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CONCEPTIONS OF SUSTAINABILITY AMONGST POST GRADUATE (MSC) CONSTRUCTION MANAGEMENT STUDENTS

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In Ghana, recent amendments to public procurement regulation and construction of sustainable buildings underscore the growing importance of sustainability in the construction industry. To align itself with such trends in industry, the Kwame Nkrumah University of Science and Technology (KNUST) has introduced sustainability related dimensions within its programmes including MSc construction management. This research investigates the variation in sustainability conceptions held by MSc construction management students of KNUST. The study explores if age and previous area of education relate to students' conception of sustainability. Appreciating what students actually know can inform what and how academics teach students about sustainability and ready them to influence sustainable construction in Ghana. Previous studies amongst undergraduate engineering students in other countries exist but students' conceptions of sustainability in Ghana is under-researched in spite of its relevance to sustainability education development. Questionnaires were employed to collect students' descriptions of sustainability and then the Structure of learning outcomes (SOLO) based analytical framework for mapping variation in student conception by Carew and Mitchell was used to classify the descriptions of sustainability. Student descriptions were also scrutinized for themes related to key principles of sustainable development (SD) by Gibson et. al., 2006. Results revealed that majority of construction management students' either did not know what sustainability was or provided broad, non-specific responses. Students also showed a narrow conception of sustainability with focus on environmental dimensions. Issues of sustainability related to precaution and adaption as well as immediate and long term integration are not mentioned at all. The study highlights the areas of sustainability that need to be emphasised in the course in order to develop graduates who have a balanced understanding of sustainability. It also brings to light the need for further research amongst Ghanaian students at all levels and in all fields to explore understanding within differing groups of students.

Keywords: construction management, sustainable development, sustainability, sustainability education

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INTRODUCTION

Sustainable construction, which is described as a subset of sustainable development (SD) (Kibert, 2016), focuses on the built environment and its contribution to the issue of sustainability. In lieu of the built environment's harmful effects such as its significant contribution to CO2 emissions and waste (Edum-Fotwe and Price, 2009) and potential contributions to a country's economy, social well-being and the environment (Kibert, 2016), sustainable construction is key to the attainment of sustainable development. In Ghana, the importance of sustainable construction is increasing (Darko et al 2017). Ghana has the first green commercial office building in West Africa, which is the One Airport Square, and Africa's first LEED-certified hospital, which is the Ridge Hospital (Darko et al 2017). Other indicators of the increasing recognition of sustainable construction in the Ghanaian context is the establishment of the Ghana Green Building Council and inclusion of sustainability issues in the amendments to the Procurement Act of Ghana as well as the new Ghana Building Code. All these actions, however, represent marginal efforts at changing the paradigm of the Ghanaian construction industry towards sustainability if corresponding efforts are not made to build capacity in terms of education and training. UNCED (1992) and WSSD (2002a) recognise education as critical for promoting sustainable development and improving the capacity of people to address sustainability related issues. Accordingly, the sustainability agenda emphasises the integration of sustainable development issues into all courses and at all levels of education (Buckler and Creech, 2014).

PROBLEM STATEMENT

The Kwame Nkrumah University of Science and Technology is the first public university established in Ghana with the mandate for science and technology education at the tertiary level. It is currently the only University running a construction management programme at the post graduate level. In keeping with the Sustainability for education agenda, KNUST has introduced sustainability related dimensions within its programmes including its MSc construction management programme. The programme includes a module on sustainable construction that helps students explore the concepts of sustainability and sustainable development and how these concepts are applied in the construction of buildings. The role of the university in bringing awareness of SD to the students is critical (Tan et al. 2017, Cotgrave & Kokkarinen, 2011) however success is not guaranteed unless curriculum and teaching methods are designed taking into cognisance the understanding students bring with them. Prior knowledge has been identified as having strong effect on current learning (Biggs and Collins 1982). Prior knowledge amongst others can inform and shape the module content, structure and teaching methods in order to improve on student knowledge and produce industry ready graduates. This study therefore explores the understanding of sustainability among Construction Management postgraduate students. It investigates empirically the variation in sustainability conceptions currently held by the students and also to identify the content of their prior knowledge.

