descriptive research design, to explore the Challenges and Opportunities of implementing Advanced Construction Technologies (ACT) in State University Campus Infrastructure Projects. Descriptive research is suitable for this study, as it aims to systematically describe the current and future state of adopting advanced construction technologies, including Building Information Modeling (BIM), drones, and Artificial Intelligence (AI) in state university infrastructure projects.

Research Locale

The study was conducted at Pampanga State Agricultural University (PSAU). Pampanga State Agricultural University. The university occupies approximately 500 hectares of government agricultural land in Magalang, Pampanga. The University has current ongoing and future campus infrastructure projects, making it an ideal research setting for the study.

Data Sources

This study utilized primary data collected through structured surveys from university stakeholders regarding campus infrastructure projects. By integrating this data, the researchers provided a well-supported analysis of the different challenges and opportunities in implementing the use of advanced construction technologies in campus infrastructure projects.

Population

The population of this study consisted of stakeholders of the state university campus infrastructure projects. These stakeholders included University Administrators, the Project Monitoring Committee, Construction Professionals, and other people involved in the decision-making process for state university infrastructure projects.

Sample and Sampling Method

This study employed a combination of purposive and convenience sampling techniques to select 15 respondents from key stakeholders of campus infrastructure projects. The sample will include representatives from various stakeholder groups to ensure that all relevant perspectives will be gathered. The stakeholder groups are comprised of representatives from university administration, the project monitoring committee, and

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other construction professionals who have direct involvement in the planning, management, or execution of infrastructure projects.

Research Instrument

This study utilized a structured survey for state university construction stakeholders. The questionnaire consisted of closed-ended questions to explore the challenges and opportunities in implementing advanced construction technologies in state university infrastructure projects. The questions were adapted from existing studies focused on the adoption of advanced construction technologies in different sectors.

Data Gathering Procedure

The study employed a quantitative approach, and the primary data will be collected from a structured survey for state university construction stakeholders. The survey was distributed electronically using Google Forms and printed survey forms. These methods were utilized to avoid inconvenience to the respondents. After all samples were gathered, the proponents then processed the data to evaluate the challenges and opportunities of implementing advanced construction technologies in state university infrastructure projects.

Statistical Treatment

The study employed descriptive statistical methods to analyze the data gathered from the structured questionnaire. The statistical treatment employed was frequency and percentage distribution. It was used to summarize the categorical responses from the structured survey questionnaire. This method identified the proportion of respondents selecting specific options, providing insights on awareness, usage, challenges, and perceived benefits that are associated with the adoption of advanced construction technologies in state university infrastructure projects.

$$\boldsymbol{Percentage = \frac{f}{N} \times 100}$$

Where:

***f* (Frequency) –** the number of respondents who selected the specific option

***N* (Total Responses) –** the overall number of responses recorded for a particular question

RESULTS AND DISCUSSION

Current level of awareness, usage, and challenges associated with the adoption of advanced construction technologies (ACT) in state university infrastructure projects

Awareness

Table 1. Awareness of stakeholders about ACT

QUESTION	RESPONDENTS	FREQUENCY	PERCENTAGE
1. Are you familiar with the following construction technologies?			
Building Information Modeling (BIM)	15	11	73.33%
Drones for site monitoring	15	13	86.67%
Artificial Intelligence (AI) in construction management	15	5	33.33%
3D Printing for construction	15	8	53.33%

As shown in Table 1, Thirteen (13) respondents, or 86.67%, were familiar with the use of drones for site monitoring, while eleven (11) respondents, or 73.33%, were aware of Building Information Modeling (BIM). On the other hand, eight (8) respondents, or 53.33%, and five (5) or 33.33% of the respondents are familiar

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with the use of 3D printing and Artificial Intelligence (AI) in construction, respectively. Most of the stakeholders are aware of some of the advanced construction technologies, like BIM and drones, while there is noticeably lower awareness of newer and more complex ACT, such as AI and #D printing. This level of awareness shows that the exposure of the university construction stakeholders to advanced construction technologies varies depending on the technology. Since awareness plays a key role in technology adoption, the limited familiarity of some of the ACT may hinder the willingness or ability of campus construction stakeholders to explore and implement newer solutions or improvements in campus infrastructure projects.

