2017-11

A Comparative Investigation of Industry, Academics' and Students' Perceptions on Essential Sustainability Knowledge, Competencies and Skills

Lloyd Scott
Technological University Dublin, lloyd.scott@tudublin.ie

Recommended Citation

Scott, L. (2017) A comparative investigation of Industry, Academics' and Students' Perceptions on Essential Sustainability Knowledge, Competencies and Skills at *1st International Conference on Sustainable Futures (ICSF) 26 –27 November 2017 / Applied Science University Bahrain*.doi:10.21427/w9sr-2h39

Theme: Sustainable Education

A comparative investigation of Industry, Academics' and Students' Perceptions on Essential Sustainability Knowledge, Competencies and Skills

Abstract:
Design and construction educational programmes offered throughout the world play a vital role in sustainability education by producing professionals knowledgeable and competent in sustainable practices. It is extremely important to align the sustainability knowledge of the graduates to the industry expectations. This paper compares industry expectations about essential sustainability knowledge with both academics and students perceptions of requisite knowledge about sustainability. A three stage mixed research approach was adopted for the study. Essential sustainability knowledge expected from recent graduates was identified through literature review and surveys of architectural design and construction firms. Students enrolled in architecture and construction programmes were surveyed to measure their perceptions about requisite knowledge about sustainability. The position and perception of academics was analysed from survey data. Subsequently, the three sets of data were analysed using Simple Relative Index and Spearman Rank Correlation Coefficient techniques to identify the level of importance and degree of agreement between the responses of the industry and the students. Upon comparison of the students versus industry and academia responses about essential sustainability knowledge for recent graduates, it was evident that the perceptions of the students were almost diagrammatically opposite to that of the industry on multiple occasions. The position of academics also revealed some interesting directions. Overall the results of this study clearly indicate the need to embed sustainability focused on Architecture Engineering and Construction (AEC) curricula for both undergraduate and postgraduate education.

Keywords:
Sustainability, Sustainability Education, Green Building Rating System, LEED, BREEAM

Introduction

Sustainability as expressed by the Brundtland Commission Report (1987) is the desired goal of development with proper control on environmental management. It is one of the most important challenges faced in the society today. Although different societies conceptualize the concept of sustainability differently, yet, indefinite human survival on a global scale can only be maintained or sustained through a healthy and environmentally stable society. Along with the escalating human growth the need built facilities is also increasing. Though built facilities enhance living standards, it also accounts for a large portion of nonrenewable energy depletion, greenhouse gas emission, raw material use, waste generation and freshwater consumption (Randolph & Masters, 2008). Thus sustainable design and construction practices can substantially reduce or eliminate negative environmental impacts through high-performance design, construction and operations practices. The design and construction industry have begun to integrate ideas of sustainability in their planning and operations. With most of the top design firms and contractors utilizing sustainable construction, there is a huge demand of skilled designed and construction professionals with profound knowledge on sustainable design and construction ideas.

Although several higher education institutions across the world have started incorporating sustainability education in their curriculum, there is little consensus on what constitutes the body of knowledge on sustainability and how to deliver it (Bhattacharjee, Ghosh, & Jones, 2012). Design and construction educational programs offered throughout the world play a vital role in sustainability education by producing professionals knowledgeable in sustainable practices. This paper compares industry expectations about essential sustainability knowledge with students' perceptions of requisite knowledge about sustainability.

Sustainability

Sustainability is being used in various context among different disciplines and the use of the term sustainability ranges from the context of sustainable yield in forestry and fisheries management to the vision of a sustainable society with a steady-state economy (Brown, Hanson, Liverman, & Merideth Jr, 1987). The original meaning of the term is strongly dependent on the context it is applied to and on whether its use is based on the social, economic or ecological perspective. With time, this simple concept of sustainability gained much prominence across the globe at various levels. As referred to earlier, 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 (EC, 2005; Helming, Pérez-Soba, & Tabbush, 2008; 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 (Elkington, 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 behaviour to address the needs of the present, without compromising the ability of future generations to meet their own needs" (2013:141).