LITERATURE REVIEW

The goal of higher education should be to produce students that develop deep knowledge in their chosen disciplines and where necessary generate a change in students' concepts and worldviews (Boulton-Lewis, G.M., 1995). Achieving this goal is hinged on a knowledge of the prior conceptions and worldviews that students bring with them. This knowledge of prior conceptions shapes the manner in which subsequent teaching and learning is organised and conducted (Prosser & Millar 1989). Specifically, it helps decide on the types of conception/s which represent desired learning outcomes for the topic at hand; as well as construct schema for assessing different kinds of understanding; and apply teaching and learning activities which are better targeted (Carew and Mitchell, 2002). Appreciating understanding is also vital because a common barrier to sustainable development is a lack of knowledge. Consequently, various authors over the years (Carew and Mitchell, 2002; Azapagic, 2005; Walshe, 2008; Nicolaou and Conlon, 2012; Ali Khalfan Al-Naqbi and Qasim Alshannag, 2018) have looked at the understanding of sustainability among students in various countries including United Kingdom, United Arab Emirates, Ireland, Australia amongst others.

In the Ghanaian context, however, especially amongst construction students, there is a lack of research regarding students' conceptions on sustainability. It is important to appreciate the Ghanaian perspective especially because Rogers (2006) for example shows that knowledge of a new phenomenon is contextually dependent. Furthermore, Darko and Chan (2016) advocate country specific research since "the more research works conducted and published on a particular topic in a country, the greater the extent of industrial innovations and developments on the topic will be in the country".

Core generic criteria for sustainability assessment

In exploring student conceptions of sustainability, it is important to clearly articulate what is meant by "sustainability/sustainable development" in this study especially since the concepts are constantly evolving and do not benefit from single distinct definitions. Although the Brundtland Report's definition of sustainable development as meeting "the needs of the present without compromising the ability of future generations to meet their needs" (WCED, 1987, p43) is widely cited, Sustainability/SD is described as a dynamic concept (Bossel 1999) and as "a contested concept with a wide range of meanings" (Giddings et al 2001) surrounded by debates and ambiguities. For some, SD involves a strong emphasis on the environment and its preservation whilst for other it involves a focus on socio-economic or human development issues and yet for others on all three dimensions described as the pillars of sustainable development (Edum-Fotwe and Price, 2009). However, despite disagreement on an overarching definition there is increasing agreement on common guiding principles that underline the concept of sustainability no matter the issues or area of focus. Sustainability, in lieu of its cross disciplinary nature, is now more of an application of broad principles rather than a prescriptive body of knowledge (Iyer-Raniga, 2010). Such principles act as a framework upon which action for sustainability can be constructed and useful basis for evaluating the different conceptions of sustainable development.

Although various sets of principles for sustainability have been proposed, this study employs the set provided by Gibson (2006). It is a sustainability based framework of broadly applicable criteria for sustainability assessment which can as well be used to interrogate the conception of sustainability. Weik (2011) for example names Gibson (2006) as an exemplary source useful for defining normative principles for sustainability. The choice of this framework is largely because it is based on thought and insight from the substantial literature of sustainability over the decades. In his framework, Gibson (2006) provides six criteria with requirements of each briefly described in Table 2. Based on these principles/criteria therefore each student response (conception) of sustainable development are evaluated.

Table 2 Core generic criteria for sustainability assessment (Gibson, 2006)

Criteria	Requirements
Socio-ecological system integrity	Build human–ecological relations to establish and maintain the long-term integrity of socio-biophysical systems and protect the irreplaceable life support functions upon which human and ecological well-being depends.
Livelihood sufficiency and opportunity	Ensure that everyone and every community has enough for a decent life and that everyone has opportunities to seek improvements in ways that do not compromise future generations' possibilities for sufficiency and opportunity
Intergenerational equity	Favour present options and actions that are most likely to preserve or enhance the opportunities and capabilities of future generations to live sustainably
Intragenerational equity	Ensure that sufficiency and effective choices for all are pursued in ways that reduce dangerous gaps in sufficiency and opportunity (and health, security, social recognition, political influence, and so on) between the rich and the poor.
Resource maintenance and efficiency	Provide a larger base for ensuring sustainable livelihoods for all, while reducing threats to the long-term integrity of socioecological systems by reducing extractive damage, avoiding waste and cutting overall material and energy use per unit of benefit.
Socio-ecological civility and democratic governance	Build the capacity, motivation and habitual inclination of individuals, communities and other collective decision-making bodies to apply sustainability requirements through more open and better informed deliberations, greater attention to fostering reciprocal awareness and collective responsibility, and more integrated use of administrative, market, customary and personal decision-making practices
Precaution and adaptation	Respect uncertainty, avoid even poorly understood risks of serious or irreversible damage to the foundations for sustainability, plan to learn, design for surprise, and manage for adaptation.
Immediate and long term integration	Apply all principles of sustainability at once, seeking mutually supportive benefits and multiple gains.