Usage

Table 2. Usage of ACT

QUESTION		RESPONDENTS	FREQUENCY	PERCENTAGE
2. Has the university implemented any of these technologies in recent construction projects?				
	Yes	15	0	0.00%
	No	15	15	100.00%
	Not sure	15	0	0.00%
3. If yes, which of the following technologies were used?				
Building Information Modeling (BIM)		0		
Drones for site monitoring		0		
Artificial Intelligence (AI) in construction management		0		
3D Printing for construction		0		

As presented in Table 2, all fifteen (15) respondents, or 100%, stated that during their stay in the university as a construction stakeholder, the university has not yet implemented any of the advanced construction technologies, like BIM, drones, Artificial Intelligence, or 3D printing in campus infrastructure projects. This indicates a clear gap between the awareness of the stakeholders and the ACT implementation in construction projects. In addition, this shows that even though the stakeholders are aware of the different advanced construction technologies, it hasn't translated to the adoption of these technologies into campus infrastructure projects.

Challenges

Table 3. Challenges in the adoption of ACT

QUESTION	RESPONDENTS	FREQUENCY	PERCENTAGE
4. What are the main barriers to adopting these technologies in your university's construction projects?			
Budget Constraints	15	15	100.00%
Lack of Technical expertise	15	13	86.67%
Resistance to change from stakeholders	15	2	13.33%
Bureaucratic processes and approvals	15	3	20.00%
Insufficient Training and support for staff	15	15	100.00%

As shown in Table 3, for the challenges in adopting advanced construction technologies, all of the respondents identified that budget constraints and insufficient training and support for staff are major challenges. While thirteen (13) respondents, or 86.67%, cited a lack of expertise. On the other hand, resistance to change from stakeholders and bureaucratic processes and approvals was chosen by two (2) or 13.33% and three (3) or 20% respondents, respectively. The identified gap between awareness and usage of ACT is directly linked to the barriers that affect the adoption of ACT. From these findings, the major barriers to the adoption of ACT in campus infrastructure projects are budget constraints and insufficient training and support for staff. While state

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university stakeholders show readiness in terms of awareness and willingness, the State Universities and Colleges remain unprepared in terms of capacity, funding, and institutional support. The status of Advanced Construction Technology adoption in state university infrastructure projects reflects that there is existing knowledge in ACT, but actual implementation is being held back by systemic and structural challenges.

Perceived benefits of state universities in implementing advanced construction technologies (ACT) in campus infrastructure projects

Table 4. Perceived benefits of the adoption of ACT

QUESTION		RESPONDENTS	FREQUENCY	PERCENTAGE
5. In your opinion, what are the potential benefits of using these technologies in university construction projects? (Rate on a scale from 1 to 5, where 1 is "Not Beneficial" and 5 is "Highly Beneficial")				
5.a. Improved project efficiency.				
	1	15	0	0.00%
	2	15	0	0.00%
	3	15	0	0.00%
	4	15	2	13.33%
	5	15	13	86.67%
5.b. Cost Savings				
	1	15	0	0.00%
	2	15	0	0.00%
	3	15	0	0.00%
	4	15	4	26.67%
	5	15	11	73.33%
5.c. Sustainability				
	1	15	0	0.00%
	2	15	0	0.00%
	3	15	0	0.00%
	4	15	4	26.67%
	5	15	11	73.33%
5.d. Enhanced Communication and Collaboration				
	1	15	0	0.00%
	2	15	0	0.00%
	3	15	0	0.00%
	4	15	3	20.00%
	5	15	12	80.00%
5.e. Reduced errors and rework				
	1	15	0	0.00%
	2	15	0	0.00%
	3	15	0	0.00%
	4	15	3	20.00%
	5	15	12	80.00%
5.f. Improved decision making				
	1	15	0	0.00%
	2	15	0	0.00%
	3	15	0	0.00%
	4	15	3	20.00%
	5	15	12	80.00%

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The perceived benefits of university construction stakeholders are shown in Table 4. Thirteen (13) or 86.67% rated that ACT is highly beneficial in improving project efficiency. While 12 or 80% rated enhanced communication & collaboration, reduced errors & rework, and improved decision making as highly beneficial as well. On the other hand, 11 or 73.33% think that these technologies are highly beneficial to cost savings and the sustainability of construction projects. The results highlight that construction stakeholders have a positive perception of the possible benefits of implementing advanced construction technologies in campus infrastructure projects. This shows that even though the adoption of ACT has not yet been implemented, the stakeholders foresee that they are highly beneficial to improve the construction of campus infrastructure projects.

