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Lloyd Scott

Technological University Dublin, lloyd.scott@tudublin.ie

Sushimita Bhattacharjee

University of Oklahoma, suchi@ou.edu

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Track 6: Market Transformation & Green Building Management

Embedding Sustainability in Higher Education Course Content: An Industry and Education Perspective

Lloyd Martin SCOTT^a, Sushismita BHATTACHARJEE^b

^a Dublin Institute of Technology, Ireland, lloyd.scott@dit.ie ^b University of Oklahoma, United States of America, suchi@ou.edu

ABSTRACT

Large amount of environmental resources are utilized towards the construction, renovation, operation and maintenance of buildings. Though buildings enhance the standard of living, it accounts for a large portion of non-renewable energy depletion, greenhouse gas emissions, raw materials use, waste generation, and freshwater consumption. Sustainable design and construction practices can substantially reduce or eliminate negative environmental impacts through high-performance design, construction, and operations practices. With most of the top design and construction firms in the globe implementing sustainable design and construction practices, there is a huge responsibility on Architecture, Engineering and Construction (AEC) professionals to be knowledgeable in sustainable design and construction practices. Although many higher education institutions have begun to provide sustainability related courses, there is a lack of consensus on what constitute the body of knowledge on sustainability and knowledge expectations from the recent graduates when they join the workforce. The purpose of the research study is to identify the industry expectations of sustainability knowledge of recent graduates and how that is delivered through course curricula.

The research methods adopted for the study will be three folds, starting with an initial literature review on sustainability and how it is addressed by AEC as well as non-AEC course curricula, followed by a survey of AEC industry professionals (listed in Engineering News Record's top 100 list) to identify the sustainability knowledge expected from recent graduates. Further, using content analysis, the AEC educators' interview data and the course descriptions will be analyzed to identify how well the industry expectations are delivered through the course curriculum.

The findings of the study will provide important feedback for AEC educators to revise

and evaluate their course curricula to address the important sustainability knowledge identified by the industry professionals.

Keywords: *green construction technology, sustainable neighbourhood, design process*

1. INTRODUCTION

There is a growing consensus that appropriate strategies and actions are needed to develop sustainable built environments and construction activity and the role and the role of education in this pursuit so the future leaders of the Architecture, Engineering and Construction (AEC) sector will need to be technically advanced, highly adaptable, collaborative, good communicators and lifelong learners (Scott, 2015). Progress toward sustainable built environment and construction activity must build on robust knowledge about the interaction between, and consequences of, the built environment and construction activity and the natural environment. This need is recognized, and "... environmental issues are now becoming a critical edge in construction research" (reference to be added)

Sustainability in the context of sustainable development is defined by the World Commission on Environment and Development (1987) as 'forms of progress that meet the needs of the present without compromising the ability of future generations to meet their needs'. This broad definition emphasises the aspect of future orientation as a basic element of sustainability. This care for the future implies, among other things, a wise use of natural resources and other aspects regarding the environmental footprint. The 'green' aspect of sustainability is recognised in many other definitions of sustainability.

The International Institute for Sustainable Development (2010) elaborates on the generic definitions in a definition more focused on sustainable management of organisations: 'Adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future.' Important in this definition is the mentioning of the 'needs of the enterprise and its stakeholders today'. Construction has been accused of causing environmental problems ranging from excessive consumption of global resources both in terms of construction and building operation to the pollution of the surrounding environment, and research on green building design and using building materials to minimize environmental impact is already underway.

The widespread acceptance of sustainability was initiated by the report published by the Brundtland Commission in 1987 titled “Our Common Future”. In that report, sustainable development was defined as “development that meets the needs of the current generation without undermining the ability of future generations to meet their own needs.” The report emphasized the importance of sustainable development at a level more than its intrinsic value to ensure there is enough resources to meet the requirement of the future generations. A plethora of attempts have been made to define sustainability since then emphasizing its importance. Today, sustainability is most popularly defined in terms of the three associated dimensions: social, economic, and environmental (Robert, Parris, & Leiserowitz, 2005; Tracey & Anne, 2008). This concept of the three dimensions of sustainability is embodied in the definition of sustainability adopted under United Nation’s “Agenda for Development” which states “Development is a multidimensional undertaking to achieve a higher quality of life for all people. Economic development, social development, and environmental protection are interdependent and mutually reinforcing components of sustainable development” (UN, 2007). The popular means of conceptualizing sustainability in terms of social, economic, and environmental dimensions originated from Elkington’s (1994) Triple Bottom Line concept. Opoku and Ahmed have advance the concept of sustainability, particularly in the context of AEC and offer the following definition “the adjustment of human behavior to address the needs of the present, without compromising the ability of future generations to meet their own needs” (2013:141). There are many researchers who advocate imminent actions to change the way in which young people become educated in matters about the environment (Cotgrove and Kokkarinen, 2013).