Students' knowledge of sustainability

There is the need to develop graduates that think critically about sustainability issues and education at higher levels should teach students to develop knowledge of the content and structure of their discipline as well as equip them with the ability to apply such knowledge effectively (Boulton-Lewis, 1995). Consequently, studies have explored tertiary students' knowledge of sustainability some of which have been summarised in Table 3.

Table 3 Articles on Tertiary Students' Knowledge of Sustainability

Author & date	Title	Country	Participants	No.	Findings
Anna L. Carew and Cynthia A. Mitchell, 2002	Characterizing undergraduate engineering students' understanding of sustainability	Australia	Survey of Year 3 undergraduate chemical engineering students (Opened ended question)	52	Students did not know or had vague perceptions of the concept of sustainability
Adisa Azapagic, Slobodan Perdan and David Shallcross 2005	How much do engineering students know about sustainable development? The findings of an international survey and possible implications for the engineering curriculum	International (10 different countries but none was African)	Survey of undergraduate student across several engineering disciplines	3134	Low level of knowledge. Gaps in social and economic aspects
Mike Summers Graham Corney & Ann Childs 2004	Student teachers' conceptions of sustainable development: the starting-points of geographers and scientists	UK	Survey of geography and science post graduate certificate in education students	61	Nearly all students identified features of sustainability but majority of the students could not identify the full scope
Iacovos Nicolaou and Eddie Conlon, 2012	What do Final Yea Engineering Students Know About Sustainable Development	Ireland	Survey that incorporated opened ended questions. Participants were final year engineering students	143	Understanding of the complexity of sustainability was low. Students connected the concept with environmental issues and neglected social aspects
Ali Khalfan Al-Naqbi and Qasim Alshannag, 2018	The status of education for sustainable development and sustainability knowledge attitudes and behaviours of UAE University students	UAE	Undergraduate students across several disciplines	823	High level of knowledge. Females were more knowledgeable than males National students' knowledge was higher than non-national students

These studies have been conducted in a wide variety of countries, with students from different programmes and at different levels. However, studies related to the African region, focused on the discipline of construction management and post graduate students are limited. Yet these same studies have shown that student knowledge may vary across nations, programmes/courses (Al-Naqbi and Alshannag, 2018), and students with experiences from industry (Tan et al 2017) as is the case with post graduate students.

Majority of these studies on student knowledge have been largely quantitative surveys (Jollands and Baez, 2015). The few that have been qualitative in nature have brought to the fore the relevance of not just identifying the level of knowledge but also appreciating the content and variation in student knowledge (Carew and Mitchel, 2002). Another limitation of many of the studies is that the knowledge concept used are undefined or vaguely defined and distinctions are not made amongst the types of knowledge being measured even though education literature has long recognised that there are different types of knowledge (Krathwol & Anderson, 2009). As such studies that seek to assess knowledge must consider and indicate what type of knowledge is the focus of assessment (Hailikari et al 2008). This study focuses on prior knowledge which is an important factor that influences learning and student achievement and has the ability to positively influence knowledge acquisition and the capacity to apply such knowledge to solve various problems (Hailikari et al 2008). It has been shown to explain between 30% and 60% of the variance in study results (Dochy, 1996). It is imperative then that any efforts at educating students on sustainability must interrogate the prior knowledge they bring as it forms a basis for constructing student sustainability knowledge and skills. Furthermore, sustainability as a concept is dynamic and has evolved over time and hence it becomes even more important to understand which conceptions/understanding students currently hold since these may either hamper or help the learning process. For the purpose of this study, knowledge is information stored in memory and prior knowledge is the knowledge available in a person's long-term memory at the outset of learning (Simonsmeier et al 2018). In the light of the gaps outlined above, the aim of this study is to explore the understanding of sustainability held by post graduate Construction Management students. The study focuses on the "knowledge of meaning" sub-component of declarative knowledge aspects which measures the understanding of the meaning of a concept (Hailikari et al, 2007). The study identifies the content of their prior knowledge, investigates the variation in sustainability conceptions currently held by the students and explores if the content and variations are associated with other variables such as education, profession and age.

