Indonesian contractor technological learning mechanism and its considerations

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Abstract. The construction industry faces considerable challenges both in terms of rising construction capitalization and increasingly stringent consumer demand for project quality and costs. This challenge needs to be addressed appropriately by the contractor as an important actor who is directly in contact with the construction production process. Through mastery of technology, contractors are expected to overcome these challenges. The process of mastering technology is part of the contractor's effort in improving its technological capabilities through technological learning. This study aims to obtain the latest information related to the mechanism carried out by contractors in the process of mastering technology and the considerations taken. This research was conducted through a survey on contractors whom operating in Indonesia. Respondents were given questions to choose the mechanism they used from 32 mechanisms that had been identified by previous researchers, which were grouped into 3 groups, import, internal, and collaboration. The results showed a difference between the contractor groups (all contractor, large contractor, and medium contractor). The mechanism that is commonly used is by introducing a formal Quality Management system; documenting and analyzing all data and information related to project acquisition and project implementation; and participating in technology exhibitions. The results of this study will become worthwhile information for the government in formulating policy to improve the performance of contractors and as a further part in the effort to map the pattern of technological capability development carried out by Indonesian contractors.

1. Introduction

The Indonesian construction industry has not been able to provide reliable support from the national economy [1]. The dependence of the Indonesian construction industry on foreign steel and the limited availability of workers with higher education, [2]. The construction industry is opaque, fragmented, and full of inconsistent incentives so that it is often where the unproductive player can succeed [3]. The condition of the construction industry has resulted in operational failures within the company, including inefficient, inadequate design time to apply the latest thinking about project management and implementation, low-skilled workforce, and lack of investment in technology and digitalization that will help increase productivity [3].

Actors in the construction sector consist of at least service providers (consultants and contractors), service users (public and private), regulators, and communities with their respective supply chains [4].
The contractor, according to the level of complexity of the work, the amount of funds used, the amount of labor involved, and the multiplier effects for both the upstream and downstream industries, has a strategic position in the construction sector [5]. Contractors in the business in the construction sector require equipment with adequate types and quantities, experience in implementing high-performance projects, access to finance and foreign exchange [6].

As Indonesia's construction capitalization is increasing, the government's desire to accelerate infrastructure provision, there are at least two situations faced by construction in Indonesia, the construction products obtained must be timely, cost and quality; Indonesian contractors must be able to compete so that they become host in their own country. This situation indicates that the ability of Indonesian contractors needs to develop, especially the ability of technology to deal with existing dynamics. This shows that there is a need to explore deeply the conditions for developing national contractors' technological capabilities in Indonesia.

Knowledge and understanding of the various mechanism in contractor technological learning mechanism is needed to determine the focus of the necessary steps to improve construction business environment thereby increasing construction industry performance.

The purpose of this study is to identify what considerations and mechanisms are the main choices of contractors in developing their technological capabilities. The result will be useful information to improve Indonesia’s construction productivity and competitiveness.

2. Contractor Technological Learning
One way to develop the construction industry is to improve the performance of construction companies, focusing on contractors and technology development, [7]. Therefore, it is important to know: 1) how the contractor's role in the dynamics of the construction industry is, 2) how big is the contribution of contractors in Indonesia to the dynamics of the construction industry in supporting national economic activities. As an illustration, Figure 1 is presented to illustrate the contractor's business pattern.

![Contractor Business Pattern](image)

**Figure 1. Contractor Business Pattern**

The issue faced by contractors is competitiveness and productivity. Both issues greatly influenced the focus of the contractor in winning the competition to get the project and complete the project successfully. [8] suggests intensifying the use of technology to overcome productivity problems. [9] state that in the long run, competitiveness comes from the ability to build, at a lower cost and faster than competitors, the core competencies that spawn anticipated products. As revealed by [10] and [11] companies need to prepare conditions for internal capabilities before determining corrective
measures to address changes in the business environment.

[12] state that technological capability is one of the factors that enables a country and its company to perform several functions (mainly innovation) that are important for economic development and international competitiveness. Efforts made by the Indonesian government to accelerate infrastructure provision are carried out through regulations on land acquisition, technological innovation, financing, leadership, and coordination between institutions [13].

To achieve a level of technological capability, a company can do so through the company’s internal learning mechanism and by utilizing external learning mechanisms, for example through collaboration with government research laboratories or by networking with other companies [14]. Based on previous studies, mechanism that be used by contractor for technological learning have been obtained from works by [14], [15], [16], [17], [18], [19].

