Study on sustainable design awareness

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Abstract. Sustainable design meaning defined by the contextual problems, chosen approaches, and the available solutions. The definition of them is very valuable for the education subject matters. This paper investigates the awareness of sustainable design in building and construction services community in Jakarta, to develop a contextual concept which has been a concern since the advent of global warming issues, in an interpretive approach. The community, which consists of professionals and academics in Jakarta – Indonesia, surveyed through online questionnaires to gather as much as possible evidence about the applied sustainable design concepts on the reality. The properties and dimensions of the sustainable design rely on the respondents’ view.

Keywords: sustainability, awareness, factors, AECFM, education

1. Introduction
Knowing, understanding, and implementing sustainable design concepts is a comprehensive education goal, especially in the fields of architecture, engineering, construction, and facility management (AECFM). Sustainability design in building and construction services establishes from best practices and researches, even character development, which emphasizes specific program objectives. Recently, Architecture 2030 – a non-profit organization, notes that buildings in the US consume almost half of all energy produced and contribute nearly half of the CO₂ emissions[1]. Then the National Institute of Building Science (NIBS) [2] initiates six fundamental principles of sustainable design to counter the issues. These threats are cross-disciplinary challenges throughout the world, which require each stakeholder to dramatically reduce the negative impacts on the environment. Now, each discipline highlights environmental issues with specific concepts and approaches, which eventually, the emergence of challenges will refine their understanding.

Education can effectively develop one’s mind. In several ways, the results manifested in works or creations. This formal education period provides space to explore the challenges of sustainable design. These processes initiate creative problem-solving. Gürel [3] exemplifies design studios that introduce sustainability with various levels of complexity, which will be a dynamic medium in learning. His research explains that studio experience can increase awareness of sustainability as a multidimensional concept and embrace a design that is responsible for the environment. Deniz [4] states that sustainable design consists of three principles, including economy of resources, life cycle design, and socially responsible design.
However, sustainable design literacy must align between education and professional practice. This paper discusses awareness among professionals in their working context by distributing online questionnaires. The investigation examines three categories, including understanding, activity, and motivation, where each section contains two questions, and the answers interpreted into dimensions. This questionnaire, however, cannot embrace many stakeholders who might make it a theory. The research merely focuses on the cognitive activities of respondents who construct a sustainable design awareness. The results will help contextualize knowledge, stay up-to-date on concepts, here in Jakarta.

2. The Landscape of Sustainable Design Concepts

2.1. Sustainable in Architecture and Design
Guy et al. [5] declare sustainable architecture from their social constructivist perspective by adopting an interpretive framework, and by exploring the notion of discourse. They highlight the social production of space, place, and environment, and argue that the concept of green building is a social construction, whose discourse develops dynamically. The logic of alternative ecological design they proposed, which is a means of raising awareness of their environmental problems, is built with the aim of understanding how sustainable design is made, legitimized and contested for a broader context where more heterogeneous practice coalitions can be developed.

Another research focuses on the designer – interior designer, who apply environmentally sustainable interior design criteria. Kang and Guerin[6] seek a relationship between the designer and how often the criteria were used, and the degree of importance of sustainability in the design practice. The larger the project, the greater the use of sustainability characteristic. The study also reports that there is a significant relationship between interior designer characteristics and how important environmentally sustainable interior design practice is to designers, but not to the designer’s firm.

Meanwhile, Gürel[3] observes and evaluates what is going on in the studio. Initially, he found that the students felt obliged to use engineering approaches before they were finally realized and perfected by the accumulation of dimensions and properties that became an emphasis on sustainable design. The use of natural light, the development of space, and energy efficiency became the top three aspects that the students applied in their projects.

2.2. Sustainable in Engineering
On the engineering field, Allenby et al [7] focus their research to develop the sustainable engineering education which rooted from experience such as green engineering and industrial ecology, as well as design for environment and life cycle assessment methodologies where all of them are quantifiable that suited engineering perspective. However, the challenges emerged from the substantive gap which is less quantifiable such as engagement to social dimensions.

The next development is done by Cliff et al [8], that escalates the earth's resources as an endangered aspect caused by the increasing global population. The demands of the materials and the energy have been the issues as well as the waste products that engineering must be addressed. Preparing the future engineers are their aim to sustainable engineering challenges by revising courses and curricula. They conducted workshops to boost the engineering education transition. The agenda that The Center for Sustainable Engineering (CSE) carried was starting by the introduction and goals of the education transition. They emphasize some area such as energy – the efficiency, the renewable and the alternate; ecology; manufacturing, materials and design; structures, construction, and infrastructure; emission and waste; also, air and water resources.

