Buildings & Cities

Afroz, R. (2020). Developing a low-carbon architecture pedagogy in Bangladesh. *Buildings and Cities*, 1(1), pp. 637–649. DOI: https://doi.org/10.5334/bc.54

SYNTHESIS

Developing a low-carbon architecture pedagogy in Bangladesh

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Abstract

Architectural education and training can help ensure low-carbon emission for projects. Despite some broad initiatives to address this, there are still gaps in the curricula, theory and practices. The current pedagogical trends and approaches in Bangladesh are identified and examined for how climate mitigation is addressed in the architecture curriculum. This has revealed a lack of awareness, limited education and training, and inadequate pedagogical (*i.e.* teaching) approaches for low-carbon education in architecture curricula. A lack of alignment exists between curricula orientation and the national agenda for climate change and low-carbon development. In order to integrate a sustainable low-carbon education in the architecture pedagogy, a set of recommendations for pedagogical approaches, education and training framework is proposed to offer crucial guidance to academia and other relevant stakeholders.

Practice relevance

Bangladesh is acutely affected by climate vulnerability due to its geographical location in the Ganges Delta. Although mitigation and low-carbon development policies are part of the national agenda, this has not been incorporated into the additional capabilities required by architects to deliver this. Low-carbon design and sustainability issues in architectural curricula are still in the initial phases of development. A lack of awareness, inadequate education and training, and lack of alignment between curricula orientation and the national agenda are identified as important factors. A set of scalable solutions and recommendations for education and training for architectural students is suggested.

Keywords: architects; built environment; climate change; education; low carbon; mitigation; pedagogy; sustainability; Bangladesh

1. Introduction

A large portion of total global CO_2 emissions in the atmosphere is due to rapid urbanisation and massive infrastructure development designed by built environment professionals. Botha *et al.* (2013) concluded that one of the key drivers promoting sustainable development (SD) in developing countries is driven by the contributions of professionals and future practitioners from the built environment (Allu 2016). Given the growing relevance of the sustainability agenda to the professions of the built environment, one way to ensure that its mandates are effectively integrated in architecture and urban design is to revisit the role that education, particularly at the university level, can play (Altomonte 2012: 54). Therefore, many schools in Europe, the US and Asia (Singapore and Malaysia) have begun to revise their syllabus content to include sustainable design and technical approaches (Ibrahim 2008, cited in Fatemi & Islam 2012: 259).

The United Nations' (UN) 57th Session declared 2005–14 as the Decade of Education for Sustainable Development (DESD). The UN DESD (2014) report stated that 'education is the key to sustainable development' (p. 6). Barth & Timm (2011) and Lozano *et al.* (2013) observed that many Western countries have started embedding environmental education into their curricula. The year 2012 was important for the SD timeline. A renewed political commitment from the global community occurred at the Rio+20 Earth Summit and a process was initiated to develop a set of Sustainable Development Goals (SDGs). The Higher Education Sustainability Initiative (HESI) (Boarin *et al.* 2019) was also created as a partnership between different UN agencies to provide a unique interface between higher education, science and policy-making (Paletta *et al.* 2019).

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The aim of this paper is to examine the current trends and approaches in Bangladesh's architectural education for creating a low-carbon built environment.

According to French (1998: 5), 'architecture is not considered a self-sufficient profession anymore but a multi-disciplinary, multi-skilled and multi-directional profession'. The argument here is that architecture is complex and comprised of several different forms of knowledge (Masri 2017: 118). It is an amalgamation of various disciplines and philosophies that plays vital roles in the total architectural learning process. 'The existence of multiple philosophies poses crucial questions about the pedagogical organization in architectural education' (Salama 1998: 128).

The built environment can be represented by different spatial scales for the purposes of exploring alternative pathways for delivering more sustainable low-carbon outcomes from the planning, design and management of cities (Newton 2017: 22). Options for adapting urban environments to a warmer climate have implications for reducing energy demand for cooling buildings (mitigation target) as well as delivering human health co-benefits (Ding *et al.* 2019).

