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Sustainable Construction — An International Comparison of Civil Engineering Students

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Abstract: Sustainable construction in the future will be influenced significantly by the beliefs and actions of civil engineering students studying at university today. A comparative investigation of the appreciation and attitudes regarding sustainable construction of civil engineering students at The NUCE (National University of Civil Engineering) in Vietnam, and the Universities of Loughborough and Liverpool in the UK were therefore conducted. Results indicate that students at all three universities appreciate the importance of the development of sustainable construction and have positive attitudes with regards to sustainability. Construction design and appropriate use of materials were two issues generally considered the most important with regards to sustainability, but were also thought to be adequately covered on the courses in all three institutions.

Key words: Sustainable construction, education, sustainability, civil engineering, Vietnam, UK.

1. Introduction

World population has increased from only one billion in 1804 to nearly seven billion in 2008, and it is estimated that it will be around nine billion by 2050 [1]. Furthermore, about 50% of the population currently lives in and around cities rather than in rural areas. This population explosion, together with increased urbanization, place enhanced demand on accompanying infrastructure such as houses, bridges, roads, water supply, sanitation utilities, and other infrastructures. Building and construction activities worldwide alone consume three billion tonnes of raw materials each year — around 40% of the global total [2]. Exploiting these natural resources together with producing construction materials can seriously affect our natural environment. This impacts directly upon water and natural mineral reduction, as well as being the cause of significant global pollution. It is therefore essential that development in construction practices

becomes more sustainable. Weaning the world's countries off its increasing use of finite natural resources is therefore crucial for the sustainable development of the planet. Good examples do exist however, of how developing countries have reigned back their consumption of natural resources, hence are developing in a more sustainable manner [3]. Moreover, countries and economies need to seek and develop new and more sustainable routes to energy development which are more in synergy with the environment and complement it rather than constrain (or damage) it [4]. If the world's population is to continue to develop on its current upward course then new and innovative ways of housing, feeding and fuelling the world's population need to be found [5].

There are many definitions of sustainable development and debate regarding its precise definition continues. However, a common view of the main components of sustainable development appears to be in agreement: the integration of economic, environmental and social elements [6–9]. These three main parts can be symbolized as the “triple bottom

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line” (Fig. 1). Other sustainable development descriptions have placed the social and economic “circles” within a larger environmental background, to symbolize the extent to which environment provides an overall constraint on development (Fig. 2).

The following definition for sustainable development in construction, from the Institution of Civil Engineers is widely used: “Sustainable construction refers to the creation, maintenance and operation of infrastructure and buildings that shape communities in a way that sustains the environment, generates long term wealth and enhances the quality of life” [7]. More importantly, a sustainability-driven approach to civil engineering leads to the adoption of the following key objectives in practice [7]: reducing the environmental impact while improving the environmental quality, maximizing the utilization of materials and their reuse, maximizing efficient use of secondary and recycled materials, minimizing waste

in design, construction and use, minimizing energy and water use, minimizing pollution from all our activities, focus on increasing peoples’ quality of life, ensuring respect for people, showing care towards the workforce and the surrounding community. In addition, the UK’s Strategy for Sustainable Construction in 2008 identified 11 key issues for the development of sustainable construction in the UK, namely: Procurement, Design, Innovation, People, Better regulation, Climate change mitigation, Climate change adaptation, Water, Biodiversity, Waste, and Materials [10].

In 2010, first-year higher education 5,763 students were surveyed to investigate the role of developing skills for sustainability literacy [11]. The results showed that current students are willing to take jobs with a small remuneration sacrifice in order that they are able to work in a socially and ethically responsible company, indicative of a future demand for the skills to project students into this graduate environment. 80% of the respondents believed that sustainability skills are going to be important to their future employers and the majority of students involved thought that it is the role of universities and courses to prepare them for graduate employment. Students agree that these skills should be delivered through a contextually sensitive reframing of curricular content. The attitude of students on sustainable development also agrees with the observation of the UK Government’s recent IGT (innovation and growth team) Low Carbon Construction report that a “quantum change” is needed in the UK construction industry’s response to the challenges of low carbon/sustainability, with the suggestion that doing more to meet these challenges would make the UK’s built environment skills more saleable overseas [12]. The UK Centre for Education in the Built Environment [13] also indicated that the built environment courses in UK universities will need more taught material on the development of sustainable construction, probably because of economic conditions

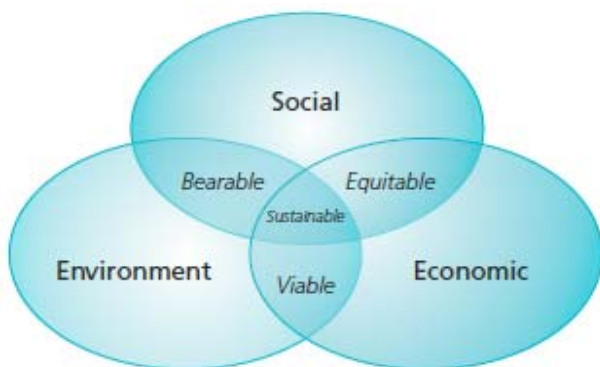


Fig. 1 “Triple bottom line” of sustainable development [7].