2. SUSTAINABILITY IN HIGHER EDUCATION

The concerns about sustainability indicate that the current way of producing, organising, consuming, living, etc. may have many negative effects on the future. In short, the current way of ‘doing things’ is not very sustainable. Therefore, some ‘matters’ have to change. Because of change in organisations, whether it is a new production plant, a new product, a new business process or a new resource, is in many cases organised as projects (Silvius and Batenburg 2009), it can be deduced that a (more) sustainable society requires projects. In fact, this connection between sustainability and projects was already established by the World Commission on Environment and Development (1987).

When discussing the implications of sustainability for AEC professionals, it is of

eminent importance to have a clear understanding of the elements of sustainability outlined above. This may be a challenging exercise as the elements are conceptual, rather than practical (Moneva et al. 2006; Pope et al. 2004) is how and to what extent they are included in the education of the AEC professional. The concept of sustainability is understood intuitively, but is not easily expressed in concrete operational terms (Briassoulis 2001). The relationship between sustainability and its position in the AEC sector is still an emerging field of study.

Sustainable and environmental education in built environment needs to be provided to students to imbue them with the concepts of environmental stewardship, sustainable design and application. More importantly, it is their responsibility to ensure that their decisions and actions are taken in the interest of environmental preservation. The demands of various interested parties need to be met, including those of traders concerned with the design of a cost-effective and superior solution; consumers who need an easy, comfortable and safe solution; and the government, which requires economic, social and advanced technologies without a negative impact on the environment.

3. RESEARCH METHODOLOGY AND METHODS

The methodology applied was determined on the basis of relevance to the focus of this research enquiry but also on the basis of pragmatic positioning. This was the case as a different methodological stance would not have allowed the research to be completed within the constraints applicable. Creswell (2009) stated that research methodology is the systemic approach that a research adopts to accomplish the research's aim and with that in mind an explorative interpretivist position has been adopted. In relation to the purpose of the research: it is concluded that the theoretical argument developed for the enquiry has the potential, by using an explorative perspective, to reveal new insights and a better understanding of stakeholder perceptions and awareness of sustainability and whether there is some alignment of those positions.

3.1 Research aim and objectives

The aim of the study was to compare industry expectations about essential sustainability knowledge with academics' perceptions of requisite knowledge about sustainability to work efficiently in the AEC industry. The specific objectives were as follows:

- To determine the expectations of the AEC firms regarding essential knowledge on sustainability of recent graduates entering the workforce.
- To determine the perceptions of the academics in design and construction programs regarding the required sustainability knowledge necessary to work efficiently in the industry.
- To compare the industry's expectations and the academics' perceptions.

The objectives were achieved by conducting surveys among the design and construction firms as well as academics teaching on construction programs. The survey questionnaire for the construction firms was divided into three sub-sections to accomplish the main objectives, which included: (1) Capturing the background information of each firm; (2) Understanding the sustainability practices adopted by the firms and their perceptions; and (3) Examining the essential sustainability knowledge expected from recent graduates. Similarly, the survey questionnaire for the academics was divided into three sub-sections including: (1) Understanding the background of individual respondents; (2) Examining the importance of sustainability practices as perceived by the respondents; and (3) Examining the essential sustainability knowledge required to work efficiently in the industry as perceived by the respondent. The overall research process of the study involved the following steps:

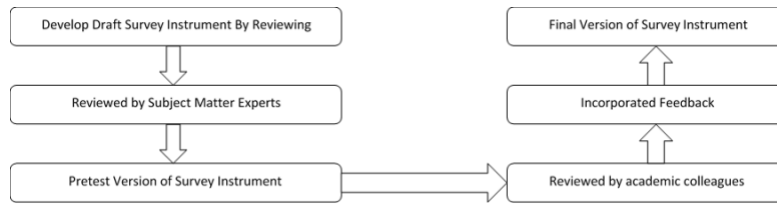
- Selecting sample firms working in the design and construction industry and academics teaching on AEC programs;
- Developing the survey instruments;
- Performing cognitive interviews for instrument validation;
- Distributing the survey questionnaire to selected samples;
- Collecting data to examine the industry's expectations and academics' perceptions; and

- Analyzing the collected data.