Among the several research projects that critically reviewed the barriers and opportunities to implement sustainable education in architecture discipline, the Environmental Design in University Curricula and Architectural Training in Europe (EDUCATE) is prominent. EDUCATE is a European project seeking to look critically at the barriers and opportunities afforded by implementing sustainability in pre- and post-professional education in architecture and urban design, and exploring some of the strategies required to promote such integration (Altomonte 2012). It proffers a positive way forward. It shows how contemporary knowledge from research and best practice can be harnessed to form the knowledge base for a sustainable environmental design to be taught at all levels. This should also reflect cultural diversity and innovation (EDUCATE Project Partners 2012). To identify best practice in integrating sustainability in academic programmes, EDUCATE has analysed the relationship between different disciplinary areas in several courses/degrees (Altomonte *et al.* 2014). The focus is on: (1) content, *e.g.* the stages of education where specific information on sustainability is provided; (2) staff-to-student ratio (SSR or full-time equivalents) for theoretical and applied modules; (3) delivery methods, *e.g.* specialist lectures, seminars, workshops *etc.*; (4) pedagogical tools, including software, live projects, *etc.*; and (5) assessment criteria, *i.e.* coursework, laboratory tests, fieldwork, *etc.* Altomonte *et al.* (2014: 22) further suggested the need to link continuous professional development (CPD) for educators and practitioners directly to change legislation, and benchmarking academic coursework against leading-edge practices.

Other researchers have also observed challenges influencing sustainability integration in built-environment curricula. **Table 1** illustrates their observations.

Different approaches integrating sustainability in architectural programmes have been implemented around the world (Boarin *et al.* 2019). Iulo *et al.* (2013) (see also Allu 2016) examined the curricula of US architectural programmes and revealed four approaches to the curriculum: core value, technological domain or systems focused, choice, and specialisation. The approaches are illustrated in **Table 2**. The 'core value' approach covers all aspects of learning, unlike 'specialisation', which is mainly for postgraduate students. However, the 'technological' and 'choice' approaches are restricted to a specific technology focus and the choice approaches appears as an elective course.

1.1 Climate change policy and low-carbon pathways for Bangladesh

Bangladesh is one of the top 10 nations most vulnerable to climate change (Mahmood 2012: 223). The mega-city Dhaka, with a population over 15 million, is growing at a fast rate of 4.2% per year, one of the highest amongst Asian cities, and it is expected to double in population by 2050. As a climate vulnerable country, its nationally determined contributions

Table 1: Summary of factors influencing sustainability integration in built environment curricula.

Reference	Challenges
Shari & Jaafar (2006)	Low knowledge and exposure; non-prioritisation by policy bodies; lack of practical skills at the right level; poor dialogue and coordination; lack of training and education in sustainability; restrictive structure towards innovating; crowded curriculum; lack of agencies to promote sustainability issues; lack of resources (books and the likes); lack of exemplar projects; and ignorance and negative attitude towards sustainability
Yang & Giard (2001), Metropolis (2002)	Complex and added skills requirements; and lack of adequately trained academic staff
Shafii & Othman (2005)	Lack of awareness; lack of research and professional network; and skills and knowledge dearth
Bobbo *et al.* (2015)	Incompatible teaching methods; and lack of training and a theory-based curriculum
Majumdar (2009)	Inability to define sustainability skills and knowledge; inability to integrate sustainability into the subject domain; and an inability to define a learning and teaching methodology
Lozano (2006)	Lack of information; disagreement with the idea; individual and organisational resistance to change; lack of facilities; lack of empowerment; rigid curricula; and lack of interdisciplinary training in learning

Source: Adopted from Ekung *et al.* (2019: 23).

Table 2: Approaches to sustainable education (SE) in higher education.

S/N	Approaches	Actions	Remarks
1	**Core value:** sustainable education is seen as a "core value" course	Included in the content of all courses	Addresses sustainable conscious design
2	**Technology domain:** contained in environmental systems courses	Fulfil the sustainable education needs of architecture students	Specific or technology courses only
3	**Choice:** sustainable education optional	Students select sustainability-related courses by choice	Seen as an elective course only
4	**Specialist knowledge:** sustainable education is a specialty course	Occurs mainly at the graduate level and in concert with centres or institutes also focused on sustainable research.	Limits future career of student who may not pursue graduate research opportunities

Sources: Adopted from Iulo *et al.* 2013; Allu 2016: 1214.