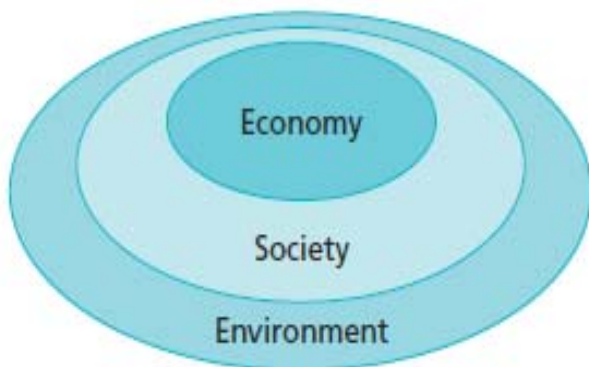


Fig. 2 Sustainable development emphasizing the environmental aspect [7].

that have affected the built environment industries, but also for other reasons, including policy shifts.

In Vietnam, the development of sustainable construction has been mentioned in a number of policies and decisions issued by the Vietnamese government, for example, the Agenda 21 for Vietnam and the Decision No. 153/2004/QĐ-TTg for the Strategic Orientation for Sustainable Development in Vietnam [14]. These actions are in response to the Rio Declaration 1992 on environment and development with the Agenda 21 [15] and the Johannesburg Declaration 2002 on sustainable development [16]. The government required all organizations operating in construction education and industry to improve the sustainability in all their activities and transfer knowledge regarding sustainable construction as widely as possible. However, the implementation of the policies in practice is generally limited. The exploitation of raw materials and natural resources for the manufacture of building materials is badly organized [17–19]. In addition, the investment in building materials' factories and industrial zones is not sufficiently effective in term of sustainable construction. Construction activities in Vietnam still use large amounts of energy and raw materials, and also produce a large amount of waste [17, 20–22]. This has caused significant environmental pollution and hence it is impacting upon the quality of life of the Vietnamese people.

As stated earlier, current undergraduate students are the Civil Engineers of the future, and hence their views and opinions on sustainability, and the subjects on which they are taught, will have a significant impact upon the sustainability of the construction industry of tomorrow. With this in mind, a survey on the views of students at the three Universities of Loughborough, Liverpool, and the NUCE (National University of Civil Engineering) of Vietnam, was conducted as part of an international collaborative project on sustainable construction between these three universities in order to promote and develop more sustainable construction

in the Vietnamese construction industry. This was funded by the Department of International Development of the British Government and the British Council DelPHE programme [23].

2. Questionnaire Survey

A questionnaire was developed based upon the UK government's recent Strategy for Sustainable Construction published in 2008 [10]. This document brings together the key issues currently considered important for the UK construction industry with regards to the development of sustainable construction. The eleven issues comprised: Procurement, Design, Innovation, People, Better Regulation, Climate Change Mitigation, Climate Change Adaptation, Water, Biodiversity, Waste, and Materials. The views of undergraduate civil engineering students with regards to the relative importance of these issues were investigated through three questions:

(1) Which of these issues do you think are the most important for development of sustainable construction?

(2) Do you think that your degree course covers this topic adequately?

(3) Do you think that your course should cover it?

The structure of a typical questionnaire is shown in Fig. 3.

The questionnaires were completed by final year Civil Engineering students at the universities of Loughborough (20), Liverpool (23) and NUCE (70).

3. Results and Discussion

The comparative views of the students at the three Universities for the first question, i.e., their opinion regarding the importance of the eleven issues concerning the development of sustainable construction, are shown in Fig. 4.

Overall, students at the three universities believe that all the eleven issues are broadly important for the development of sustainable construction, with no one issue being marked lower than five out of ten, correlating with other recent studies on the importance

British Council DelftHE project 743 – An international collaboration project on sustainable construction between National University of Civil Engineering (Vietnam), Loughborough University (UK) and The University of Liverpool (UK), Sept 2010 to March 2013.