For construction actors in this case contractors, developing a learning mechanism system is generally seen as a technical process [20]. Technological learning strategies play a decisive role in guiding and monitoring the application of firm-level technological capability patterns effectively [16], [12], [21] state that technological capabilities will affect the performance of companies, as well as [16] outline the relationship between learning technology, technological capabilities, and company performance.

Increased understanding of construction technology will help identify opportunities for improvement and help companies seek competitive advantage based on advanced technology [22]. The process of introducing new technology to the construction industry is quite slow when compared to other industries, especially in the field of field process automation using industrial robotics [23]. Companies can improve their technological knowledge and strengthen their technological capabilities through the process of searching and using external technology, [24].

[25] state that, industries in developing countries generally do not have the ability to compete with the latest technology. Important points in terms of technological capabilities, the absorption of higher technology in developing countries cannot be taken for granted. [26] describes at least three barriers experienced by latecomer companies in building technological capabilities namely, not having access to information and knowledge about the latest technological developments, lack of market demand for advanced technology, and research and education infrastructure often not providing companies with graduates trained, and information and knowledge about the latest technological developments.

[27] describes that there are enough people who have conducted studies on technology learning at the international level including the learning process, learning determinants, and modeling of technological learning. However, for Indonesia, studies on this subject are still limited and lead more to interactions in technology learning, technology learning models, and technological learning processes.

[28] said that contractors in carrying out construction projects use a combination of tacit and explicit technology including plant construction and equipment, project engineering, construction and management processes, and intuitive ideas that are included in project design, and managing processes construction. This shows that the contractor can conduct technology learning through the experience of implementing construction projects. [29] describe that through construction projects, individuals can learn through five approaches, namely learning through individual networking; learning through organizing; learning through experimenting; learning through reading; and learning through attending courses and seminars.

For contractors, individual learning needs to be facilitated so that it becomes corporate learning. To facilitate the process, as presented by [17], contractors can perform several mechanisms both at the locus of learning in the project and in the organization through pre-learning system processes, experience accumulation, knowledge articulation, codification/storage, dissemination/distribution.
Based on past research, in conducting technological learning, there are several aspects that need to be examined, namely:

- Factors that influence the contractor so that technological learning needs to be done.
- Factors that hinder contractors in doing technological learning.
- Considerations underlying the contractor in choosing a technological learning mechanism.
- Learning mechanism that is in accordance with the conditions of the contractor.
- Construction engineering elements that are expected to develop through technological learning.

The factors which were identified from research are used as a basis for preparing a questionnaire to investigate the considerations and mechanisms which are the main choices of contractors in developing their technological capabilities.

3. Research Method

3.1. Research methods

Data collection will be carried out by using questionnaire distributed to contractor that had qualification of medium and big in Indonesia. In this study, an ordinal measurement scale 1 to 5 was used to determine the effect level. Respondents were asked to rank factors related to how contractor deploy their technological learning according to the degree of importance.

In this study, the driving factors, obstacle factor, consideration factor, and learning mechanism have 5, 6, and 12 indicators, respectively. These indicators can be seen in Table 1. On the Driving factors, the 1-5 Likert scale indicating answer for “Very Low”, “Low”, “Average”, “Strong”, “Very Strong”; on Obstacle factors: “Yes” or “No”; on Consideration factors and on Learning Mechanism: “Never”, “Rarely”, “Occasionally”, “Frequently”, “Always”; and on construction engineering elements: “Not a Priority”, “Low Priority”, “Medium Priority”, “High Priority”, “Urgent Priority”. For analyzing data by ordinal scale, a relative importance index (RII) was used by following equation (1):

\[
Relative\ \text{Importance} \ \text{Index} = \frac{\sum_{i=1}^{n} W_{i} X_{i}}{\sum_{i=1}^{n} X_{i}} \tag{1}
\]

Where:

\( W_{i} \) = the rating given to each factor by the respondent ranging from 1 to 5

\( X_{i} \) = the percentage of respondents scoring

\( i \) = the order number of respondents

The relative importance index (RII) for all factors was calculated. Meanwhile, the group index was calculated by taking the average of factors in each group [30]. The maximum value of the index is 5 when all respondent answered, “very high effect” and the minimum value of the index is 1 when all respondents answered, “affects with little degree”. Since the results are obtained as decimal numbers instead of integer numbers, a specific scale should be established. Thus, 5 expressions are defined by the intervals of 0.80 to classify the effect level (see Figure 2).
3.2 Data analysis

As a result of surveying, mailing, and following up, a total of 100 questionnaire were returned and can be analyzed further from various district in Indonesia (see Table 1). A close personal contact with contractors is needed due to a lot of item in questionnaire to be filled. The respondents from large contractor (46%) and medium contractors (54%). The classification of large or small and medium contractors is based on valid regulations in Indonesia.