Measurement of students' conceptions

The structure of learning outcomes (SOLO) taxonomy is a non-content specific framework developed by Biggs & Collis, (1982). It can serve as a tool to determine students' prior knowledge of the content of a discipline and is therefore amenable also as a tool to explore the variation in structure and content of knowledge of sustainable development (Jollands and Baez, 2015) within a group of students as illustrated by Carew and Mitchel (2002). The taxonomy describes five stages indicated in Table 43. The table also describes what is expected of students within each stage with respect to their conceptions as defined by Carew and Mitchel, (2002). Table 3 describes briefly how the features were operationalised in the study. In analysing responses in the study, additional features were introduced to augment those specified by Carew and Mitchel, (2002).

Table 4 Stages for SOLO analysis for students' responses

SOLO Stage	Features of sustainability statement expected of each stage (Carew and Mitchel, 2002)	Application (by Authors)
Pre-structural	Either did not know what sustainability was or provided a broad, non-specific response	Included respondents who indicated a lack of knowledge of the subject and respondents with broad, non-specific responses e.g. literal definitions of sustainability
Uni-structural	Provided one definitive example of something concrete or abstract with relevance to sustainability	Included descriptions/examples associated explicitly or implicitly to only one of the sustainability principles described by Gibson 2006
Multi-structural	Provided two or more qualitatively different examples of concrete and/or abstract things relevant to sustainability	Included descriptions/examples associated explicitly or implicitly to more than one of the sustainability principles without relating the examples
Relational	Constructed a cohesive, internally consistent statement about sustainability by relating two or more concrete and/or abstract things relevant to sustainability	Included descriptions/examples associated to more than one of the sustainability principles and showing relatedness of the examples provided.
Extended abstract	Constructed a cohesive, internally consistent statement about sustainability by relating two or more concrete and/or abstract things relevant to sustainability, and provided evidence of critical thinking, ethical judgement, consideration of context or creative/original thinking relevant to sustainability	Included descriptions/examples associated explicitly or implicitly to more than one of the sustainability principles. Additionally, the responses must articulate underlying principles and show an appreciation of the interrelatedness of the principles and complexity of the concept

RESEARCH METHOD

A questionnaire was developed to examine the understanding of sustainability/sustainable development amongst post graduate students of construction management of the Kwame Nkrumah University of Science and Technology. The first part made up of mostly open ended questions asked students to explain in their own words the concepts of sustainable development/sustainability. This use of open ended questions is described as adequate for measuring "knowledge of meaning" components (Hailikari et al 2007). The second part of the questionnaire contained questions on various characteristics of the respondents including age, profession, work experience, educational qualification and prior lessons in sustainability, sustainable development or sustainable construction. The questionnaire was administered to first year Master of Science students in Construction Management of the Kwame Nkrumah University of Science and Technology. Fifty-nine students responded out of a total of sixty-four students in 2017. The high response rate was because the questionnaires were administered during class before the start of the module on sustainable construction.

The data pertaining to student explanations of the concepts were analysed by scrutinizing for the presence or absence of themes related to key principles of sustainable development by Gibson (2006) outlined in the literature review. Table 54 provides two examples of responses and the related sustainability principles as per analysis. The protocol for categorising student knowledge/understanding

developed by Carew and Mitchel based on the SOLO taxonomy was then used to categorize responses according to the five stages of the SOLO taxonomy. The frequency of occurrence for each was identified. Together, Gibson's criteria and the SOLO Taxonomy provided a measure of the sophistication of each student's and collective conception of sustainability.