Sustainable Design and Construction

The AEC sector is responsible for high pollution rate due to energy consumption during the process of extraction, processing, and transportation of raw materials and construction of the structure using the raw materials, large-scale use of land. The process of building construction impacts biodiversity through extensively uses non-renewable resources, increasing air and water, waste generation, and noise pollution (Ofori, Briffett IV, Gang, & Ranasinghe, 2000). It is important to improve the building design and construction practices to reduce its harmful effect on the environment. This harmful effect on the environment can be reduced through the process of technology innovation (Spence & Mulligan, 1995), adoption of low carbon fuels (Hendriks, Worrell, De Jager, Blok, & Riemer, 1998), identification of alternative low-carbon raw materials (Herzog, 2001). The concepts of sustainable design, sustainable construction, green building, product recycling, and eco-labelling have gained prominence in the design and construction industry across the globe (Cole, 1999; Crawley & Aho, 1999; Johnson & Carter, 1993; Rees, 1999).

Sustainable design and construction practices have been accepted across the globe due to their potential benefits to the environment, economy, and the larger society. While the benefits to the environment and society can be easy to measure, adoption of sustainable practices in design and construction can result in tangible and intangible benefits to the stakeholders. As a result, several design and construction firms are implementing sustainable design and construction methods. This has created a demand of skilled design and construction professionals knowledgeable in sustainability concepts and practices. Design and construction programs in the United States have a vital role in preparing professionals with formal knowledge in sustainable construction. To keep up with the growing demand, design and construction programs have incorporated course on sustainability in their curricula.

Sustainability Education in Construction Programmes

Several researchers in the past have identified the benefit of sustainable education in the construction programmes, how sustainable should be taught and to what level should it be introduced in the course curriculum. In a review of the sustainability related courses offered by the construction programs in the United States, Tinker and Burt (2004) discussed the content of those courses and suggested how those could be integrated into the existing construction curriculum. Mead (2001) agreed that sustainability education could easily be integrated into

construction programs. He suggested two ways to do so: (i) incorporating sustainability ideas into existing courses such as materials and methods, mechanical/electrical courses, or (ii) creating new courses that focus primarily on sustainable construction. In their article, Cotgrave and Alkhaddar (2006) developed sustainable curricula within construction programs in the United Kingdom where the course was delivered as a stand-alone course. The challenge for programmme teams is whether to embed sustainability education across the program or include it as a stand-alone course.

Using a systematic course development approach Ahn, et al. (2008) proposed a sustainable course for construction programmes, whose learning objectives were in accordance to the industry expectations. The authors further suggested that courses when designed based on industry expectation is more effective as the actual knowledge gained by the students would then be more applicable in actual construction projects. Ahn and Pearce (2007) surveyed industry professionals along with construction students to create a bench mark against which the future changes in the industry could be measure over time.
Bhattacharjee et. al (2011) identified that more than 50% of the courses are offered at the senior level, followed by 30% offered at the junior level of bachelorette degree. The authors further analyzed the course content of the different sustainability courses and grouped them under eight categories of summarized under eight of, (i) environment/ eco-system, (ii) health, (iii) sustainable construction, (iv) sustainable rating systems, (v) role of stakeholders, (vi) lifecycle cost, (vii) ethics, and (viii) community. In another study performed by Bhattacharjee et. al (2012), a comparative analysis of the content of the sustainability courses offered at construction programs with the expectations of the recruiting construction industry practitioners.

Sustainability Education in Architectural Design Programmes

The architecture community in US historically is known to have embraced the idea of introducing sustainability into architecture education as early as in 1987 when the five national architectural organizations that play varying roles in architectural education in the USA (National Architectural Accrediting Board (NAAB), National Council of Architectural Registration Boards (NCARB), Association of Collegiate Schools of Architecture (ACSA), the American Institute of Architects (AIA), and American Institute of Architecture Students (AIAS) approached The Carnegie Foundation for the Advancement of Teaching to provide an independent study of professional education and practice. The results of the study published in a special report, *Building Community: A New Future For Architecture Education and Practice* contained several recommendations on sustainability, the most important of which is:
Architects and architecture educators assume a leadership role in preserving the environment and the planet's resources. It is this priority, we are convinced, that could have the most far- reaching implications about the way schools, and the profession itself, conduct themselves in the next century (Boyer & Mitgang, 2002).

Based on the effort initiated by the five national architectural organizations Wright (Wright, 2003) conducted a study to identify different ways to introduce sustainability into architecture curriculum in United States. Performing a thorough literature review the author identifies various

approaches to introducing sustainability into the architecture curriculum, followed by the identification of criteria to be used to integrate sustainability into architecture curriculum, educational programs, and practice.

