Knowledge, skills and attitudes of civil engineers in Indonesia

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Abstract. Civil engineer plays an important role in construction industry because they have been entrusted to create sustainable world and to enhance the quality of life. In order to play their role successfully, civil engineer needs to possess many and varied knowledge and skills, as well as supported by embracing attitudes. This study is aimed to explore the importance and achievement of attributes of civil engineers based on profile of the 2025 civil engineer that has been launched by American Society of Civil Engineering (ASCE). The attributes consist of 21 points those are organized into the categories of knowledge, skills, and attitudes. The research was conducted by asking respondents to fill out a questionnaire to assess the importance and performance of each attribute. The data has been collected from 100 practitioners who work in various construction companies in Indonesia. Descriptive Statistic, Importance Performance Analysis (IPA) and correlation analysis have been implemented to analyze the data. The study found communication is considered as the most important attribute and in a highest performance. Thoroughly the Spearman Rank Correlation analysis shows the level of importance and performance have a strong and positive correlation. However, the importance and performance level of knowledge about sustainability only in the rank of 16 and 18. This result shows that in Indonesia knowledge about sustainability has not been considered important.

1. Introduction
Civil engineering plays an important role in people’s life because it is the field responsible for providing and maintaining physical assets that is needed for people’s daily activities. The construction of buildings, facilities of transportation, systems of drainage and sewage definitely cannot be separated from the role of civil engineering [1]. In addition, several developments, such as globalization, sustainability, new technology and project complexity forces the change of the manner in which civil engineering is implemented [2].

Talking about civil engineering cannot be separated from the role of civil engineers as the main players in carrying out the civil engineering. Civil engineers play various roles in civil engineering, such as land surface mapping, design of various kinds of structure, project supervision, project planning, project management, etc. [1]. In order to meet these demands, civil engineers are required to have competencies in several areas of civil engineering. These competencies must be continuously developed along with the development in the construction industry that are changing rapidly.

In order to deal with rapid changing in civil engineering, The American Society of Civil Engineers (ASCE) has published the Civil Engineering Body of Knowledge. This Body of Knowledge determines the breadth and depth of knowledge, skills, and attitudes which becomes the requirement for engineers
to involve at the professional level of civil engineering practice in this century [3]. This Body of Knowledge has been referred for the implementation of civil engineering in several countries.

In Indonesia, civil engineering education has been carried out for almost 100 years since 1919. Although civil engineering has an important role in the development of the construction industry in Indonesia and has been carried out in Indonesia in a relatively long time, there is little research effort focused on the important issues of civil engineering. Therefore, this study is directed to bridging the gap in civil engineering research in Indonesia by exploring the importance and achievement of civil engineers’ competencies. Particular circumstances of civil engineering in Indonesia will influence this study because the data is collected from the experiences of civil engineers in Indonesia. Furthermore, special focus on the competencies that relate to sustainability issues will be carried out in order to meet the important issues that currently get special attention in the construction industry around the world.

2. Literature review

Civil engineering has great and significant effects to peoples’ life. The procurement of all facilities for people’s daily activities such as buildings, transportation facilities, drainage and sewage systems involving civil engineering. In order to meet this responsibilities, civil engineer as a person who involve intensively in civil engineering’s activities has several duties as explained here [1].

- Earth’s surface measuring and mapping.
- Design and supervise the construction of several structures, such as: bridges, tunnels, large buildings, dams, and coastal
- Plan, construct and maintain transportation facilities
- Design traffic systems
- Plan and build river navigation and flood control projects
- Provide water supply and sewage plants and systems

The challenge of civil engineers is not only to have competencies to meet the current demands of their profession only. Civil engineers realize that they cannot stay in the current condition because civil engineering changes continuously in many aspects. In order to deal with this situation, ASCE had an initiative to conduct the Summit on the Future of Civil Engineering in 2006. The summit attended by civil engineers and engineers from various other disciplines such as: architects, educators, the executives of association and society. The participants are not from the United States only but also from eight other countries. The Summit has a purpose to articulate an aspirational global vision for civil engineering in the future. The summit participants see the civil engineers’ world will be very different and even more challenging in 2025. In addressing the issues of ‘what could be done by civil engineers in 2025?’, the summit participants defined the profile of civil engineer in 2025. This profile mandates that civil engineers must be knowledgeable, skillful and embraces conducive attitudes to achieve professional practices [4].

Finally, the summit participants identified 21 attributes that are grouped into three categories of knowledge, skills and attitudes. Those attributes are presented as follows.