(NDCs) are central to the Paris Agreement that set out an approach to becoming a low-carbon and climate-resilient economy. Bangladesh ratified the Paris Agreement and its NDC can now be found on the United Nations Framework Convention on Climate Change's (UNFCCC) interim NDC Registry. According to the Paris Agreement, Bangladesh is requested to submit an updated NDC (n.d.) by 2020 with a timeframe to 2030.

The intended nationally determined contributions (INDC) (2015: 2) include both unconditional and conditional emissions reduction goals: (1) an unconditional contribution to reduce greenhouse gas (GHG) emissions by 5% from business-as-usual (BAU) levels by 2030 in the power, transport and industry sectors, based on existing resources; and (2) a conditional 15% reduction in GHG emissions from BAU levels by 2030 in the power, transport and industry sectors, subject to appropriate international support in the form of finance, investment, technology development and transfer, and capacity-building. Therefore, a twin approach against climate change impacts adopted by Bangladesh is: increasing 'resilience' to the impacts of climate change and working to achieve lower GHG emissions.

Although the country's carbon emissions are <0.35% of global emissions (INDC 2015: 2); the government of Bangladesh prepared the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) (2009) for adaptation and Low Carbon Development (LCD). INDC (2015: 1) shows the intention to manage growing emissions without compromising development, and to allow Bangladesh to play its role in global efforts to limit temperature rise.

Newton (2017: 20) stated that 'sustainable low carbon urban development roadmaps need to include both mitigation (decarbonisation) and adaptation (resilience) pathways'. According to the BCCSAP (2009: 61–70) under the theme Mitigation and Low Carbon Development (T5), there are 10 programmes. Among the subprogramme objectives, several are relevant to built-environment professionals: improved energy efficiency, renewable energy development (decarbonisation), management of urban waste, expansion of energy-saving devices, and water efficiency. Therefore, both the low-carbon development scenario and climate-change policy context offer a legal basis for built-environment professionals to be trained in mitigation and adaptation strategies

1.2 Architectural education in Bangladesh

During British rule (1757–1947), the Indian subcontinent had no formal architectural education, and 'prototypical plans were sent by architects in England to be adapted by local draftsmen or expatriate engineers to meet local needs' (Islam & Dunham 2012, cited in Parvin & Moore 2019: 3; Islam 2012b). Until the 1950s, most of the architectural projects were undertaken by foreign architects, surveyors and local draftsmen due to the non-existence of local architects (Begum *et al.* 2011). Important buildings during the colonial period designed by British architects and surveyors were mostly exact replicas of those in Europe, with minor modification. Islam *et al.* (1985: 26) noted, 'Almost all contemporary works are basically rooted in western culture, though the architects, local and foreign, have tried to solve problem with local conditions in mind'.

Formal architectural education started in Bangladesh in 1961 under an exchange programme managed by the United States Agency for International Development (USAID) (Parvin & Moore 2019). The programme was based in Dhaka, at Ahsanullah Engineering College (AEC), which became the East Pakistan University of Engineering & Technology (EPUET) and was renamed the Bangladesh University of Engineering and Technology (BUET) (Ahmed 2012; Parvin & Moore 2019). The architectural department was initially staffed by Professor Richard E. Vrooman from Texas A&M University. The curriculum was modelled on that at Texas A&M (Mallick 2007; Tigermann 2011). Three other expatriate faculty members, including Daniel C. Dunham, James C. Walden and Sam Lanford (Islam 2012b, cited in Parvin & Moore 2019: 7; Dunham & Westconmbe 2012), assisted Vrooman, and later two additional US architects, Jack R. Yardley and R. Volmer, joined the team (Ali 2012, cited in Parvin & Moore 2019).

Vrooman and his faculty put in place the most up-to-date and modern pedagogy known: that of the German Bauhaus, which was by this time dominant in the US and Europe (Parvin & Moore 2019). The unintended consequences of this teaching approach were a pedagogical disconnection to the place, people and culture of Bangladesh, and to the architectural heritage of Bengal in particular (Benninger 2012). **Table 3** compares the pedagogical approaches used at

Table 3: Comparison of the pedagogical features and teaching focus between architecture curricula of Texas A&M University and Bangladesh University of Engineering and Technology (BUET), 1961–62.