In addition to the sustainable design education efforts listed above, the Council of Interior Design Accreditation (CIDA) accreditation guidelines reference the terms “environmental ethics”, “sustainability”, “sustainable building methods and materials”, “green design” and “indoor air quality” in the goals of the five out of fourteen standards. Both sustainability and collaborative learning are addressed in the 2014 Council for Interior Design Accreditation (CIDA) professional standards (2, 5, and 14) for programme accreditation (Council for Interior Design Accreditation, 2016).

Research Goal and Objectives

The goal of the study was to compare industry expectations about essential sustainability knowledge with students’ perceptions of requisite knowledge about sustainability to work efficiently in the construction industry. The specific objectives were as follows:

1. To determine the expectations of the architectural design and construction firms regarding essential knowledge on sustainability of recent graduates entering the workforce.
2. To determine the perceptions of the students in architecture and construction programmes regarding the required sustainability knowledge necessary to work efficiently in the industry.
3. To determine the perceptions of the academics teaching on architecture and construction programmes regarding the required sustainability knowledge necessary to work efficiently in the industry.
4. To compare the industry’s expectations with the academics’ and the students’ perceptions.

Methodology

This research gains high motivation from the approach to study and gain a better understanding of industry expectations about essential sustainability knowledge with students’ perceptions of requisite knowledge about sustainability to work effectively and efficiently in the construction industry. 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.

The objectives were achieved by conducting surveys among the design and construction firms as well as students enrolled in design and 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 students 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: (1) selecting sample firms working in the design and construction industry and students enrolled in the design and construction programs; (2) developing the survey instruments; (3) performing cognitive interviews for instrument validation; (4) distributing the survey questionnaire to selected samples; (5) collecting data to examine the industry's expectations and students' perceptions; and (6) analyzing the collected data.

Scope of the Study

The survey questionnaires were restricted in distribution to design and construction firms located in the United States and Europe. The design and construction firms listed in the Engineering News Record's (ENR) top 100 list and Construction Index in Europe were included in the sample for the study. It was assumed in the study that the respondents' answers reflected the corporate policy and philosophy of the respective organizations. The authors assumed that the knowledge of an individual delegating the organization is representative of the organization's philosophy and goals, and the delegates' responses to the survey questionnaires accurately represent the organizations by which they are employed.

The students included in the study were enrolled in the undergraduate and graduate programs in member institutions of Association of Collegiate Schools of Architecture, Interior Design Educators Council, and Associated Schools of Construction. While the surveys were sent to students at all levels, responses from students who were within one to two years of their graduation were included in the data analyses. This was done to ensure the respondents had well-developed perceptions about the necessary skills required to be successful in the industry. On the other hand, the students at the freshman and sophomore level were relatively new to the programs and might not have well-developed perceptions about the design and construction industry.

Sample Selection

The population for the study was firms doing business in the design and construction industry and listed in the ENR's list of top 100 design firms and top 100 contractors, and in the

Construction Index in Europe published in 2015. These firms were diverse in their geographic locations and can be considered leaders of the industry. All the firms on the previously mentioned list were contacted through general e-mails and phone calls for the purpose of acquiring the contact information of the personnel who will be best suited to respond to the survey questionnaire. 118 email addresses and phone numbers of concerned personnel were collected (35% of the sample of 250). The questionnaires were sent via email with multiple reminders. 72 out of the 118 firms provided their responses, but nine out of them were not included in the analyses due to their incompleteness. 63 complete responses with a response rate of 53% were included in the data analyses.

The sampled student population included those enrolled in member institutions of Association of Collegiate Schools of Architecture, Interior Design Educators Council, and Associated Schools of Construction. As mentioned previously, responses from students with junior and senior standing (as per their standing during spring semester of 2016) of the four-year undergraduate construction degree programs were included in the data analyses. Emails with link to the survey questionnaires were sent to the member institutes using the list serve of the organizations, which were in turn forwarded to the students.

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.