Table 1. Survey area and number of respondents.

| No | Area of Survey                  | Number of respondents |
|----|---------------------------------|-----------------------|
| 1  | West Java                      | 44                    |
| 2  | Jakarta and surrounding area    | 37                    |
| 3  | Western Region                  | 9                     |
| 4  | Eastern Region                  | 10                    |
|    | Total                           | 100                   |

Meanwhile according to their working experience, the majority of respondents (70%) working experience more than 5 years, more over 39% have working experience more than 10 years. The experiences of the respondents include various projects from road and bridges, water building and irrigation, and low-rise buildings to high rise buildings, respondents can choose more than one type of projects (see Table 2).

Table 2. Type of project.

| Buildings < 8 Floors | Buildings > 8 Floors | Road & Bridges | Water Building & Irrigation | Industrial Building | Others | Number of respondents |
|----------------------|----------------------|----------------|-----------------------------|---------------------|--------|-----------------------|
| 31%                  | 10%                  | 33%            | 26%                         | 7%                  | 7%     | 100                   |

4. Result and Discussion

Based on past researches, 32 learning mechanism have been identified and were groups into 3 groups according to their characteristics, namely: 1. Import (6 mechanism); 2. Internal (21 mechanism); 3. Collaboration (5 mechanism). The level of driving factor which influence contractor to deploy technological learning by each group of contractors is presented in Table 3. The first and second rank of the driving factor are same within all, large, and medium contractor, namely client and internal respectively. In all contractor the third rank of driving factor is regulation, in the large contractor is competitor, and in medium contractor is regulation. This is due to the fact that in the medium contractor most of the project acquisition processes do not compete with certain technological capabilities.

Result shows that the regulation is not the main factor that influence contractor to deploy technological learning in all group of contractors. This indicates that the prevailing laws and regulations in general have not been able to stimulate contractors to invest in developing their technological capabilities.
Table 3. The rank of driving factor.

| Group Contractor | Driving Factor | RII  | Effect | Rank |
|------------------|----------------|------|--------|------|
| All contractor   | Client         | 3.96 | Strong | 1    |
|                  | Internal       | 3.89 | Strong | 2    |
|                  | Supplier       | 3.53 | Strong | 5    |
|                  | Regulation     | 3.70 | Strong | 3    |
|                  | Competitor     | 3.58 | Strong | 4    |
| Large            | Client         | 4.09 | Strong | 1    |
|                  | Internal       | 4.04 | Strong | 2    |
|                  | Supplier       | 3.59 | Strong | 5    |
|                  | Regulation     | 3.80 | Strong | 4    |
|                  | Competitor     | 3.83 | Strong | 3    |
| Medium           | Client         | 3.85 | Strong | 1    |
|                  | Internal       | 3.76 | Strong | 2    |
|                  | Supplier       | 3.48 | Strong | 4    |
|                  | Regulation     | 3.61 | Strong | 3    |
|                  | Competitor     | 3.37 | Average| 5    |

The level of obstacle factor which hinder contractor to deploy technological learning by each group of contractors is presented in Table 4. In all contractor groups, the top three factors that hinder contractors from implementing technological learning are budget, lack of staff to support technology adoption, and lack of knowledge about what new technology is available. This result shows that most contractors have not been able to set aside income from the projects they have acquired for the development of the company, especially the development of their technological capabilities. For intermediate contractors, it seems they lack employees who are competent in conducting technological learning. In large contractors, it seems they lack knowledge of the latest technological developments that are in line with their business scope.

Table 4. The rank of obstacle factor.

| Group Contractor | Obstacle Contractor                                      | Number of Contractor | Rank |
|------------------|----------------------------------------------------------|----------------------|------|
| All contractor   | Budget                                                   | 59%                  | 1    |
|                  | Lack of staff to support technology adoption             | 50%                  | 2    |
|                  | Lack of knowledge about what new technology is available | 47%                  | 3    |
| Large            | Budget                                                   | 43%                  | 1    |
|                  | Lack of staff to support technology adoption             | 30%                  | 3    |
|                  | Lack of knowledge about what new technology is available | 39%                  | 2    |
| Medium           | Budget                                                   | 37%                  | 1    |
|                  | Lack of staff to support technology adoption             | 37%                  | 1    |
|                  | Lack of knowledge about what new technology is available | 26%                  | 3    |