3.2 Survey instrument development

The individual survey questionnaires were composed of two types of questions: (1) Close-ended questions with ordered choices; and (2) Five point Likert-type scale questions. The survey instrument development process is summarized in figure 1 and described in this section.

Figure 1: Survey instrument development process



As mentioned previously, the survey questionnaires were divided into three sub-sections. The first section in the questionnaires was meant to understand the background of educational programs. The second section contained items to determine the perceptions about sustainable design practices. The third section contained items to determine the topics that were included in the sustainability courses in the education program.

Survey data were analyzed using Simple Relative Index (RI) and Spearman Rank Correlation Coefficient (SRCC) techniques to identify the level of importance and degree of association between the responses of the firms and the educators. An ordinal scale was used for the measurement of each survey item, each respondent being asked to assign a level of importance from 1 to 5, where 1 = most important and 5 = least important. From this, the magnitude of the RI for each item was calculated. All the numerical scores of each item on the questionnaire were transformed to relative indices to decide the rank orders. The RI was calculated using the following formula:

$$\frac{\sum w}{W_n}, (0 \leq RI \leq 1)$$

Where,

w = weighing given to each item by the respondents ranging from minimum of 1 (denoting least important item) to a maximum of 5 (denoting most important item);

W = the maximum weighting (which was 5 in the study);

n = total number of respondents.

This was followed by rank ordering of the items based on the RI, where the highest RI = highest rank and vice versa. For items with equal RI, they were ranked in accordance with the percentage of respondents assigning 5 to the item. The ranked variables gave insight as to the essential sustainability knowledge expected by the industry and sustainability knowledge provided to the students to work efficiently and effectively in the industry.

4.1 Background information on the program or institution of responding educators

All the respondents (N = 54) were educators of construction program. For accurate analysis only the perspective of the construction firms was used to compare the essential sustainability knowledge with the actual topics covered through sustainability courses. 67% of the total respondents were from US, followed by 13% from EU, 11% from the continent of Africa, 5 from Australia and 2 from Hong Kong and Turkey respectively. The number of students in the program of the responding educators were used to identify the size of the program. The number of students ranged from less than 50 students per program to greater than 400 students in a program. Though there was a fair distribution of program size among the respondents, yet the major respondent group with respect to program size was 100 – 200 and 200 – 300 students per program as shown in Figure 3 below. It has been noted that the average program sizes in EU and Australia are larger than in US.

Respondents indicated that sustainability is taught both as standalone course and integrated with other courses. Results indicate a wide variation in the number of courses where different topics related to sustainability are addressed. The distribution of the number of courses addressing sustainability among the different construction programs across the globe were captured. It has been noticed that programs in Australia and Ireland has more number of courses addressing sustainability than average program in US or UK. Further the results indicate that sustainability is being addressed at all levels during the course of the study. As shown in Figure 2 only 12.77% of the programs indicated that they have specific courses addressing

sustainability in their graduate program. Maximum number of institutions indicated that sustainability is being addressed at the Year 3.

w = Weighing given to each item by the respondents ranging from minimum of 1 (denoting least important item) to a maximum of 5 (denoting most important item);