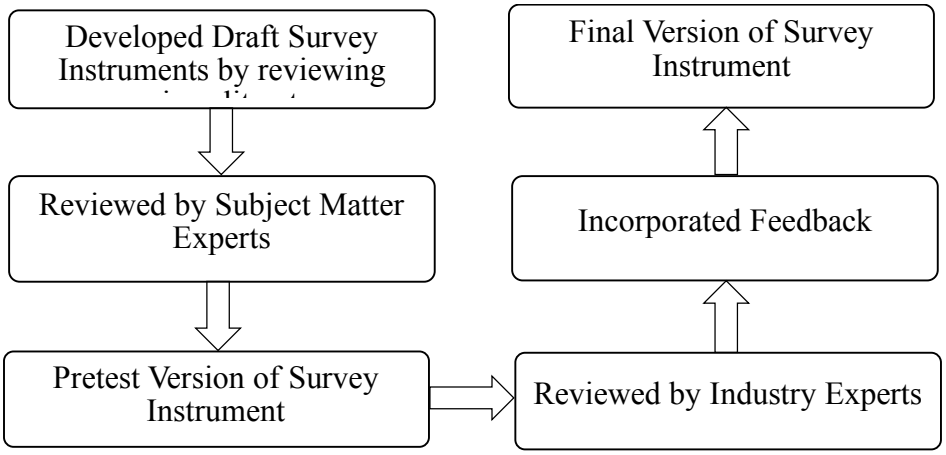

Figure 1: Survey instrument development process

The authors identified the survey items based on the study's key constructs of interest. Once the first drafts of the survey instruments were developed, a research measurement expert and two academic experts reviewed those in order to ascertain the content validity of the items in terms of relevance, representativeness and technical quality. Feedback from the subject matter experts was incorporated into the second draft, the pretest version of the survey instruments.

The pretest versions of the instruments were next evaluated by two experts from the construction industry. Information obtained from the cognitive interview sessions were incorporated into final version of the survey instruments. Several typographical errors were corrected and language was revised to increase clarity of the questionnaires.

Distribution of Survey Questionnaires and Collection of Data

The developed and validated survey instruments were encoded using a web survey tool (Qualtrics) to facilitate the distribution and collection of the survey questionnaires via internet. After successfully developing the web survey questionnaire, the invitation email along with the survey questionnaire was sent to the study sample. The survey link was open for two months to limit the collection period. After two weeks of the first invitation to participate in the survey, two wave of reminder emails were sent to motivate the study sample for participating in the survey.

Analyses of the Data

As mentioned previously, both the survey questionnaires were divided into three sub-sections. The first section in both the questionnaires were meant to understand the profiles of the responding firms and the background of individual students respectively. The second section contained items to determine the perceptions about sustainable design practices. The third section contained items to determine the expected and perceived essential sustainability knowledge to work effectively in the construction industry.

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 students. The RI ranking technique is used extensively in construction research for measuring perceived level of importance (Holt, 1997; Wong, Holt, & Cooper, 2000). 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 = least important and 5 = most important. From this, the magnitude of the RI for each item was calculated. To evaluate the overall rank orders, the mean and standard deviation of each individual item was considered inappropriate, as they fail to demonstrate any relationship between the items. Thus, 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:

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

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 perceived by the students to work efficiently and effectively in the industry.

Findings

Upon collection and verification of all the data, the data was analyzed. The following sections present the findings of the analysis.

Profile of Responding Firms

Several firms from Europe and US responded as shown in Figure 2. Of the total respondents to the survey of were 41.4% Design Firms, 46.5% Contractors, 6.9% Engineering Firms and 5.2% other which includes quantity surveyor, consultancy etc. as shown in Figure 3.

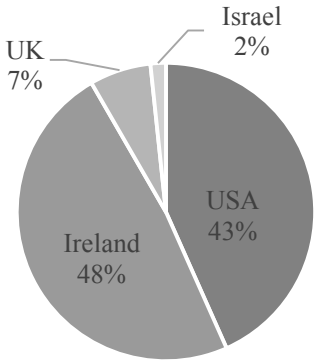

Figure 2: Location of the responding firms

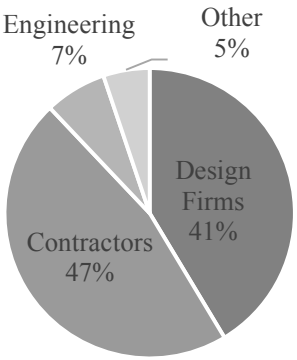

Figure 3: Primary contractual role of responding firms

Among the responding firms 39% of them have been in business for more that 50 years followed by 37% of the responding firms who have been in business from anywhere between 21-50 years as shown in Figure 4.