VIEWS ON SUSTAINABLE CONSTRUCTION

"Sustainable construction refers to the creation, maintenance and operation of infrastructure and buildings that shape communities in a way that sustains the environment, generates long term wealth and enhances the quality of life" - Sustainable Development Strategy and Action Plan for Civil Engineering, July 2007.

Please give a score of 1 to 10 for each of these 3 Questions:

Q1 - Which of these issues do you think are MOST important for sustainable construction?
(1 for least important, and 10 for most)

Q2 - Do you think that your degree course covers this topic adequately?
(1 for least covered, and 10 for most)

Q3 - Do you think that your course SHOULD cover it?
(1 for No, and 10 for Yes)

* Note: Please do not rank the issues in order, hence you can have more than one issue scoring the same mark.

| Action/Target | Explanation for each action/target | Q1 | Q2 | Q3 |
|---------------------------|---|----|----|----|
| Procurement | To achieve improved whole life value through the promotion of best practice construction procurement and supply side integration... throughout the supply chain. | 7 | 5 | 8 |
| Design | Good design is to ensure that buildings, infrastructure, public spaces and places are buildable, fit for purpose, resource efficient, sustainable, resilient, adaptable and attractive. | 9 | 8 | 8 |
| Innovation | To enhance the industry's capacity to innovate and increase the sustainability of both the construction process and its resultant assets. | 7 | 8 | 8 |
| People | A commitment to training (e.g. Skills pledges; training plans; Investors in People or other business support tools; CPD; lifelong learning). | 9 | 4 | 7 |
| Better Regulation | To reduce the administrative burdens and regulation affecting the private and third sectors. | 8 | 8 | 7 |
| Climate Change Mitigation | Reducing total Greenhouse Gas (GHG) and Carbon Dioxide (CO2) emissions. | 8 | 5 | 7 |
| Climate Change Adaptation | To develop a robust approach to adaptation to climate change. | 6 | 5 | 7 |
| Water | To reduce per capita consumption of water | 9 | 5 | 8 |
| Biodiversity | Consider conservation and enhancement of biodiversity within and around construction sites is throughout all stages of a development. | 6 | 5 | 5 |
| Waste | Reduction of construction, demolition and excavation waste to landfill. | 10 | 5 | 8 |
| Materials | Materials used in construction should have the least environmental and social impact as is feasible both socially and economically. | 10 | 7 | 8 |

Name: Gender: MALE
 Course/Degree: CIVIL ENGINEERING (BEng)
 University: LOUGHBOROUGH CHARACTER UNIT

Your name, if given, will remain anonymous. Thank you very much for participation in this survey.

Fig. 3 A typical completed questionnaire from Loughborough University.

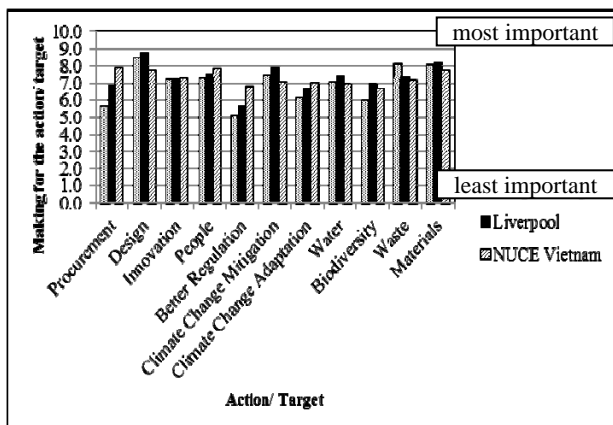


Fig. 4 Q1 — which of these issues do you think are most important for development of sustainable construction?

of sustainability issues as perceived by students [11]. The average marks for all eleven issues given by the students at Loughborough, Liverpool and NUCE universities are 7.0, 7.3 and 7.3 respectively with coefficients of variation of 32.3%, 24.1% and 29.2%.

The three groups of students have very similar views on the importance of five issues, including Innovation (7.2-7.3), People (7.3-7.8), Water (7.0-7.4), and

Materials (7.7-8.1). However, they have very different views on the importance of Procurement (5.7-6.9-7.9) and Better Regulation (5.1-5.7-6.8), in order of (Loughborough-Liverpool-NUCE). These different views might imply that in Vietnam, a developing country, (improved) Procurement and Better Regulation are needed to help develop sustainable construction. One of main factors influencing Procurement and Regulation in Vietnam is that the competitiveness between construction enterprises is not really open as state-owned companies often have more advantages and opportunities than private-owned ones. However, these issues appear not highly marked in the UK, a developed country, where the competitiveness is considered to be more open and equitable. Procurement and Better Regulation in the construction industry in the UK are reviewed, critiqued and updated more regularly. Students at the two UK universities consider “Better Regulation” as the least important, with “Design” the most important. In comparison, NUCE students consider “Biodiversity” the least important and “Procurement” the most.

