

Key Determinants of Technology Adoption in Construction Projects in Magelang

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Article Information	ABSTRACT
Article History Received : February 04, 2025 Revised : March 12, 2025 Published : April 10, 2025 Keywords: <i>Construction; Influential Factors; Rank; Relative Importance Index; Use of Technology.</i>	The development of the construction sector in Indonesia is expected to increase annually. Magelang had various large construction projects with a completion target of 2024. However, the use of construction technology in this region is limited resulting in delays in work, increased costs, and decreased quality. This study aims to identify, analyze, and rank factors influencing the use of technology in construction projects in Magelang based on their level of importance. Understanding those factors can help identify the right strategy to increase the wider and optimal adoption of technology in the construction sector for effective and efficient implementation. Data were collected by distributing questionnaires. The questionnaire consisted of 30 factors influencing the use of technology classified into three main categories: (1) human/workforce, (2) industry, and (3) management. This study found the first rank for each category, namely "lack of experience in using technology software" (human/labor category), "Availability of materials and ease of handling" (Industry category), and "Willingness of owners, supervisors, builders, and suppliers to participate in information management" (management category). Construction industry practitioners can utilize the findings of this study in developing systems to improve technological adoption in construction projects for more effective and efficient project implementation.

INTRODUCTION

Recently, the construction sector has developed significantly in Indonesia. The Director General of Construction Development, Rachman Arief Dienaputra, reported that this sector significantly contributes to the national economy. The construction sector contributed 9.92% to the Gross Domestic Product (GDP) in 2023, placing the sector as the fifth largest sector after the Industry, Processing, Trade, Agriculture and Mining sectors. To increase Gross Domestic Product (GDP), the construction sector needs to answer some existing challenges such as the availability of competent workers, technological adoption in the implementation of construction projects, raw material problems, project management, and free trade. The Competitiveness Index data show that the quality of infrastructure in Indonesia is lower than other ASEAN countries such as Singapore, Malaysia, Brunei Darussalam, and Thailand.

One of the main causes is the lack of acceleration in the application and development of technology in the construction sector, so the value produced is lower than in other sectors. Technology plays an important role in realizing project results that are on time, high quality, and

cost-efficient. The use of technology in construction projects is important to improve efficiency, quality, and safety. Therefore, the use of technology in construction projects in Indonesia needs to be maximized to encourage the implementation of effective and efficient construction. The construction sector in one of the regions in Indonesia, Magelang District, Central Java Province, is developing in line with the increasing need for infrastructure to support economic and social development. Magelang City Government data reveal that some construction projects in this region are targeted for completion in 2024, namely the Great Mosque of Central Java, the Ngembik Bridge, the Cangkuk Flyover, and the Borobudur Art Village. However, the implementation of the construction projects faced significant challenges such as the slow implementation of construction projects due to less optimal use of technology. The available technology is not used effectively and efficiently causing delays in the work process, increased costs, and decreased quality of project results.

The implementation of technology in construction projects can be influenced by some factors and those factors can be an obstacle. The influence of the factor on one project may differ. In the UK, the factors influencing the use of technology are organizational, environmental, and project dimensions (Fernandes, K. J., et al., 2006). Meanwhile, the use of technology has not reached the expected target in China due to limited management resources (Jia, M., et al., 2020). The limited implementation of technology in construction projects can be caused by some factors such as lack of knowledge, workforce skills, budget constraints, and resistance to change. This study aims to identify factors influencing the use of technology in construction projects in Magelang District. Understanding those factors can help identify strategies to increase the adoption of technology in the construction sector more widely and optimally. This research is expected to contribute to accelerating the implementation of construction projects in Magelang District by strengthening the implementation of more effective and efficient technology.