2.3. Sustainable in Construction
In contrast, Ding's research[9] stated that the construction process had been accused of causing environmental problems. Therefore, an assessment is needed to reduce the impact of the initial stage. Ding compares several assessment methods and characteristics around the world that are used as design tools. In conclusion, he stated several dimensions such as the efficient allocation of resources, minimum energy consumption, low energy intensity contained in building materials, reuse and
recycling, and other mechanisms. There are many other aspects involved because building construction is a complicated decision and causes an increase in environmental problems. This is a gap where the social dimension is present and cannot be easily quantified for assessment.

2.4. Sustainable in Facility Management

In global climate change, sustainable design has become a mainstream building design goal in recent years. The efforts that have been done are not easy. Traditional CAD-based facility management process is time-consuming and expensive. Therefore, significant work must still be done which results in the examination being unreliable and more difficult to follow. Building Information Modeling (BIM) is an ideal concept in improving the quality of design and building performance, by optimizing the delivery of information [10]. The two main features of BIM that are useful in sustainable building design are integrated projects delivery (IPD) and optimization design.

ALwaer and Clements-Croome proposed a conceptual model of intelligent buildings Key Performance Indicators (KPI) to facilitate sustainability assessment [11]. The KPIs conclude in three dimensions such as environmental, socio-cultural and economic indicators which carried out by various stakeholders. These KPIs have the potential to provide useful lessons from current sustainability assessment methods for a strategic future to improve building performance and provide objective results.

3. Methods

Data on sustainable design awareness was collected using an online questionnaire to obtain the quality of understanding from respondents across Jakarta. Then, categorizing qualitative data is the interpretation that becomes the structure of dimensions. Followed by corresponding data interpretation blocks to find implicit phenomena. These properties are then quantitatively analyzed to concept the sustainable design awareness. The concept emerges within the context of building and construction service practitioners, as well as the contribution of academic respondents.

3.1. Respondents

There are 31 respondents gave their views on this topic represent Architecture Engineering Construction and Facility Management (AEC FM) field, including academics. They come from the building and construction services community in Jakarta who have diverse educational backgrounds and competencies. Figure 1 shows the respondent's education level, and Figure 2 reflects the respondents' expertise certification. It clearly shows that the architect's point of view will contribute significantly to this survey. Although, the focus of this research does not lie in how much a person's comprehension is, but rather on the quality of the understanding.

**Figure 1.** Respondent education.

**Figure 2.** Respondent certification.
3.2. Questionnaire settings

There are three sections in the questionnaire to explore the sustainable awareness inside the respondent’s mind. The first of the questionnaire section is concerning the respondent viewing regarding sustainable design concept, also explores the factors of sustainable design that respondents aware. The questions are “What do you think/understand about the principle of sustainable design?” and “What are the factors in sustainable design that you aware in your working process?” The qualitative answers interpreted as keyword themes and factors, respectively.

The second section investigates the significant factor they observe, also have they contribute to apply them, as applications categorization. Questions like “What is the significant factor?” and “What is the factor applied in most of your working process? Please explain within an example” were asked to collect the applicable factors which occurred in their project.

The third section questions the significance of sustainable design on their project and their living environment. There are two questions asked: “To what extent the sustainable design concept is significant to your project? Please explain within a project example” and “To what extent the sustainable design concept is significant to your living environment? Please explain your answer”. Their answers concluded into project-centered reasons and environmental reasons categorizations.

These series of the question have related one another to describe the understanding, action, and motivation beneath. The open-ended questions were chosen to explore quality over quantity, to anticipate the small number of respondents involved in the community.

4. Results and Discussions

The results of the questionnaires interpreted into categories provide new opportunities to see the picture that occur in the field. There are at least seven correspondences that analyzed to build the dimensions of each sustainable design awareness properties. They are understanding, action, and motivation which summarized in Table 1 below. On the following subsections, each correspondence is analyzed and described. The JMP 14 bubble plots are chosen to visualize the data, by fitting two variables at a time.

Table 1. Correspondences of sustainable design awareness properties.

| Understanding                  | Action                          | Motivation                         |
|--------------------------------|---------------------------------|------------------------------------|
| • Keyword Themes by Factors    | • Factors by Applications       | • Applications by Project-centered Reasons |
| • Industry by Factors          | • Industry by Applications      | • Applications by Environmental Reasons |
| • Industry by Significant Factor |                                |                                    |

4.1. Keyword Themes by Factors Correspondence

Open-ended questionnaires indeed open a vast possibility to see what is going on in the field of building and construction services. At least there are 48 factors interpreted, and six themes built from the data. The most intersecting factor with the themes is the environment, as shown in Figure 3, that represented by all darker bubbles. The environment seems to be a central consideration in terms of conducting sustainable design decisions. Second place most important is the group of factors relatively represented by five bubbles. They are cultural, energy and social factors. The energy conservation emerges as an understanding to efficiently use the produced energy, while the resources conservation understanding is to conserve the raw materials for both the renewables and the non-renewables.