Table 5. Contribution to Sustainability Goals

QUESTION	RESPONDENTS	FREQUENCY	PERCENTAGE
6. How do these technologies contribute to the university's goals of sustainability and green building practices?			
Reduced energy consumption during construction	15	15	100.00%
Improve waste management and reduce material waste	15	11	73.33%
Enhance building energy efficiency	15	11	73.33%
Support sustainable materials and construction methods	15	15	100.00%
Help track environmental impacts in real-time	15	11	73.33%

According to Table 5, all respondents (100%) agreed that ACT can help reduce energy consumption during construction and promote the use of sustainable materials and practices. Moreover, eleven (11) or 73.33% of the respondents believe that ACT contributes to improved waste management and reduced material waste, enhanced building energy efficiency, and helps track environmental impacts in real-time. These findings support the idea that ACT aligns well with the university's sustainability goals. As state universities are increasingly expected to emphasize sustainable development, ACT provides tools to meet these goals.

Factors influencing the adoption of advanced construction technologies (ACT) in campus infrastructure projects

Table 6. Future of ACT adoption

QUESTION	RESPONDENTS	FREQUENCY	PERCENTAGE
7. Do you believe that the adoption of advanced construction technologies will become more widespread in state universities in the future?			
Yes	15	13	86.67%
No	15	2	13.33%
Not Sure	15	0	0.00%
8. In your opinion, what steps can state universities take to better integrate advanced construction technologies into campus development projects?			
Increase funding for technology adoption	15	15	100.00%
Provide professional development and training for staff	15	12	80.00%
Foster partnerships with technology providers	15	4	26.67%
Establish clear policies and guidelines for technology use	15	4	26.67%

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Increased awareness and education about the benefits of these technologies	15	11	73.33%
Streamline approval processes	15	3	20.00%

As seen in Table 6, thirteen (13) respondents, or 86.67%, believe that ACT can become more commonly used in state university infrastructure projects in the future. On the other hand, all respondents (100%) believe that increasing funding for technology adoption can facilitate the adoption of ACT. Other key recommendations are to provide professional development and training for staff (80%) and increase awareness and education about the benefits of ACT (73.33%). These findings further emphasize that stakeholders believe that with viable support, the adoption of advanced construction technologies in campus infrastructure projects can be feasible. In addition, if the identified challenges can be addressed, the stakeholders' awareness and positive perception can be transitioned into actual implementation and long-term innovation in university construction practices.

CONCLUSION

This study explored the current status, perceived benefits, challenges, and the future of adopting advanced construction technologies (ACT) in state university campus infrastructure projects, with a specific focus on Pampanga State Agricultural University. The results showed that while most construction stakeholders are aware of commonly known ACTs such as drones and Building Information Modeling (BIM), the actual usage of these technologies remains absent in recent campus infrastructure projects.

The gap between awareness and implementation is primarily due to major barriers such as budget constraints, insufficient training and support, and a lack of technical expertise. Despite these challenges, stakeholders expressed strong confidence in the potential of ACT to improve project efficiency, reduce errors, enhance communication, support sustainability, and lower costs.

These findings suggest that there is readiness among stakeholders in terms of knowledge and perception of benefits to these innovations. However, the State Universities remain unprepared due to limited resources and structural limitations. The overall conclusion is that the successful adoption of advanced construction technologies in state university campus infrastructure projects is only possible if existing barriers are addressed through strategic planning, investment, and institutional support.

RECOMMENDATION

Based on the findings of the study regarding awareness, usage, challenges, and future of the adoption of Advanced Construction Technologies (ACT) in state university campus infrastructure projects, the following recommendations are proposed:

1. **Increase funding for ACT implementation**

   It is recommended that the university, in collaboration with other government agencies, allocate a dedicated budget for the procurement and integration of ACT in campus infrastructure projects. This is essential to initiate the transition from traditional to technology-enhanced construction practices.

2. **Provide Capacity-Building and Training Programs**

   Structured training and professional development can be offered to university stakeholders involved in infrastructure projects. The training should be focused on the practical use of ACT and improving the technical capabilities of construction stakeholders.

3. **Develop Institutional Policies and Implementation Guidelines**

   The development of university-level policies and clear guidelines is recommended to standardize the use of ACT. These should cover all construction phases from planning to monitoring.

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