Table 5 Examples of responses and related underlying criteria

Response 1	"sustainability is simply developing/ bringing something out that would not have any negative consequence or implication on both current and future inhabitants (economic, social, and environmentally friendly"
Related sustainability principles	Socio-ecological system integrity Livelihood sufficiency and opportunity Intergenerational equity Intragenerational equity
Response 2	"Is where development is managed such that resources are properly plan and use. It is also to replace such resources"
Related sustainability principles	Resource maintenance and efficiency

RESULTS AND DISCUSSION

Characteristics of Respondents

The fifty-nine (59) respondents were made up of various construction professionals (Table 6) currently registered on the MSc construction programme with most having worked ten years or less in the industry (Figure 1). The ages of the respondents ranged from twenty-four (24) to fifty-six (56) (Table 5).

Table 5 Age distribution of respondents

Age	No. of responses	
Missing	9	15%
20-24	3	5%
25-29	7	12%
30-34	13	22%
35-39	18	31%
40-44	5	8%
45-49	2	3%
50-54	1	2%
55-59	1	2%
Total	59	
Mode	38	
Mean	34.39	
St.dev	8.48	

The concentration of respondents from the construction industry is as a result of the fact that the programme of study (MSc construction management) is largely targeted at professionals within the industry. Furthermore, qualification criteria requires that applicants of the programme have a minimum working experience of at least 2 years except in the rare cases where this requirement is waived for previous undergraduate students of the department who serve as teaching assistants. The implications are that although the sample is in no way representative of construction professionals, the results may be indicative of

problems related to knowledge of sustainable development/sustainability in the industry.

Table 6 Profession of respondents

Profession	No. of responses	
Architect	1	2%
Structural Engineer	10	17%
Quantity Surveyor	28	47%
Construction/project manager	7	12%
Other	2	3%
Teaching assistant	6	10%
Construction engineer	3	5%
Contractor	1	2%
Missing	1	2%
Total	59	

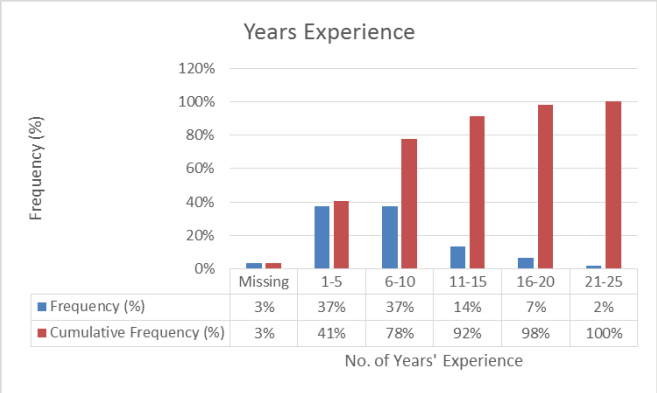

Figure 8 Work Experience of Respondents (Years)

Awareness of Sustainability

The study investigated whether students had previously heard about the concept of sustainability/sustainable development/sustainable constructions.

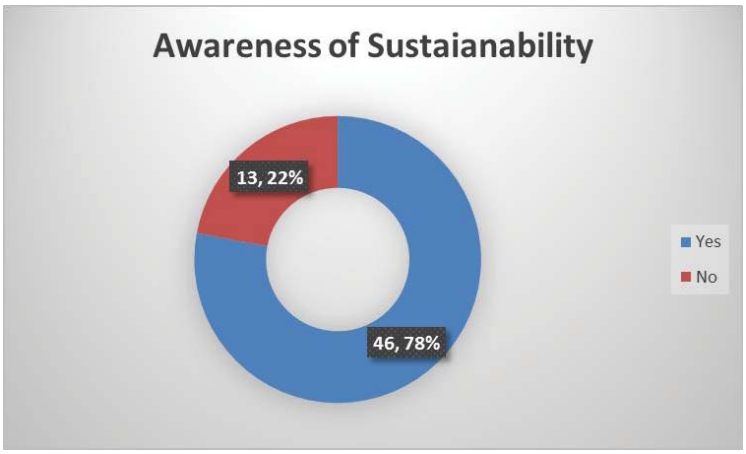

Figure 9 Awareness of Sustainability/Sustainable Development/Sustainable Construction