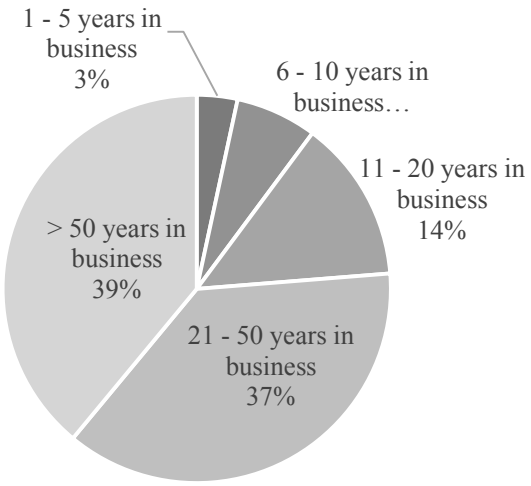

Figure 4: Number of years the firms has been in Business

The annual revenue and the number of employees of responding firms (see table 1) were used to identify the versatility of the representative sample. The annual revenue ranged from <1 million USD to more than 50 million USD among the responding firms. The major respondent group with respect to the annual revenue was in the range of 1 – 10 million USD (32.1%). In regard to the number of employees, there were almost equal number of responding firms that had employees in the range of 1-4 (22.1%), 5-19 (23.6%), 20-99 (23.5%) and 100 or more employees (30.5%).

In terms of involvement with public funded projects, response indicated that for around 50% of the firms, the proportion of public funded projects each year was less than 20% of their total work volume. Out of which, for 13.6% of the responding firms the proportion of public funded projects was in excess of 80%, as shown in Table 1.

Table 1: Background information of the responding firms

Background Information		**Responding Firms (%)**
Annual Revenue	< 1 Million USD	21.4 %
	1-10 Million USD	32.1 %
	11-25 Million USD	10.7 %
	26-35 Million USD	7.1 %
	36-50 Million USD	7.1 %
	> 50 Million USD	21.4 %
Number of Employees	1-4 Employee	22.1 %
	5-19 Employee	23.6 %
	20-99 Employee	23.5 %
	>100 Employee	30.5 %
Proportion of Public Projects Completed Each Year	None	3.4 %
	< 20% Public Projects	47.5 %
	20% - 40%	16.9 %

	41% - 60%	6.8 %
	61% - 80%	11.9 %
	> 80%	13.6 %

Profile of Responding Students

66.4% of the responding students were male and 52.2% of the students were in the age group of 21-30 years old. Out of all the respondents, 27.3% are at the graduate level followed by 19.9% who are at the senior level. Overall, 58.8% of the responding students are majoring in Construction or related field. Only 9% of the students has more than twenty years of design/construction related experience. The vast majority (51.8%) has no design/construction related work experience. Based on their responses, it was found they have worked for a variety of companies in the Architecture, Interior Design, Construction, and Engineering fields.

Table 2 – Background Information of the Student Respondents

Background Information		**Student Respondents (%)**
Gender	Male	66.4
	Female	33.6
Age (years)	18-20 years	23.6
	21-30 years	52.2
	31-40 years	11.3
	41 -50 years	8.6
	51 -60 years	4.3
School Year	Freshman	13.8
	Sophomore	18.9
	Junior	18.5
	Senior	19.9
	Graduate	27.3
	Other	1.7
Major	Design	23.6
	Construction	58.8
	Engineering	3.7
	Other	14
Work Experience (Years)	0	51.8
	< 1	3.7
	1-5	30.6
	6-10	5.0
	>10	9.0

Student Awareness about Sustainability Design and Construction

Approximately 90% of the students agreed about the increasing concern of climate change as

important. Student demonstrated an overall awareness about sustainability. More than 95% of the student respondents indicated that built facilities have significant impact on the environment, which can be altered by the way buildings are designed and constructed through technological innovations. Only 38.75% of the above mentioned 95% student respondents have participated in courses or school projects related to sustainability. 33.9% of the above mentioned 95% of the student respondents has worked on sustainable design or construction projects of which 18.7% has taken courses related to sustainability and also worked on projects related to sustainable design or construction.