Knowledge

1. The basic knowledge of engineering such as: Mathematics, physics, chemistry, biology, mechanics, and materials
2. Design of structures and systems
3. Managing uncertainty and risk
4. Sustainability and its dimensions such as: social, economic, and physical
5. Public policy and public administration, including the process of politic, regulations, laws and mechanisms of funding
6. The basis of business such as economic and legal aspects of business, market and marketing
7. Social sciences such as economics, history, and sociology
8. Ethical behavior that upholding client confidentiality, code of ethics and profession responsibility

Skill
1. Implementing tools of basic engineering, such as statistics, computer modeling, codes and standards, and project monitoring
2. Mastering new technologies to increase effectiveness and efficiency of individual and organization
3. Communication to the audiences with several different background
4. Cross, intra and multi-disciplinary collaboration both traditionally and virtually
5. Managing projects to meet budgets, schedules and other constraints
6. Leader that formulating and articulating environmental issues by practicing inclusive, empathy, compassion, persuasive, patience behaviors, and thinking critically.

Attitudes
1. Entrepreneurship that encourages a creative and proactive actions
2. Commitment to the ethics and to the individuals and organization's goals
3. Curiosity that encouraging continuous learning and developing
4. Honesty, integrity and rightness
5. Optimism, committed, tenacity and flexible
6. Respect and tolerate the rights and values of others
7. Accuracy and self-discipline in keeping with the implications of safety, public health and welfare, as well as interdependence within and between project teams and with project stakeholders

3. Research methodology

3.1. Data collection
Data was collected using questionnaire that was filled by engineers that have been worked in various construction companies for several years. The first part of questionnaire consists the questions about respondent’s background, while the second part is the main part of the questionnaire that consists of questions about the competencies of civil engineers. The questions in second part were developed based on 21 attributes of civil engineers’ competencies that are proposed by ASCE [4].

The questionnaire was distributed to the respondents that working for various construction companies in Indonesia. The distribution and filling in the questionnaires are carried out with an online system through WhatsApp application and e mail.

3.2. Data analysis
The data of civil engineers’ competencies has been analyzed using several different methods. First, descriptive statistic has been implemented by calculating mean and standard deviation of each competency both for its importance and performance. Based on mean value, the rank of each competency is assigned. Then the rank of importance level and performance level are compared using Spearman Rank Correlation method.

Furthermore, this study also adopted Importance – Performance Analysis (IPA) that initially developed by Martilla and James [5] to carry out assessment in the field of marketing. Recently this method is still widely applied in various fields, such as: banking industry [6], project management [7]. The output of IPA will be Importance – Performance Matrix (IPM) as can be seen in figure 1. The vertical and horizontal axis of the grid are represented the importance measure and the performance measure. The grid is divided into four quadrants that each quadrant calls the different strategy. In this study, each quadrant represents the strategy for improving the competencies of civil engineers.
4. Research findings

The data has been collected from 100 civil engineers who works in various construction companies such as: contractors, consultants and suppliers, as well as works as civil servants and entrepreneurs in construction. Several statistical methods have been implemented to analyze the data. Finally, several results have been found and these findings is presented in the following parts. Based on this findings, further and deeper discussions will be carried out.

4.1. Importance and performance rank

The descriptive analysis results mean, standard deviation and rank of each attribute, as well as each group of attributes. All results of descriptive analysis are presented in table 1. The result of descriptive analysis shows communication is the attribute that has highest mean in both importance and performance. This result shows that communication is considered as the most important attribute for civil engineers in Indonesia, and they also have highest performance in communication.

Surprisingly, knowledge is ranked in the lowest position, because it has lowest group mean compared to skill and attitude. This finding shows that to be a knowledgeable civil engineer only is not adequate. Good civil engineers must be skillful and have good attitudes.

Considering environmental sustainability, this study gives special attention to the competency of civil engineers that relates to the environmental issue. Currently environmental sustainability becomes an important issue in construction industry around the world because construction process produces waste that potentially becomes an environmental burden [8]. Among 21 attributes of civil engineers’ competencies that have been adopted in this study, sustainability is one of them. According to this standard, civil engineers are required to understand the overall concept of sustainability, from several different dimensions, such as physical, social and economic. However, this study found among 21 attributes, sustainability in the rank of 16 for its importance and the 21 for its performance. This finding shows that sustainability as the important issue has not received adequate attention in Indonesian construction industry.

The direct comparison between means of importance and performance are illustrated in figure 2 and figure 3. The comparison shows that in all attributes, the performance of civil engineers in Indonesia is higher than their importance. The Spearman Rank Correlation also carried out to measures the strength and direction of association between ranks of the importance and the performance of civil engineers’ competencies. The analysis found the correlation coefficient of 0.892. This value indicates a strong...
positive association between the ranks importance of competencies and their performance. It means the higher ranks in importance, the higher rank in performance.