Conceptions of sustainability/sustainable development

The respondents were then asked to explain the concept of "sustainable development/sustainability" in their own words in order to determine the nature/extent of their knowledge. Although a majority of respondents indicated

awareness, results showed a range of structurally different sustainability conceptions as also obtained by Carew & Mitchel 2002. Most respondents' conceptions fell within the pre-structural and uni-structural categories (Table 67). Some responses fell within the multi-structural and relational categories but relational responses are more of what Biggs & Collins (1989) call transitional responses. The content of such responses were not entirely relational in that although they were cohesive and internally consistent statements on two or more features of sustainability, they did not mention any of the underlying principles of the features they described. As with the study by Hayles et al (2007) no student response was classified as 'extended abstract'. Exploring the content of the responses also revealed that the themes largely related to the environment (Figure 10). However, the responses also showed recognition of other sustainability related issues (e.g. inter and intra-generational sufficiency). This may be because the Brundtland definition for sustainable development as well as the social, environmental and economic dimensions of sustainability are widely cited and referred to in literature. In fact five of the respondents quoted the Brundtland definition and specifically mentioned the three dimensions in their explanations whilst three others mentioned the three dimensions and still three others provided the Brundtland definition alone. This implies that the Brundtland definition and the three dimensions of sustainability have had a notable influence on conceptions of the students. However, other aspects of sustainability (Socio-ecological civility and democratic governance, Precaution and adaptation, Immediate and long term integration) have been understated and require more emphasis. It may also be the case that like the case of Iyer-Raniga et al (2010) students may be using such common definitions without necessarily understanding their meaning.

Table 6 Structural variation in students' conceptions

Solo classification	No. of respondents	%	Examples of responses
Pre-structural	29	49%	the ability to be maintained at a certain rate or level
Uni-structural	14	24%	sustainable development refers to both the structure and the using of processes that are environmentally responsible
Multi-structural	6	10%	Using methods and materials when developing products so that the products will be environmentally friendly and can be used by successive generations
Relational	10	17%	sustainability is satisfying the needs of the current generation without compromising on the environment, social and economic needs of the future generation
Extended abstract	0	0	0
Total	59	100%	

The results also seem to indicate that age may not necessarily account for differences in the knowledge of participants and rather the time at which respondents completed their undergraduate education may be more relevant. This of course may be explained by the fact that over the years, issues of sustainability have been increasingly integrated into academic curricula to reflect corresponding emphasis in research and practice.

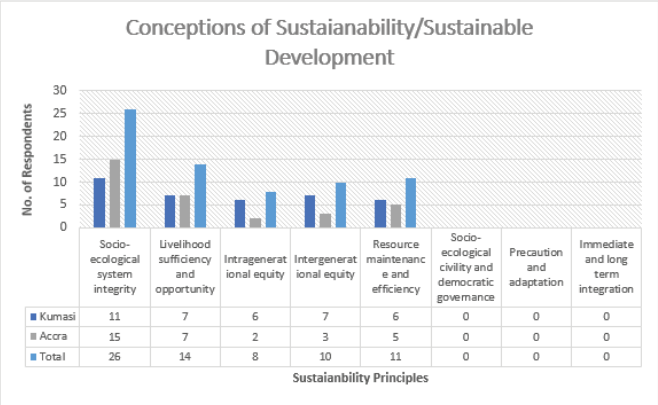

Figure 10 Content of students' conceptions

The results also revealed differences in conception of respondents whether they indicated a prior education (through undergraduate studies or continuous professional development) in sustainable development/sustainability (Figure 1). Even where there was prior education, most of the respondents conceptions were low level (pre or uni-structural) meaning that prior education does not guarantee knowledge and it is important to interrogate the nature of training and education as well as the content. This occurrence is also described by Tan et al (2017) where students showed gaps in knowledge despite having sustainability embedded curriculum. On the other hand, although respondents who indicated a lack of prior education also showed low levels of conception, about forty percent of them provided explanations that fell within multi-structural and relational categories. This may indicate that alternative sources of knowledge exist (interaction with other colleagues, personal reading etc.) which when exploited can serve as useful means of improving knowledge and understanding of sustainability/sustainable development. It is also possible that experiences in industry may account for knowledge on sustainability as was the case with part-time student in the study by Tan et al (2017).