Industry Awareness about Sustainable Design and Construction

Approximately 84.75% of the responding firms indicated their firm's familiarity with sustainable design and construction practices. Additionally, 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. 42.4% of the responding firms either encourage or require their employees to attend trainings or workshops on sustainable design and construction practices.

Analyses and Discussion

In order to compare the industry expectations about essential sustainability knowledge matches with students' perceptions of requisite knowledge about sustainability to work efficiently in the industry, students were asked to indicate their perception about the required level of knowledge for the nine items related to sustainable design and construction identified from literature. The firms were also asked to indicate their expectations about essential sustainability knowledge based on the same nine items. The internal consistency reliability coefficients (Cronbach's alpha = α) were calculated for both the questionnaires. It was found that α = 0.85 for the students' questionnaire and α = 0.88 for the industry questionnaire. According to Morgan, Leech, Gloeckner, and Barrett (Morgan, Leech, Gloeckner, & Barrett, 2007), Cronbach's alpha greater than 0.70 provide good support for internal consistency reliability.

Based on the two sets of response from the students and industry, 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 items are given in Table 3. In the next step, SRCC test was performed on the pair of ranks. No significant positive correlation between the ranks of the various sustainability knowledge items was found amongst the students and the industry ($r = 0.2$, $p>0.05$ [two tailed], $df = 7$). In other words, there was minimal agreement between the perception of the students and the expectation of the industry about the required sustainability knowledge to work efficiently in the industry.

Table 3: Summary of Derived RIs of Essential Sustainability Knowledge for Recent Graduates

Essential Sustainability Knowledge	Industry Expectations		Students Perception		Diff. in Ranks
	RI	**Rank**	**RI**	**Rank**	

Green building design process	0.671	1*	0.571	3	2
Building codes related to green technology	0.671	2	0.570	4	2
Green building rating systems	0.667	3	0.578	2	1
Principles of green building construction	0.651	4	0.555	8	4
Life cycle cost analysis of green buildings	0.647	5	0.565	6	1
Green buildings products and materials	0.635	6*	0.556	7	1
Climate change	0.635	7	0.568	5	2
Green building construction means and methods	0.624	8	0.553	9	1
Biomimicry	0.569	9	0.583	1	8
* Equal RI; ranked in accordance with the percentage of respondents assigning 5 to the item					
Spearman's Rank Correlation Coefficient, r = 0.2 p>0.05 (two tailed), df = 7					

Table 4: Comparison of Knowledge Requirement about Rating System and Assessment Tools

Rating Systems	**Industry Feedback**		**Student Feedback**		**Diff. in Ranks**
	Freq.	**Rank**	**Freq.**	**Rank**	
LEED	70%	1	78%	1	0
BREEAM	31%	2	36%	3	1
Green Globes	2%	3	27%	5	2
Living Building Challenge	2%	3	29%	4	1
Energy Star	<1%	4	56%	2	2
NAHB Green Rating System	<1%	4	<1%	7	3
CASBEE	<1%	4	9%	6	2
Impact Assessment Tools					
Other Assessment Tools	65%	1	12%	5	4
Ecotect	14%	2	47%	2	0
Equest	14%	2	30%	4	2
Green Building Studio	14%	2	54%	1	1
Athena	8%	3	35%	3	0
Spearman's Rank Correlation Coefficient, r = 0.846 p<0.05 (two tailed), df = 10					

Discussions

Upon comparison of the students versus industry responses about essential sustainability knowledge for recent graduates, it was evident that the perceptions of the students were almost diagrammatically opposite to that of the industry on multiple occasions. One such instance was observed when respondents were asked about the required knowledge about 'Biomimicry.' Biomimicry, which is a relatively innovative approach to sustainable solutions imitating nature's strategies has not been adopted and implemented heavily in the design and construction industry. As a result, the industry practitioners do not expect the students/recent graduates to have the operational knowledge about biomimicry. On the contrary, the students believed they should be aware of the novel concepts related to sustainability as that might put them in an advantageous position to gain professional success. While this study did not provide a means to further explore this apparent contradiction, the results suggest a need for further investigation to better understand the reasoning behind this potential discrepancy. The authors believed this was a classic instance of disconnect between theory and practical knowledge. For some of the essential knowledge items, the students' perceptions were closely aligned with the expectation of the industry.