For Question 2, all three sets of students seem to believe that their courses do not adequately cover the eleven sustainability issues (Fig. 5). The average marks for all eleven issues given by the students at Loughborough, Liverpool and NUCE universities are 5.4, 5.0 and 4.7 with the coefficients of variation of

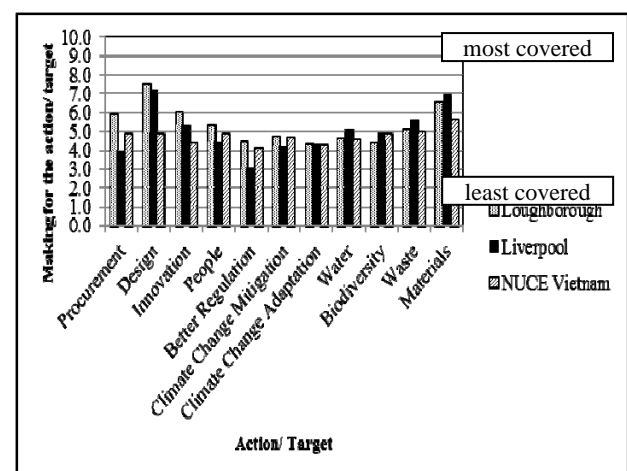


Fig. 5 Q2 — Do you think that your degree course covers this topic adequately?

48.6%, 44.1% and 56.8%, respectively. In particular, NUCE students marked 10 of the 11 issues lower than five, with the only exception being Materials (5.6). Loughborough students marked six issues over five, whilst Liverpool students marked five issues over five, as well as sharing the same views on the four issues of Design, Innovation, Waste, and Materials. This could imply that the courses at the two UK universities appear to cover the issues more comprehensively than at NUCE. It could also be a reflection however, of the aspirations and expectations of the students with regards to their course.

For Question 3, on whether the 11 issues should be covered in their courses, students at all three universities generally implied that they should be covered (Fig. 6).

The average marks for all eleven issues given by the students at Loughborough, Liverpool and NUCE universities are 6.2, 6.0 and 6.9 with the coefficients of variation of 48.3%, 41.9% and 31.5%, respectively. This correlates with similar studies, who believe that it is the role of universities and courses to prepare the students with regards to sustainability for graduate employment [11].

Students at NUCE marked all 11 issues over five, with the lowest being 6.2 (Water) and the highest 7.6 (Procurement). This implies that the students want more information about sustainable construction to be presented in their courses. It could also be a

reflection however, of an increased appetite for all knowledge in general, or of a more demanding student culture in general. Students at the two UK universities agreed closely on the low importance of People (Loughborough 5 and Liverpool 4.9). Liverpool students also viewed Better Regulation as the least necessary issue which needs to be covered in their courses, with a mark of only 4.3.

4. Conclusions

These preliminary results and analysis present only a brief snapshot of the views of civil engineering students at the three institutions. They do seem to indicate, however, that students at all three universities appreciate the importance of the development of sustainable construction and have positive attitudes towards the subject. Students at NUCE are aware that their courses need to further cover the issues of sustainable construction, compared with their colleagues at the two UK universities. This can not be simply attributed to cultural or national differences however, as differences in opinion were also found between the two UK institutions. This correlates well with the objectives of the international collaborative DelPHE project aimed at developing and transferring knowledge regarding sustainable construction to the National University of Civil Engineering of Vietnam.

Acknowledgments

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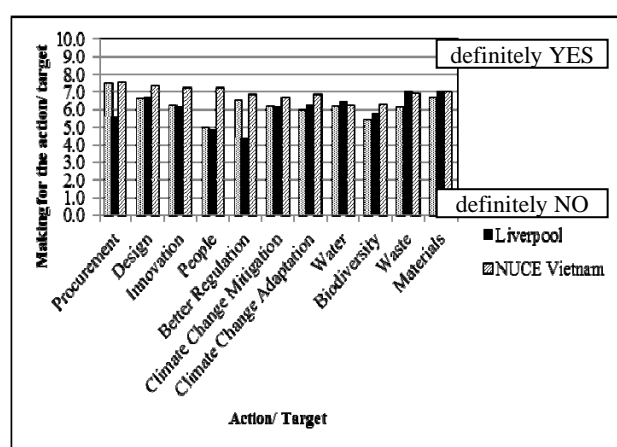


Fig. 6 Q3 — do you think that your course should cover it?

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