Features	Texas A&M	BUET
Pedagogical approach	· Encourage students to develop sensibly and apply their acquired fundamental knowledge and skills to the social and architectural problems of contemporary society · Develop the capacity to analyse, plan and recognise space in order to serve the needs and welfare of people with the full recognition of their professional responsibilities to an individual as well as to his/her community	· Develop skills to serve the real needs of drafting, designing, building and managing the construction of buildings · Based on 'advocate no style', style and design matters were left to the individual students, while academic matters were leavened by 'doing'
Teaching focus	· Techniques of drafting and principles of design and construction · Comprehensive problems of architecture	· Basic elements of abstract architectural composition; techniques of drafting and presentation

Source: Adopted from Parvin & Moore (2019: 8).

Texas A&M and BUET at that time. Over the decades, when additional schools of architecture were established, they also followed the BUET model (Mostafa & Parvin 2012).

A key individual who had a pivotal role in curriculum development was architect Mazharul Islam. He was trained in architectural studies at the University of Oregon (1952) and briefly studied in 1957 at the Department of Tropical Architecture at the Architectural Association School. Islam and S. Tigermann based their architectural work on climatic- and later cultural-responsive design (Ahsan *et al.* 2012: 328). Their built work in Bangladesh helped to establish climatic design. In the late 1970s, M. A. Muktadir,[1] an educator at BUET, returned to Bangladesh after completing his doctorate at the University of Edinburgh on tropical climatic design. He added an emphasis on climatic design and incorporated changes to BUET's curriculum accordingly (Ahsan *et al.* 2012: 329). According to Muktadir, he had made substantial alteration by introducing practical field observations along with theoretical knowledge (private conversation, August 2020). The similar influence is apparent in other curricula as well (see below).

Bangladesh's second School of Architecture opened at Khulna University (KU) in 1991 (Ibrahim *et al.* 2012). A large number of private schools have also been established in Bangladesh: the first was established in 1995 at Ahsanullah University of Science and Technology (AUST). Due to increasing demand for architecture professionals, the recent trend shows the establishment of architectural schools in the capital as well as different parts of the country numbering more than 20.

In Bangladesh, the five-year Bachelor programmes are composed of two or three semesters a year. BUET has a postgraduate programme offering MArch and PhD courses; and AUST also offers an MArch. The five-year undergraduate programme is design based, with the greatest credit hours (CRs) allotted to 'design studios'. The Accredited Standard of the Institute of Architects Bangladesh (ASIAB) has recommended 60 CRs (ASIAB 2010: 11); however, there is some variation in different schools.

The total programme has a minimum of 160 CRs (ASIAB 2010) in addition to CRs earned from internship. The teacher and student ratio must not exceed 1:15 in the studio-based class (ASIAB 2010: 4), and at least one teacher must be a professor. The current accreditation system is largely derived from the American system (Islam 2011; Begum *et al.* 2011). A comparative chart of the primary areas of emphasis is shown in Table S1 in the supplemental data online, with the recommended guidelines of the ASIAB and the US National Council for Architectural Registration Boards (NCARB) (2011).

The University Grants Commission (UGC), established in 1973, is attached to the Ministry of Education in Bangladesh. The Institute of Architects Bangladesh (IAB) is the statutory body for architecture graduates from an IAB-accredited university to apply for membership application and examination. To become a registered architect, graduates obtain two years of working experience under a member architect before they sit for the registration examination. The ASIAB is the regulatory body for accrediting and evaluating different schools which started operating in 2010. The ASIAB (2010: 11) has produced a guideline on the teaching–learning process: (1) the programme must encourage and protect continuous interaction between practice and teaching of architecture; and (2) the programme is advised to create systems for self-evaluation and peer review conducted at regular intervals. As discussed above, the

> BUET has been a strong influence in shaping the general curricular bias of architecture education in Bangladesh.

Other observations are:

> an emphasis on drafting and presentation, lesser number of humanities courses and emphasis on teaching skills and techniques. (Ahsan *et al.* 2012: 337)

and lack of a strong 'link between studio and theory courses' (Begum *et al.* 2011: 27).

Previously the entire curricula fell under objective-based education, meaning the course objective was the main focus. However, currently all the universities under the aegis of the UGC are advised to alter their syllabus according to an outcome-based education (OBE) template. This template is vigorously designed to align the course learning outcome (CLO) with the program learning outcome (PLO). This will allow the courses to focus on the learning outcomes.