The knowledge about the different rating systems were almost equally valued by the students and the industry. On a similar note it is evident from Table 4 that there is statistically significant agreement between the industry and the students on the value of the knowledge about LEED among other rating systems currently in use. 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. Another observation was the heavy usage of LEED and BREEAM in the industry in comparison to the students' perception about the importance of other rating systems such as Green Globes, Living Building Challenge and Energy Star.

The respondents also expressed similar views on the importance of sustainable design processes and understanding of building codes related to green technology. Knowledge related to climate change found place further down the list for both set of respondents. While concerns related to climate change seems to appear in a plethora of literature lately and receive global attention, the respondents of this survey did not rate that as one of their top priorities. Regarding the impact assessment tools the authors found that large proportion of the responding firms utilize their in-house impact assessment tools. The students were not exposed to these in house tools and thus they differed in their opinions about the usage of the individual assessment tools.

Conclusion

This study developed an understanding of the current status of sustainable design and construction knowledge perception and requirement among students and industry practitioners. The study taped a random pool of respondents and reflected on the perception of the broad diverse population sample of design and construction industry practitioner and students around the globe. From the findings it can be concluded that though there has been a lack of agreement between the students and industry practitioners about their perception on the essential sustainability knowledge, yet there is significant agreement between them about the importance of LEED and BREEAM as the most predominantly used rating system.

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 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, restrict innovation. To succeed in this interprofessional, 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.
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.

References

Ahn, Y., Kwon, H., Pearce, A., & Wells, J. (2008). *Integrated sustainable construction: A course in construction for students in the USA.* Paper presented at the Proceedings of the 2008 Annual Conference of the American Society for Engineering Education.

Ahn, Y. H., & Pearce, A. R. (2007). Green construction: Contractor experiences, expectations, and perceptions. *Journal of Green Building, 2*(3), 106-122.

Altomonte, S., Rutherford, P., & Wilson, R. (2014). Mapping the way forward: Education for sustainability in architecture and urban design. *Corporate Social Responsibility and Environmental Management, 21*(3), 143-154.

Beery, T. (2013). Making sustainable behaviors the norm at the University of Minnesota Duluth. *The Journal of Sustainability Education, 5*.

Bhattacharjee, S., Ghosh, S., & Jones, J. (2012). *Sustainability Teaching Approach in Construction Management Curriculum.* Paper presented at the Proceedings of International Conference on Sustainable Design and Construction.

Bhattacharjee, S., Ghosh, S., Jones, J., & Rusk, B. (2011). *Sustainability education in the United States: analyses of the curricula used in construction programs.* Paper presented at the Proceedings of International Conference on Sustainable Design and Construction, Kansas City, MO.

Boyer, E., & Mitgang, L. (2002). Building Community: A New Future for Architectural Education and Practice (Princeton: Carnegie Foundation for the Advancement of Teaching, 1996). *This study was commissioned by five national architecture organizations: ACSA, NAAB, NCARB, AIA, and AIAS. For an insightful critique of the Boyer Report and counter-proposal, see Robert Segrest,"The Architecture of Architectural Education," Assemblage, 33*, 76-80.

Brown, B. J., Hanson, M. E., Liverman, D. M., & Merideth Jr, R. W. (1987). Global sustainability: Toward definition. *Environmental management, 11*(6), 713-719.

Cole, R. J. (1999). Building environmental assessment methods: clarifying intentions. *Building Research & Information, 27*(4-5), 230-246.

Cotgrave, A., & Alkhaddar, R. (2006). Greening the curricula within construction programmes. *Journal for Education in the Built Environment, 1*(1), 3-29.

Council for Interior Design Accreditation. (2016). Professional Standards 2014. Retrieved from http://accredit-id.org/wp-content/uploads/2015/03/Professional-Standards-2014.pdf

Cramer, J. P. (2004). America's Best Architecture and Design Schools. *Design Intelligence, 10*(11), 2-39.

Creswell, J.W. (2009) *Research design: Qualitative, quantitative and mixed methods approaches* London: SAGE Publication

Crawley, D., & Aho, I. (1999). Building environmental assessment methods: applications and development trends. *Building Research & Information, 27*(4-5), 300-308.

EC. (2005). *Impact Assessment Guidelines*. Retrieved from European Commission: Brussels, Belgium: http://ec.europa.eu/agriculture/sfs/documents/documents/sec2005-791_en.pdf

El-Zeney, R. M. (2011). Towards sustainable interior design education in Egypt. *Asian Journal of Environment-Behaviour Studies, 2*, 61-72.