RESEARCH METHODS

Research data are information collected to support the analysis and proof process in research. This study used both primary and secondary data. Primary data were obtained from questionnaires distributed to the directors of each construction service company in Magelang District and City. Secondary data were previously available data, such as relevant reports or statistics to complement and strengthen the analysis. A preliminary study was conducted to test and ensure that the questionnaire was well-designed, clear, and relevant for research purposes. In the first stage of the preliminary study, the questionnaire was distributed to 10 directors of construction service companies. Based on their input, revisions were then made. Then, in the second stage of the preliminary study, questionnaires were distributed to 30 company directors who did not participate in the first stage. The questionnaire presents data in the form of factors influencing the use of technology in the implementation of construction projects. After the questionnaire was filled out, the questionnaire was then returned to the researcher for further analysis. The researcher reviewed 30 factors influencing the use of technology and then classified them into three categories, namely factors related to humans/labor, industry, and management. In the questionnaire, respondents were asked to rank the factors influencing the use of technology with the following scale:

- "0" for no influence;
- "1" for very small influence;
- "2" for small influence;
- "3" for moderate influence;
- "4" for high influence;
- "5" for very high

The research population covered all members who are the target of the research, namely construction service companies in Magelang District and City with a total of 420 companies. The construction company data were obtained from the website of Statistics Indonesia of Magelang City and District in 2023. Magelang City has 123 companies consisting of 109 small companies, 8 medium companies, 2 large companies, and 4 non-qualified companies. Meanwhile, Magelang

District has 230 companies consisting of 191 small companies, 17 medium companies, 1 large company, and 21 non-qualified companies. The researcher used a Slovin formula to calculate the sample size of a population by considering a certain margin of error. This formula is useful when the population size (N) is known and the researcher wants to determine a representative sample size (n).

$$n = \frac{N}{1 + N \cdot e^2} \quad (1)$$

Notes:

n = required sample size

N = total population

e = the desired margin of error, usually expressed in decimal (using a value of 0.05 for 5%).

With the formula above, the sample size can be identified. With a population value of 420 companies, the sample size is:

$$n = \frac{N}{1 + N \cdot e^2}$$

$$n = \frac{420}{1 + 420 \cdot (0.05)^2}$$

$$n = 204,878$$

Based on the formula above, this study involved 205 construction companies in Magelang City as a sample representing a total population of 420 construction companies.

Data analysis used the Relative Importance Index (RII) formula to determine the level of importance or relative priority of various factors based on the opinions of respondents. The formula is used to determine the relative importance or priority of various factors based on the respondents' opinions. In this study, the selection of the Relative Importance Index (RII) is based on the purpose of the analysis, ease of application, and interpretation of the results. RII is used to identify and prioritize factors that influence a phenomenon based on their level of importance which is useful in research that aims to determine which factors significantly influence certain results (Yanuar et al., 2024). The Relative Importance Index (RII) used the following formula (El-Gohary, et. al., 2014):

$$RII \text{ (\%)} = \frac{6(n_6) + 5(n_5) + 4(n_4) + 3(n_3) + 2(n_2) + n_1}{6(n_1 + n_2 + n_3 + n_4 + n_5 + n_6)} \times 100 \quad (2)$$

Notes:

n_6 = number of correspondents "very high influence"

n_5 = number of correspondents "high influence"

n_4 = number of correspondents "moderate influence"

n_3 = number of correspondents "small influence"

n_2 = number of correspondents "very small influence"

n_1 = number of correspondents "no influence"

RESULTS AND DISCUSSION

Data Analysis

The researcher analyzed 30 factors influencing the use of technology in construction projects perceived by respondents. These factors were divided into three categories, namely 9 factors for the labor category; 10 factors for the industry category; and 11 factors for the

management category. This study involved a sample size of 205 construction companies representing a population of 420 companies in Magelang. The questionnaire was distributed and then filled in by the company's director. The analysis of factors influencing the use of technology in construction projects in each category used the Relative Importance Index (RII) formula (2).