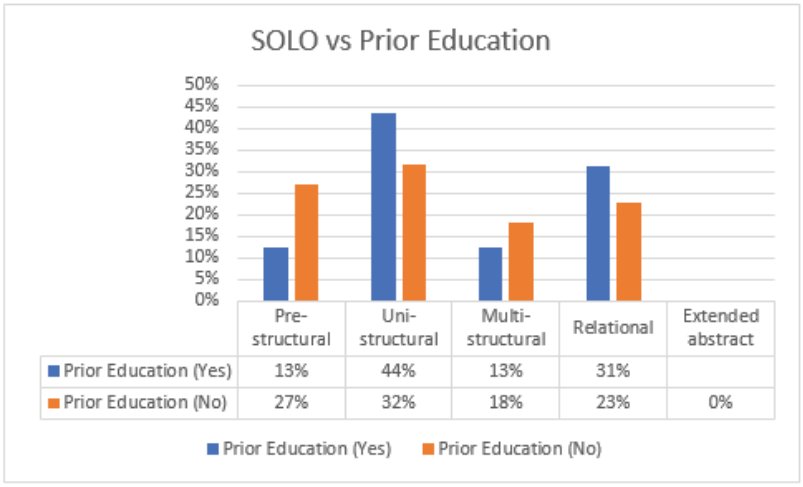

Figure 11 SOLO classification vs Prior education

IMPLICATIONS CONCLUSIONS AND RECOMMENDATIONS

The major significance of this study is the investigation within a completely new context and the exploration of variation of knowledge rather than just the level of

knowledge as is the case with studies in the Ghanaian construction management space. This study sought to investigate the range of students' conceptions of sustainable development and investigate the principles of sustainability highlighted in students' conceptions and is explicit on the type of knowledge assessed. At the end of the study it was found that conceptions of sustainability among post graduate MSc students of KNUST ranged from conceptions that revealed a lack understanding/knowledge of the concept to clearly articulated descriptions of concrete and/or abstract examples of the concept. However, the absence of high level understanding which should be present in a sample of this nature who serve as consultants to clients in the construction industry is worrying. These results highlight the need for teaching methods and learning environment that is suited to allowing students with differing knowledge gaps to develop deeper understanding and applications of the concepts of sustainable development. It is important to also develop content that emphasises sustainability principles that are especially absent in students conceptions. Although the sample is not representative enough to allow for generalisations to the larger construction industry and other construction related students, it highlights the need for such studies that clearly interrogate and examine the nature of the gaps in sustainability knowledge both amongst students and with professionals in the construction industry in Ghana. Further research is therefore need to investigate understanding within different population and also studies that employ interviews to allow for richer data. Assessment should also include other subcomponents of declarative and procedural knowledge and other assessment methods such as concept mapping.

Ghana's efforts towards sustainability has been slow compared with other developed countries; but universities such as KNUST have the potential to serve as a vehicle for change and considerably influence the direction and speed of change towards sustainability through integrated sustainability education that is based an appreciation of the gaps in knowledge and understanding of the students.

REFERENCES

Al-Naqbi, A.K. and Alshannag, Q., 2018. The status of education for sustainable development and sustainability knowledge, attitudes, and behaviours of UAE University students. International Journal of Sustainability in Higher Education, 19(3), pp.566-588.

Azapagic, A., Perdan, S. and Shallcross, D., 2005. How much do engineering students know about sustainable development? The findings of an international survey and possible implications for the engineering curriculum. European Journal of Engineering Education, 30(1), pp.1-19.

Biggs, J.B. and Collis, K.F., 1982. Evaluating the quality of learning: The SOLO taxonomy (Structure of the Observed Learning Outcome). Academic Press.

Bossel, H., Indicators for Sustainable Development: Theory, Method, Applications.

Boulton-Lewis, G.M., 1995. The SOLO taxonomy as a means of shaping and assessing learning in higher education. Higher Education Research and Development, 14(2), pp.143-154.