In the meantime, BIM as a tool to aid the sustainable design process, gain the least representation on the analysis. It seems BIM has not reached its potential to support design sustainability in Jakarta. On the contrary, respondents believe that sustainable design best achieved by an integrated solution.
4.2. Industry by Factors Correspondence
Next is the correspondence of industry by factors (see Fig. 4) that shows the convergences of factors in several areas. The earlier prediction of the architect and the academics domination have denied by this figure. The construction practitioners explain an extensive range of factors. Energy, environment and materials are mentioned frequently amongst other factors across industries, but in the construction field, there are more factors described by the respondents. As Ding [9] explained that construction industries impact many hazardous factors in the process. Certainly, respondents in this field are fully aware of what they do in terms of sustainability. This perspective mostly derived from the willingness of the actors to get involved in creating a better environment.

4.3. Industry by Significant Factor Correspondence
Based on the data acquired, there are 9 significant factors responded most. Energy and environment become significant factors that discussed by the most respondents. On Figure 5, bubble plots concentrate on the environment factor significantly on the architecture and construction industries. Clearly, both industries are the main drivers of sustainable design, especially on energy consumption and environmental impacts. On the education, the discussion of significant factors looks more evenly distributed in general. However, there are several factors that matter in the AECFM industry which has not received sufficient attention. The curriculum should cover more factors such as air, management, material, and technology. Of course, these factors have the potential to be developed in education to support the professional industry.
Figure 5. Bubble plot of industry by significant factor.

4.4. Factors by Applications and Significant Factor by Applications

Correspondence

This subsection discussion captures the application of the factors that respondents have done in their contribution to sustainable design, as illustrated in Figure 6. Building design and materials applications are actions that are often carried out in sustainable design efforts. Those factors seemingly answer the circumstantial problems and the available solutions. On the other side, controlled construction, good project management, and resources efficiency are shown as difficult solutions to execute in real conditions. Significantly, economic and managerial factors are the most influential factors in each application category. There seems to be a non-technical problem that is strong enough to provide changes in decisions in the field related to these two factors.

Figure 6. Bubble plot of factors by applications.
Even though in the significant factor categorization (see Fig. 7), environment factor is embodied almost in all sustainable design applications, and materials applications are still the most widely applied solutions. What is interesting is that many of the application carried out in each industry have done so based on company policies under the office campaign. The distribution of plots in the office campaign application occurs in matters relating to the environment, human resources, management, and technology. The distribution of plots in the office campaign application governs in matters relating to the environment, human resources, management, and technology. It means that the company has tried to initiate the awareness, and shared social engagement. These efforts require broader socialization between industries so that the meaning has more impact on the environment. In addition, best practices in the industry can support the government programs.

![Figure 7. Bubble plot of significant factor by applications.](image)

4.5. Industry by ApplicationsCorrespondence

As stated in subsections 4.2 and 4.3, the architectural and construction industries are the main actors who play an active role in sustainable design. Figure 8 shows their roles in many applied categories. In addition to the materials application category, building design is also an action that has a significant impact on achieving sustainable design across industries. It means that both of the above applications have been widely recognized and applied well. Although there are still many other potential applications that have not been done by many building and construction industry players. Likewise, there are still many unexplored applications in the education domain. Industrial and academic collaboration seems to be a way to optimize awareness of sustainable designs that have a real operational impact.

![Figure 8. Bubble plot of Industry by Applications.](image)
4.6. Applications by Project-centered and Environmental Reasons Correspondence

In this subsection, the presented description is the motivation behind the awareness of the respondents in implementing the sustainable design. From the data collection, the analysis of application category in Figure 9 and Figure 10 is still dominated by building design, both in correspondence with the project and the environment. It means, respondents who choose to carry out sustainable design control through building design, have many reasons for the benefit of the project, as well as environmental interests. Additionally, that respondents who applied waste management in their projects also had strong reasons in favor of sustainable design in their projects. Design quality, health, cost, energy and measurable success are some of the motivations behind the effort to accomplish the sustainable design.

Whereas, the application of other categories is more scattered. Low environmental impact and reducing electricity bills are the main reasons that encourage respondent’s awareness on the Project-centered categorization analysis. Meanwhile, environmental quality becomes a significant reason for people to implement sustainable design.