Labor Category

The company directors expressed that the "Lack of experience in using technology software" had the highest influence value in the Labor category with a Relative Importance Index (RII) value of 88.29%. The lack of experience in using technology software often becomes a major challenge in various contexts including education, work, and training. Lack of experience in using technology software is the main factor influencing the use of technology in carrying out construction projects as the complexity of this industry requires specific technological skills to support efficiency, accuracy, and effective management (Chien et al., 2014). Jia et al. (2020) reported that overall, workforce ability, awareness, and organization are core in all areas of Construction Management. In the study, the company's information technology innovation capability is a key factor in all aspects of management including cost, schedule, quality, and occupational safety and health. This can encourage scientific management and optimize the collection, processing, and application of data to improve management efficiency. On the other hand, the lack of experience in using technology software in pilot projects causes the inability to formulate a feasible plan for the implementation of multi-technology integrated technology and data processing which ultimately affect the success of the project as a whole. This is related to knowledge of how to integrate technology, process data effectively, and analyze information for better decision-making. Hendrawan, H. (2018) argues that knowledge of the technology developed is the main factor influencing the success of technology implementation. In this study, "lack of experience in using technology software" is the main factor in the human resources category because in carrying out their work, the workforce still uses conventional methods. Conventional work in construction projects has been used for a long time, such as project schedules, task lists, and resource allocations recorded in notebooks, not in project management software such as Microsoft Project or Primavera. Lack of experience in using technology software directly affects the ability of the workforce to optimize the use of technology in various aspects of the project such as the ability to understand software functions, integrate data, and utilize technology to improve work efficiency and accuracy. Consequently, this results in dependence on traditional methods, reduced productivity, increased risk of errors, and slowed down decision-making, which overall has a negative impact on project success.

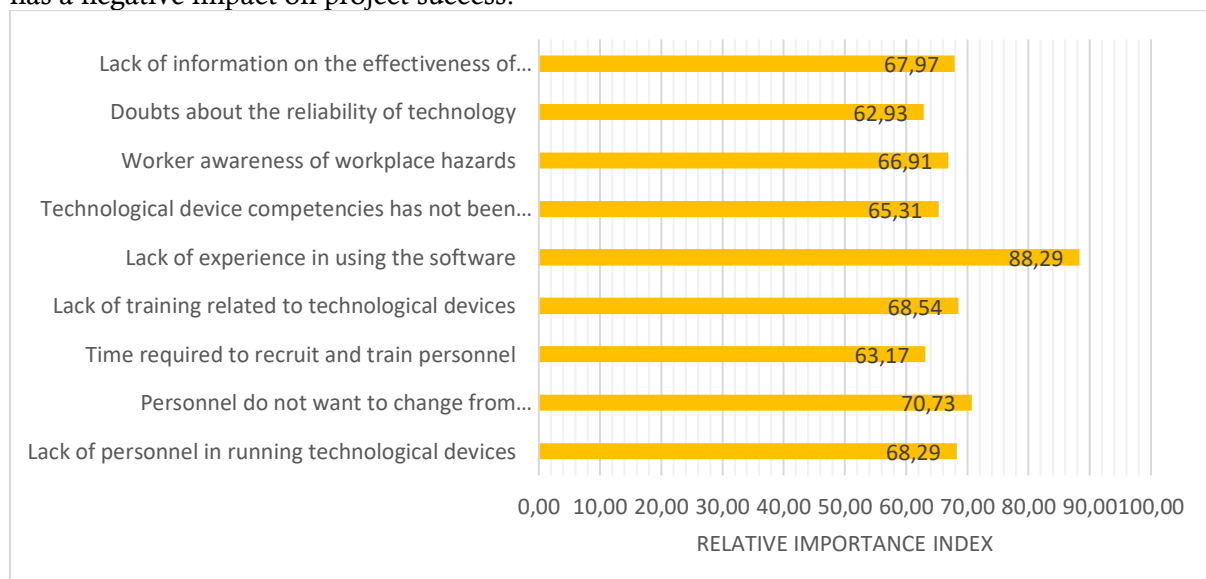


Figure 1. RII Values and Ranks of Factors Influencing Construction Labor Productivity in the Labor Category