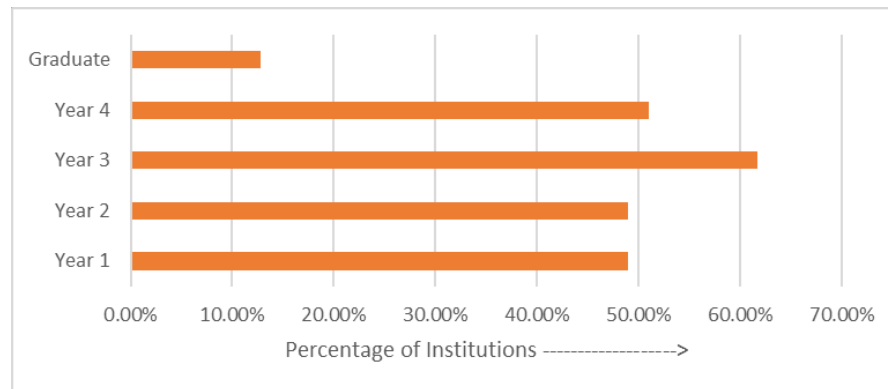


Figure 2: Total number of courses per institution addressing sustainability

4.2 Respondents perception about importance of sustainability knowledge

When asked about the importance of sustainable knowledge and practices for students, approximately 69% of the respondents indicated it to be important. This is very much in congruence with the response received from the design and construction firms, where 66.1% of the responding firms indicated that their firm has implemented sustainable design or construction practices in the past of which 2% of the firms have sustainable components integrated with all their design or construction projects (Figure 3). Further, 42.4% of the responding firms indicated that they either encourage or require their employees to attend trainings or workshops on sustainable design and construction practices.

When asked about the importance of knowledge about team building and goal setting for green building design and construction for professional success, approximately 70% of both group of respondents (industry practitioners and educators) indicated it as extremely or very important.

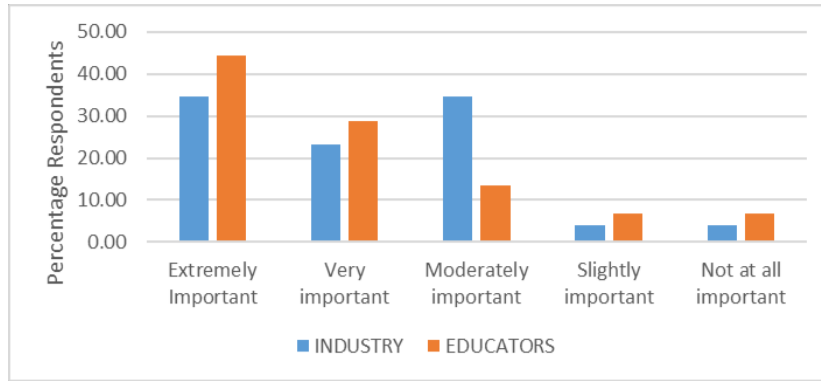


Figure 3: Comparison of industry perception versus educators about the importance of team building and goal setting knowledge for green building design and construction

In order to compare the industry expectations about essential sustainability knowledge with the actual topics covered in sustainability education, educators were asked to indicate the level of inclusion of nine specific topics related to sustainable design and construction as identified from literature. The educators' responses were compared with the responses of the industry practitioners.

Based on the two sets of response from the educators and industry practitioners, the RIs for each of the items were calculated followed by rank ordering of the survey items. A summary of the derived RIs and ranks for all the topics are given in Table 1. In the next step, SRCC test was performed on the pair of ranks. Negative correlation between the ranks of the various sustainability knowledge items was found amongst the educator and the industry practitioners ($r = -0.28$, $p > 0.05$ [two tailed], $df = 7$). In other words, there is absolutely no agreement between the expectation of the industry practitioners about the required sustainability knowledge to work efficiently in the industry and the actual topics covered as part of sustainability education. One such example was the topic of 'Biomimicry' which is barely introduced to the students through sustainability courses, but the industry practitioners have listed that as a required knowledge for student success.

Industry Expectations		Actual Inclusion in Education	
RI	Rank	RI	Rank
0.569	1	0.934	9
0.624	2	0.568	4

0.635	3	0.8	8
0.635	4*	0.55	3
0.647	5	0.645	5
0.651	6	0.514	1
0.667	7	0.526	2
0.671	8	0.696	7
0.671	9*	0.65	6

Table 1: Summary of derived rlsk of essential sustainability knowledge

Essential Sustainability Knowledge

Diff. in Ranks

Biomimicry 8 Green building construction means and methods 1 Climate change 5
 Green buildings products and materials 1 Life cycle cost analysis of green buildings 0
 Principles of green building construction 5 Green building rating systems 5 Building
 codes related to green technology 1 Green building design process 3 * Equal RI;
 ranked in accordance with the percentage of respondents assigning 5 to the item