1.3 Sustainability influences in the architectural curricula

Under the section 'Technical system' is a specific direction on 'Environmental Control System' (ASIAB 2010: 15–16) that elaborates on energy efficiency, energy transmission, environmental systems and sustainability. This topic is defined as building elements that pertain to the modification of the microclimate for the purpose of human use and comfort. Acceptable topics include acoustics, air-conditioning, building core systems, energy, energy efficiency, energy transmission, environmental systems, fire protection, heating, lighting (natural and artificial), plumbing, sanitary systems, solar energy utilisation, sound, and sustainability.

Only level IV design (for fourth-year students) includes sustainability (ASIAB 2010: 17) in the synthesis of complex building and multi-building complexes within the urban context; integration of technical information; general proficiency in the total synthesis of complex buildings and related systems; transportation, communication, lifestyle systems, and social ramifications of planning and architecture; and principles of sustainability.

2. Methods

According to the above discussion, in order to understand the connection and gap between the curricula, theory and practice of low-carbon architecture pedagogy, a conceptual framework is derived that aims to study the integration of a sustainable low-carbon built environment in the architecture pedagogy (**Figure 1**).

The methodology is supported by the best-practice strategies and pedagogical approaches and a semi-structured questionnaire for discussion, followed by recommendations. In order to identify the connection and gaps between the curricula, theory and practice of a sustainable low-carbon architecture pedagogy, two methods are followed: (1) the assessment of the programme structure of courses that include low-carbon built environment contents; and (2) qualitative data analysis (QDA) with a questionnaire.

This study compares the BArch programme's structure in five different schools of architecture (**Table 4**). It considers two public universities: BUET and Architecture Discipline and KU; together with three private universities: AUST, University of Asia Pacific (UAP) and Department of Architecture at BRAC University (BRACU). The reason behind selecting these five universities is that BUET, KU and AUST have the oldest architecture departments with a large number of graduates, and UAP and BRACU are randomly selected from the well-reputed ones.

For the core design studio and other studios (only), credits are based on twice the number of contact hours per term semester, *e.g.* one credit requires two CRs, while for core and optional theory, contact hours will remain the same as CRs.

In order to understand the pedagogical strengths, opportunities and approaches of sustainability education and low-carbon issues in Bangladesh, the analytical framework proposed by EDUCATE (2011) (cited in Altomonte *et al.* 2014: 151) and the sustainable education approaches in higher education are considered. This can identify the gap between prevailing local curricula structure and global best-practice theories and approaches. To receive the cumulative observation from the veteran educators, fresh graduates, practicing architects and built-environment professionals,

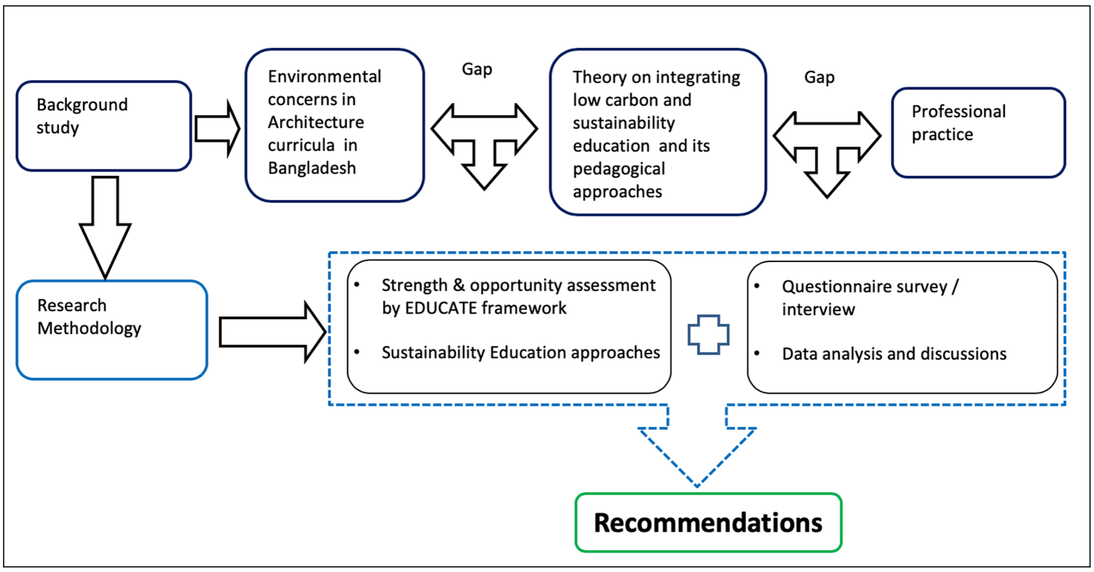

Figure 1: Conceptual framework for the study of a sustainable low-carbon architecture pedagogy.

an analytical qualitative method was used through a semi-structured three-point Likert-scale questionnaire. The questionnaire included multiple-choice questions (agree, neutral and disagree) and open-ended fields for each question.