Table 1. Importance – performance of civil engineers’ competencies.

| Code | Competencies                                           | Importance | Performance |
|------|--------------------------------------------------------|------------|-------------|
|      |                                                        | Mean   | SD    | Rank | Mean | SD  | Rank |
| K1   | The foundation of engineering                          | 3.03   | 0.84  | III  | 3.06 | 0.74 | 20   |
| K2   | Design                                                 | 3.26   | 0.72  | 11   | 3.44 | 0.70 | 10   |
| K3   | Risk/uncertainty                                       | 3.02   | 0.82  | 17   | 3.34 | 0.82 | 17   |
| K4   | Sustainability                                         | 3.10   | 0.81  | 16   | 3.3  | 0.79 | 18   |
| K5   | Public policy and administration                       | 3.02   | 0.82  | 18   | 3.2  | 0.81 | 19   |
| K6   | Business basics                                        | 2.96   | 0.90  | 20   | 3.34 | 0.77 | 16   |
| K7   | Social sciences                                        | 2.68   | 0.89  | 21   | 2.74 | 0.88 | 21   |
| K8   | Ethical behavior                                       | 3.20   | 0.90  | 15   | 3.4  | 0.83 | 13   |
|      | Knowledge                                              | 3.23   | 0.74  | II   | 3.53 | 0.71 | I    |
| S1   | Apply basic engineering tools                          | 3.26   | 0.75  | 12   | 3.4  | 0.70 | 12   |
| S2   | New technology                                         | 3.32   | 0.74  | 7    | 3.54 | 0.76 | 5    |
| S3   | Communication                                          | 3.50   | 0.51  | 1    | 3.78 | 0.42 | 1    |
| S4   | Collaboration                                          | 3.30   | 0.81  | 8    | 3.42 | 0.84 | 11   |
| S5   | Manage tasks, projects, and programs                   | 3.36   | 0.75  | 5    | 3.58 | 0.70 | 2    |
| S6   | Leadership                                             | 3.22   | 0.82  | 13   | 3.46 | 0.71 | 8    |
|      | Skills                                                 | 3.34   | 0.73  | I    | 3.48 | 0.72 | II   |
| A1   | Creativity and entrepreneurship                        | 3.22   | 0.79  | 14   | 3.38 | 0.75 | 14   |
| A2   | Commitment to ethics and goals                         | 3.30   | 0.76  | 9    | 3.54 | 0.68 | 4    |
| A3   | Curiosity                                              | 3.28   | 0.78  | 10   | 3.38 | 0.75 | 15   |
| A4   | Honesty and integrity                                 | 3.44   | 0.73  | 2    | 3.58 | 0.73 | 3    |
| A5   | Optimism                                               | 3.40   | 0.67  | 3    | 3.52 | 0.71 | 7    |
| A6   | Respect for and tolerance of others                    | 3.38   | 0.67  | 4    | 3.44 | 0.73 | 9    |
| A7   | Thoroughness and self-discipline                       | 3.34   | 0.72  | 6    | 3.52 | 0.68 | 6    |

Figure 2. Bar-chart of importance – performance.
4.2. Importance and Performance Matrix

In this study, the IPM is developed by plotting the means of importance and performance of civil engineers’ competencies in the grid. The horizontal axis represents the performance, while the vertical axis represents the importance of civil engineers’ competencies. The IPM of civil engineers’ competencies as one of the findings of this study is drawn in Figure 4.

The IPA Matrix shows that all competencies are in quadrant 2 that calls for a good condition, in which the importance is high and the performance is also high. This result shows, in general, civil engineers in Indonesia perform good competencies in the competencies that are considered very important. The appropriate strategy for this condition is to keep up this condition and even strive to improve its performance.

5. Conclusions

The study found skills and attitudes are considered as the competencies of civil engineers that are more important compared to knowledge. Among 21 attributes of competencies, communication is considered
the most important. Similar to the importance of competencies, the performance of civil engineers in Indonesia also good in skills and attributes compared to knowledge. The best performance also found in communication. The other finding shows the importance and the performance for all attributes of competencies have a strong positive association. The IPM shows that all attributes of competencies are located in quadrant two that means all of them are high in importance and also high in performance.

This study contributes valuable contribution to the civil engineering education. The higher education institutions that offer civil engineering program can consider the findings of this study in their curriculum. The construction company can use the findings of this study to develop the program for human resources development.

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