Spearman's Rank Correlation Coefficient, $r = -0.28$ $p > 0.05$ (two tailed), $df = 7$

A summary of the derived RIs and ranks for all the rating systems are given in Table 2. Upon performing SRCC test on the pair of ranks, significant positive correlation was found amongst the responses of the educators and industry practitioners ($r = 0.73$, $p > 0.05$ [two tailed], $df = 7$). In other words, significant agreement was identified between the required knowledge of rating system as indicated by the industry practitioners and actual information about rating systems included in sustainability education. Similar to before the rating systems were rank order based on the importance as indicated by the industry practitioners and implemented in current sustainability education. LEED and BREEAM has been rated as by far the most important rating system adopted in US and UK respectively. This could be due to the significant importance given to the rating systems in the text books as well as in literature coming out of professional organizations.

Table 3: Comparison of knowledge requirement about rating system and assessment tools

5. CONCLUSION AND FUTURE RESEARCH

This study developed an understanding of the current status of sustainable design and construction knowledge perceptions and requirements among academics and industry practitioners. The study had access to a random pool of respondents and reflected on the perception of the broad diverse population sample of design and construction industry practitioner and academics around the globe. From the findings, it can be concluded that though there continues to be a gap between what academics and industry practitioners consider and reflect about their perception on the essential sustainability knowledge, yet there is significant agreement between them about the importance of the need to expose the future professionals and leaders of the AEC to the principles and knowledge areas with respect to sustainability.

There is a depth of agreement in the need for the graduate professionals to have a sound and well developed understanding of the current knowledge and best practices that are required within the AEC to embed sustainability as a matter of routine practice. The students perceive that they must embrace them and include sustainable approaches in the daily protocols of built environment processes. The industry practitioners believe and have confirmed that graduates need be fully equipped with the knowledge and competences of sustainable strategies so that their futures employers can be informed by and benefit from their knowledge. Langford (2008) refers to embracing and encouraging the new construction professional on graduation as, while they lack experience, they will bring the innovation and creativity that those who are more established will lack. Looking to this research the construction professionals survey indicated that sentiment and the importance of the AEC industry being open to the supporting those new recruits.

As the AEC industry strives forward in the modern technological world it is the current student AEC body that will be the leaders in the next 10 to 15 years and their current educators have a responsibility to challenge and equip them to take on this role. Being sustainable will be part of that as recognized by those who have researched in the area but also those who have had an input into this research enquiry. Their message is clear, create significant learning opportunities that embed the necessary competences, understanding, skills and knowledge of sustainability so that society will be enhanced and sustainable. The potential to explore further research in this

important area are boundless and this research group propose to achieve a deeper understanding through more interpretive qualitative methods of the participants.

It is clear from analyses in the paper that there is still much to do to improve the embedding of sustainability focused AEC curricula for the undergraduate. Key to the success of this process is taking students [and academics] deliberately out of the institutionalized frameworks that bind them - frameworks that often, ironically, hinder innovation and success. To succeed in an inter-professional, intercultural collaboration requires improvisation, both in mind-set and in design technique, and requires a willingness to operate with uncertainty whilst embracing risk, and risking failure.

The study confirms that AEC enterprises have the opportunity to offer powerful jobs in the industry. However, there is a lack of connection in order to increase and fully impact on real development as there is little commitment to invest in the education of the AEC future professionals. There is a huge gap between education and industry in terms of a commitment to investing in the future needs of the industry. There is as one respondent put it” a boom to bust attitude in the industry and so companies are reluctant to invest in education. This is one of the largest inhibitors to moving forward on the education front.

Sustainability and knowledge of our evolving technological driven society, are key skills in a world of rapid change and unpredictable unknowns. The professional roles in the built environment sector are rapidly evolving, and new formats of processes and transactions developing at an unprecedented rate. Successfully navigating this environment requires graduates with essential inter - professional skills, effectively acquired through collaborative inter-disciplinary projects that embed the principles of sustainability. Going forward this study propose that sustainability be embedded in as many forms of collaborative professional education as possible.

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