Figure 9. Bubble plot of applications by project-centered reasons.

Based on the project-centered reason categories (Fig. 9), the motives categorize into three groups. The first is a group of reasons that oriented to the needs of the project (project-oriented). The second group is the reasons oriented to fulfill the client’s request (client-oriented). Lastly, is a group of reasons that indeed built on the company policy (company-oriented).

On the environmental reasons correspondence – Figure 10, the motive is clustered into two groups. First, there are a number of reasons that focus on implementing sustainable designs for the benefit of the present, which grouped as hodiurnal motivation. In the second cluster, the reasons emphasis on the urge to prepare a better future for the environment. The motivation is known as future-oriented. Arguably that both motivations equally play a role in building the character of stakeholders.
Figure 10. Bubble plot of applications by environmental reasons.

5. Conclusions
The Jakarta's growth is increasingly complex, creating new challenges that have an impact on the environment. Based on this research, several important results exposed as the knowledge that shapes awareness of sustainable design, especially in building and construction services. Listed in Table 2 below, are the properties and dimensions of sustainable design awareness that are increasing in this community. The list below cannot be considered a rigid definition, but rather as a discourse for further development which is more sensitive to explore possibilities that are untouched.

Table 2. Sustainable design awareness properties and dimensions.

| Understanding                       | Action                          | Motivation                        |
|-------------------------------------|---------------------------------|-----------------------------------|
| Energy conservation                 | Building design                 | Natural lightings                 |
| Environmentally friendly            | Controlled construction         | Office campaign                   |
| Future-oriented                     | Cost estimating                 | Performance evaluation            |
| Integrated solution                 | Design savings                  | Reducing construction impact      |
| Resources conservation              | Efficient mobility              | Reducing operational cost         |
| Technical responsibility            | Feasibility study               | Reducing operational impact       |
|                                     | Good project management         | Resources efficiency              |
|                                     | Greenery coverage               | Technology approach               |
|                                     | Materials application           | Waste management                  |

Environmental reason:
- Project-centered reason:
  - Project-oriented
  - Client-oriented
  - Company-oriented
- Environmental reason:
  - Hodiernal
  - Future-oriented
Three major findings determined from this study:

- The dimensions of sustainable design awareness from the respondents’ point of view are quite extensive. Nonetheless, there are many factors still requires intensive attention;
- The described applications seem to be repeated actions that concentrate on specific factors. There is room for breakthroughs such as a multidimensional performance;
- The motivation that shapes sustainable design awareness should synergize between interests, which will make it a shared social responsibility.

The overview of sustainable design concept in Jakarta presented through this text. The academic curricula could develop their subject matter from these potential discourses. Prepare graduates with the best practices and breakthrough to untouched niches, so that they can have a real impact and knowledge dissemination in every dimension of sustainable design.

References

[1] Architecture 2030 2013 Why the Building Sector? Archit. 2030 http://architecture2030.org/buildings_problem_why/
[2] The WBDG Sustainable Committee 2018 Sustainable Whole Build. Des. Guid. - a Progr. NIBS https://www.wbdg.org/design-objectives/sustainable
[3] Gürel M Ö 2010 Explorations in teaching sustainable design: A studio experience in interior design/architecture Int. J. Art Des. Educ. 29 184–99
[4] Deniz D 2016 Sustainable Thinking and Environmental Awareness through Design Education Procedia Environ. Sci. 34 70–9
[5] Guy S and Farmer G 2001 Reinterpreting sustainable architecture: The place of technology J. Archit. Educ. 54 140–8
[6] Kang M and Guerin D A 2009 The characteristics of interior designers who practice environmentally sustainable interior design Environ. Behav. 41 170–84
[7] Allenby B, Murphy C F, Allen D and Davidson C 2009 Sustainable engineering education in the United States Sustain. Sci. 4 7–15
[8] Davidson C I, Hendrickson C T, Matthews H S, Bridges M W, Allen D T, Murphy C F, Allenby B R, Crittenden J C and Austin S 2010 Preparing future engineers for challenges of the 21st century: Sustainable engineering J. Clean. Prod. 18 698–701
[9] Ding G K C 2008 Sustainable construction-The role of environmental assessment tools J. Environ. Manage. 86 451–64
[10] Wong K and Fan Q 2013 Building information modelling (BIM) for sustainable building design Facilities 31 138–57
[11] ALwaer H and Clements-Croome D J 2010 Key performance indicators (KPIs) and priority setting in using the multi-attribute approach for assessing sustainable intelligent buildings Build. Environ. 45 799–807

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