Elkington, J. (1994). Towards the sustainable corporation: Win-win-win business strategies for sustainable development. *California management review, 36*(2), 90.

Gürel, M. Ö. (2010). Explorations in teaching sustainable design: A studio experience in interior design/architecture. *International Journal of Art & Design Education, 29*(2), 184-199.

Helming, K., Pérez-Soba, M., & Tabbush, P. (2008). *Sustainability impact assessment of land use changes*: Springer.

Hendriks, C. A., Worrell, E., De Jager, D., Blok, K., & Riemer, P. (1998). *Emission reduction of greenhouse gases from the cement industry.* Paper presented at the Proceedings of the fourth international conference on greenhouse gas control technologies.

Herzog, H. J. (2001). Peer reviewed: what future for carbon capture and sequestration? *Environmental science & technology, 35*(7), 148A-153A.

Holt, G. D. (1997). Construction Research Questionnaires and Attitude Measurement: Relative Index or Mean? *Journal of Construction Procurement, 3*(2), 88-96.

Johnson, S., & Carter, B. (1993). *Greener buildings*: Macmillan.

Mead, S. (2001). *Green building: current status and implications for construction education.* Paper presented at the ASC Proceedings of the 37th Annual Conference.

Morgan, G. A., Leech, N. L., Gloeckner, G. W., & Barrett, K. C. (2007). *SPSS for introductory statistics: Use and interpretation* (3rd ed.): Psychology Press.

Ofori, G., Briffett IV, C., Gang, G., & Ranasinghe, M. (2000). Impact of ISO 14000 on construction enterprises in Singapore. *Construction Management & Economics, 18*(8), 935-947.
Opoku, A. and Ahmed, V. (2013) check reference
Porras Álvarez, S., Lee, K., Park, J., & Rieh, S.-Y. (2016). A Comparative Study on Sustainability in Architectural Education in Asia—With a Focus on Professional Degree Curricula. *Sustainability, 8*(3), 290.
Randolph, J., & Masters, G. M. (2008). *Energy for sustainability: technology, planning, policy*: Island Press.
Rees, W. E. (1999). The built environment and the ecosphere: a global perspective. *Building Research & Information, 27*(4-5), 206-220.
Robert, K. W., Parris, T. M., & Leiserowitz, A. A. (2005). What is sustainable development? Goals, indicators, values, and practice. *Environment: science and policy for sustainable development, 47*(3), 8-21.
Ruff, C. L., & Olson, M. A. (2009). The attitudes of interior design students towards sustainability. *International Journal of Technology and Design Education, 19*(1), 67-77.
Spence, R., & Mulligan, H. (1995). Sustainable development and the construction industry. *Habitat international, 19*(3), 279-292.
Stegall, N. (2006). Designing for sustainability: A philosophy for ecologically intentional design. *Design Issues, 22*(2), 56-63.
Stieg, C. (2006). The sustainability gap. *Journal of Interior Design, 32*(1), vii-xxi.
Tinker, A., & Burt, R. (2004). Greening the construction curriculum. *International Journal of Construction Education and Research, 1*(1), 26-33.
Tracey, S., & Anne, B. (2008). *OECD Insights Sustainable Development Linking Economy, Society, Environment: Linking Economy, Society, Environment*: OECD Publishing.
UN. (2007). *The United Nations Development Agenda: Development for All*. Retrieved from Department of Economic and Social Affairs: United Nations, New York:
US Green Building Council. (2009). Green building and LEED core concepts guide. *US Green Building Council, Washington*.
Vezzoli, C. (2003). A new generation of designers: perspectives for education and training in the field of sustainable design. Experiences and projects at the Politecnico di Milano University.

Journal of Cleaner Production, 11(1), 1-9.

Wiersum, K. F. (1995). 200 years of sustainability in forestry: lessons from history. *Environmental management, 19*(3), 321-329.

Wong, C. H., Holt, G. D., & Cooper, P. A. (2000). Lowest Proce or Value? Investigation of UK Construction Clients' Tender Selection Process. *Construction Management and Economics, 18*, 767-774.

Wright, J. (2003). Introducing sustainability into the architecture curriculum in the United States. *International Journal of Sustainability in Higher Education, 4*(2), 100-105.