Industry Category

The availability of technological infrastructure such as the internet and networks is the main factor in the industry category with a Relative Importance Index (RII) value of 91.54%. The availability of technological infrastructure, especially the internet and networks, is a vital factor in increasing the adoption of technological devices in the construction industry. This means that a reliable network supports collaboration, and operational efficiency, and reduces the risk of errors and project delays. Dakhli and Lafhaj (2020) explained that fast communication through technological networks allows for better coordination on construction sites, reduces errors, and increases efficiency. Therefore, construction companies in France need to modernize their production facilities and transform their business models through digital technology. Jia M., et al. (2020) argued that data integration and interaction systems are important for the development of information products and platforms. This provides a reference for improving the level of information technology application in construction management projects, facilitating the smooth promotion of information technology, and ultimately realizing the sustainable and healthy development of the construction industry. In Malaysia, internal factors influencing the construction industry are related to technological adaptability. In this case, technological adaptability involves technology that is easy to use and can adapt to some situations or even geographical conditions (Khudzari, et al, 2021). Magelang region has a topography consisting of plateaus, valleys, and rural areas where company directors believed that such conditions can make it difficult to install network infrastructure, such as telecommunications towers or fiber optic cables, particularly in remote areas. Construction projects often involve many parties, such as contractors, subcontractors, consultants, and project owners. Network infrastructure allows for more efficient communication through a cloud-based platform in order to minimize errors and increase collaboration between parties.

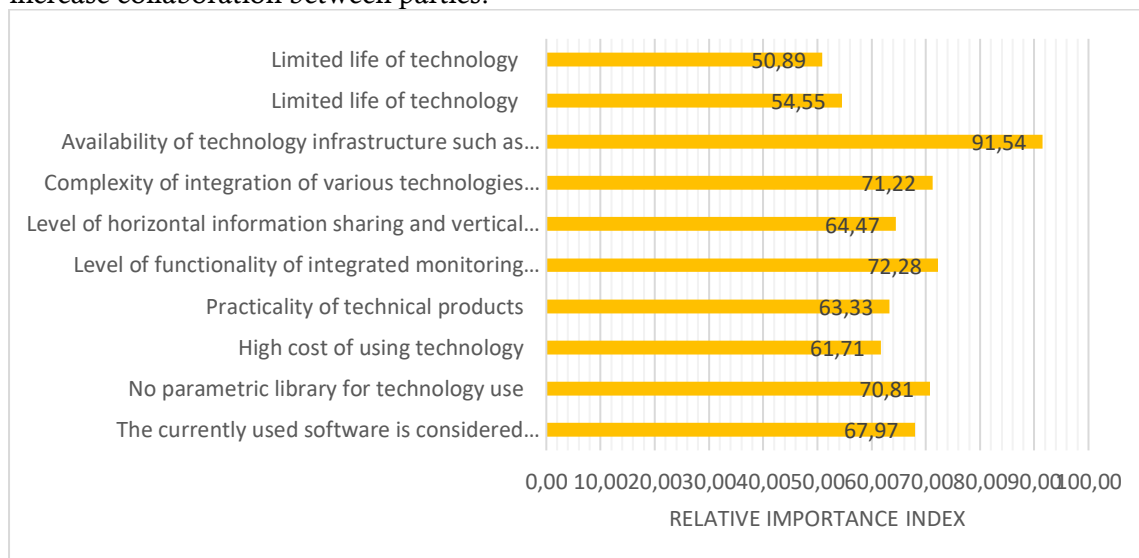


Figure 2. RII Values and Ranks of Factors Influencing Construction Labor Productivity in the Industry Category

Management Category

In the Management category, the most influential factor in the use of technology in construction projects in the Magelang region is “The willingness of owners, supervisors, builders, and suppliers to participate in information management” with a Relative Importance Index (RII) value of 89.84%. Each party in the construction project has different responsibilities, such as the owner who determines the needs, the supervisor who ensures compliance with standards, the implementer who manages operations, and the material supplier who provides materials. Their willingness to share and integrate data through information technology allows for more efficient collaboration. This participation ensures effective and efficient collaboration in terms of time and cost, improves project quality, and reduces the risk of errors. Without the active participation of all parties, the benefits of information technology management cannot be fully perceived, which

can ultimately obstruct the success of the project. A study conducted in China revealed that “The willingness of owners, supervisors, implementers, and material suppliers to participate in information management of participant cooperation” was considered less important in all areas, but could still affect disputes and risk sharing. Lee et al. (2015) emphasized that technological innovation depends on a good organizational environment and the formation of strategic cooperative relationships. The concept and perception of leaders play a major impact on investment, planning, organizational structure, workforce skills, and the scale of information in the company, while the organizational mode can also affect data sharing, the level of synergy, and process conformity (Jia, M., et al., 2020). In this present study, not all parties, for example, implementers and field workers, had sufficient understanding of the use of the latest technology, so they tended to choose not to be willing to participate in collaboration on the use of technology in construction projects. They prefer to choose familiar methods such as manual working drawings on paper without using design software such as AutoCAD, Revit, or SketchUp. The reluctance of implementers and workers to abandon conventional techniques can hinder the use of technology in the construction project environment.