The level of learning mechanism considerations used by contractors in determining what technological learning mechanisms are appropriate to the conditions of the company is presented in Table 5. The main consideration factor for all of the contractor groups is market/client/project needs.
Table 5. The rank of learning mechanism considerations.

| Group Contractor | Consideration Factor | RII  | Effect     | Rank |
|------------------|----------------------|------|------------|------|
| All contractor   | Market / client / project needs | 3.82 | Frequently | 1    |
|                  | Based on with the development of the contractor's current needs | 3.78 | Frequently | 2    |
|                  | Beneficial to both parties | 3.77 | Frequently | 3    |
| Large            | Market / client / project needs | 4.15 | Frequently | 1    |
|                  | Based on with the development of the contractor's current needs | 4.13 | Frequently | 2    |
|                  | Beneficial to both parties | 4.09 | Frequently | 3    |
| Medium           | Market / client / project needs | 3.56 | Frequently | 1    |
|                  | Based on with the development of the contractor's current needs | 3.52 | Frequently | 2    |
|                  | Beneficial to both parties | 3.52 | Frequently | 2    |

The level of use by contractors to each group is presented in Table 6. In all contractor the level of use by all contractor in chronological order are: import, internal, and collaboration. While in medium contractor reflects the same order as in all contractor, the large contractor use internal as its main learning mechanism. The results indicate that medium contractors have not carried out continuous technological learning. The top three of learning mechanism that frequently used by contractor to develop their technological capability are introducing a formal Quality Management system; documenting and analyzing all data and information related to project acquisition and project implementation; and participating in technology exhibitions.

Table 6. The rank of group mechanism of all companies.

| Group Contractor | Group mechanism | RII  | Effect     | Rank |
|------------------|-----------------|------|------------|------|
| All contractor   | Import          | 3.43 | Frequently | 1    |
|                  | Internal        | 3.29 | Occasionally| 2    |
|                  | Collaboration   | 2.92 | Occasionally| 3    |
| Large            | Import          | 3.58 | Frequently | 2    |
|                  | Internal        | 3.69 | Frequently | 1    |
|                  | Collaboration   | 3.29 | Occasionally| 3    |
| Medium           | Import          | 3.31 | Occasionally| 1    |
|                  | Internal        | 2.95 | Occasionally| 2    |
|                  | Collaboration   | 2.61 | Occasionally| 3    |

The priority level of the construction engineering elements that are expected to develop from the implementation of technological learning is presented in Table 7. As expected, the main construction engineering element by which hopefully to be improve as an output from the deployment of technological learning is construction methods which is reflected in all group of contractors. While in large contractor the second priority is the development of construction equipment, in medium contractor the development of principles of construction engineering is the second priority.
Table 7. The rank of construction engineering element.

| Group Contractor | Construction Engineering Element | RII  | Effect          | Rank |
|------------------|----------------------------------|------|-----------------|------|
| All contractor   | Principles of Construction Engineering | 3.66 | High Priority   | 2    |
|                  | Construction material            | 3.58 | High Priority   | 4    |
|                  | Construction Equipment           | 3.62 | High Priority   | 3    |
|                  | Construction Methods             | 3.92 | High Priority   | 1    |
| Large            | Principles of Construction Engineering | 3.83 | High Priority   | 3    |
|                  | Construction material            | 3.70 | High Priority   | 4    |
|                  | Construction Equipment           | 3.87 | High Priority   | 2    |
|                  | Construction Methods             | 4.13 | High Priority   | 1    |
| Medium           | Principles of Construction Engineering | 3.52 | High Priority   | 2    |
|                  | Construction material            | 3.48 | High Priority   | 3    |
|                  | Construction Equipment           | 3.41 | High Priority   | 4    |
|                  | Construction Methods             | 3.74 | High Priority   | 1    |

5. Conclusion

Contractors carry out technological learning mainly because of client demands and internal needs. Constraints that generally apply to contractors in implementing this policy are related to budgets, employee capabilities, and proper knowledge of the latest technology. In addition to stimulation of influence factors, contractors also have certain considerations in determining what mechanisms will be used in implementing technology learning. The main consideration is what technology can meet market / user / project needs. This is in line with the findings of the influence factor. The technology learning mechanism used by contractors is generally more about learning from parties outside the contractor. Although all elements have a high priority level, especially construction methods, this shows that in general the contractor has not been able to distinctly determine what elements should be prioritized.

Acknowledgements

The authors would like to greatly appreciate the willingness of all respondent from various companies/institutions who took their valuable time to answer the survey that made this research possible.

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