Brundtland, G.H., Khalid, M. and Agnelli, S., 1987. Our common future. New York.

Buckler, C. and Creech, H., 2014. Shaping the future we want: UN Decade of Education for Sustainable Development; final report. UNESCO.

Carew, A.L. and Mitchell, C.A., 2002. Characterizing undergraduate engineering students' understanding of sustainability. European journal of engineering education, 27(4), pp.349-361.

Cotgrave, A.J. and Kokkarinen, N., 2011. Promoting sustainability literacy in construction students: implementation and testing of a curriculum design model. Structural Survey, 29(3), pp.197-212.

Darko, A., Chan, A.P.C., Gyamfi, S., Olanipekun, A.O., He, B.J. and Yu, Y., 2017. Driving forces for green building technologies adoption in the construction industry: Ghanaian perspective. Building and Environment, 125, pp.206-215.

Djokoto, S.D., Dadzie, J. and Ohemeng-Ababio, E., 2014. Barriers to sustainable construction in the Ghanaian construction industry: consultants' perspectives. Journal of Sustainable Development, 7(1), p.134.

Dochy, F.J., 1996. Assessment of domain-specific and domain-transcending prior knowledge: Entry assessment and the use of profile analysis. In Alternatives in assessment of achievements, learning processes and prior knowledge (pp. 227-264). Springer, Dordrecht.

Edum-Fotwe, F.T. and Price, A.D., 2009. A social ontology for appraising sustainability of construction projects and developments. International Journal of Project Management, 27(4), pp.313-322.

Hailikari, T., Katajavuori, N. and Lindblom-Ylanne, S., 2008. The relevance of prior knowledge in learning and instructional design. American journal of pharmaceutical education, 72(5), p.113.

Hailikari, T., Nevgi, A. and Lindblom-Ylänne, S., 2007. Exploring alternative ways of assessing prior knowledge, its components and their relation to student achievement: A mathematics based case study. Studies in Educational Evaluation, 33(3-4), pp.320-337

Hayles, C. and De la Harpe, B., 2007, September. A study of student perceptions and awareness of sustainability issues. In Third Annual Built Environ. Ed. Conf., University of Westminster, London.

Iyer-Raniga, U., Arcari, P. and Wong, J., 2010, September. Education for sustainability in the built environment: what are students telling us? In Egbu, C. Proceedings of 26th Annual ARCOM Conference, Leeds, UK (pp. 1-10).

Jollands, M. and Baez, E., 2015. Pedagogical approaches to developing understanding of sustainability in STEM graduates. In ISDRS 2015: Tipping Point: Vulnerability and Adaptive Capacity (pp. 1-9). International Sustainable Development Research Society (ISDRS).

Krathwohl, D.R. and Anderson, L.W., 2009. A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Longman.

Lim, Y.S., Xia, B., Skitmore, M., Gray, J. and Bridge, A., 2015. Education for sustainability in construction management curricula. International Journal of Construction Management, 15(4), pp.321-331.

Nicolaou, I. and Conlon, E., 2012. What do final year engineering students know about sustainable development? European Journal of Engineering Education, 37(3), pp.267-277.

Prosser, M. and Millar, R., 1989. The "how" and "what" of learning physics. European Journal of Psychology of Education, 4(4), p.513.

Rogers, E.M., 2010. Diffusion of innovations. Simon and Schuster.

Simonsmeier, B.A., Flaig, M., Deiglmayr, A., Schalk, L. and Schneider, M., 2018. Domain-Specific Prior Knowledge and Learning: A Meta-Analysis. Research Synthesis 2018, Trier, Germany.

Tan, A., Udeaja, C., Babatunde, S.O. and Ekundayo, D., 2017. Sustainable development in a construction related curriculum–quantity surveying students' perspective. International Journal of Strategic Property Management, 21(1), pp.101-113.

Wiek, A., Withycombe, L. and Redman, C.L., 2011. Key competencies in sustainability: a reference framework for academic program development. Sustainability science, 6(2), pp.203-218.

World Commission on Environment and Development (WCED), 1987. Our common future. Oxford: Oxford University Press