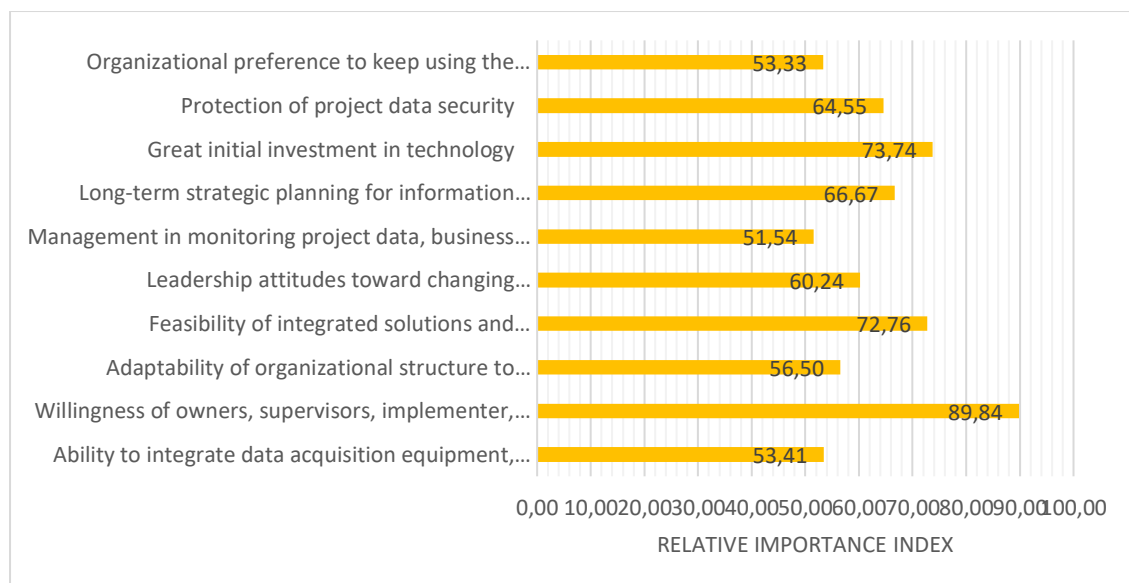


Figure 3. RII Values and Ranks of Factors Influencing Construction Workforce Productivity in the Management Category

CONCLUSION

This study identifies key determinants of technological adoption in construction projects in Magelang using the Relative Importance Index (RII) method. The results of the analysis show three main factors in three different categories. In the Labor category, the most influential factor is the lack of experience in using technology software (RII = 88.29%). Many workers are still accustomed to conventional methods, so direct practice-based training is needed and the provision of devices such as computers and smartphones in the project environment. In the Management category, the main factor is the availability of technology infrastructure such as the internet and networks (RII = 91.54%). Many projects are carried out in remote areas with limited internet access, so companies need to provide portable Wi-Fi and use software that supports offline mode to ensure smooth communication and project management. Meanwhile, in the Industry category, the most influential factor is the participation of owners, supervisors, builders, and suppliers in information management (RII = 89.84%). The lack of involvement of these parties hinders the adoption of technology, so companies must involve all parties from the planning stage. In addition, companies need to provide an easily accessible project management platform, allocate a special

budget for technology training, and ensure the availability of supporting devices for all stakeholders. Overall, efforts to improve the efficiency and effectiveness of technology use in construction projects must be carried out in an integrated method. Companies need to prioritize improving workforce competency, ensuring adequate technological infrastructure, and encouraging the active involvement of all related parties in information management for optimal digital transformation in the construction industry.

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