A total of 15 questions were divided into five subcategories: (1) climate change, low-carbon development and sustainability awareness; (2) content in current curricula; (3) curricula revision and execution; (4) professional training and support; and (5) new ideas, *i.e.* open-ended questions for suggestion/recommendation.

Questionnaires were sent to 50 people, and 45 responses were received. The sample size (n = 45) represents only a small proportion of the architectural community and cannot be extended to all schools and situations. There is room for further improvement by broadening the survey and accommodating more institutions. The sample size varied from seven to 10 from each alumni group consisting of members from the five selected universities. The percentage and medium of interviews were 76% face to face, 13% over the phone and 11% via mail. **Table 5** shows the distribution of the respondents.

The selection process was a combination of random selection, intentionally requested for an interview (for some educators and architects) and through personal connections. The place of interview was either in their office or their department or authors' office, whichever the interviewees preferred. The selected course materials and the interviewees only belong to these five institutions. Finally, the observations are discussed according to findings from both of the above steps.

This paper only considers undergraduate level (*i.e.* Bachelor of Architecture) theoretical courses.[2] The interview was offered to recent graduates, professionally accredited practicing architects and eminent educators who have graduated from or are working in the five selected universities.

3. Findings and discussion

3.1 Programme structure

The comparative study shows that all the selected courses are theory courses in all five schools: only BUET has an applied course, *e.g.* Environmental simulation, which is a software-based course. All course work is assessed through assignments, class tests, and midterm/final examinations. It shows that the theoretical discussions related to sustainable low-carbon

Table 4: Comparison of the BArch programme structure of the selected universities in Bangladesh using credit hours (CRs).

	BUET (public)	KU (public)	AUST (private)	UAP (private)	BRACU (private)
Core design studio	60	75	78	60	60
Other studio	24	21	25.5	31	20
Core theory	67	74	88	70	85
Optional	18	30	0	16	10
Subtotal	190	200	191.5	198	199
Internship (weeks)	6		6	6	8

Note: BUET = Bangladesh University of Engineering and Technology, and Architecture Discipline; KU = Khulna University; AUST = Ahsanullah University of Science and Technology; UAP = University of Asia Pacific; BRACU = BRAC University.
Source: Adopted from Ahsan *et al.* (2012: 333). AUST's intern information is being updated by the university's administration.

Table 5: Distribution of respondents.

	Total	Face to face, 76%	Over phone, 13%	Via mail, 11%
BUET	9	2 educators 1 LEED AP[a] 2 architects (including IAB president)	2 architects	2 architects
KU	9	3 educators 5 architects	1 educator	
AUST	10	4 educators 6 architects		
UAP	8	5 architects	1 architect	1 architect
BRACU	9	5 architects	2 architects	2 architects
Subtotal	45	34	6	5

Notes: For abbreviations, see Table 3.
[a] LEED Accredited Professional (LEED AP) is a certification that distinguishes those with advanced knowledge in green building plus have expertise in a particular LEED rating system (USGBC 2020).

issues include mostly energy efficiency, thermal control and passive cooling of buildings. No course mentions the low-carbon built-environment directly; however, many highlight energy and sustainability issues (**Table 6**).

The approaches determine that all five curriculums serve the 'technology domain' purpose, *i.e.* they fulfil the sustainable education needs of architecture students through the specific theory course only. However, only BRACU has the scope for choices/optional courses.

The staff-to-student ratio varied from 1:33 to 1:55 from course to course because it depends on the number of semesters (*e.g.* two to three per year), and the student intake per year. Generally, all theoretical courses follow regular class lectures. Various types of pedagogical tools, such as live projects and application technical/advanced software, are absent. However, these facilities hold ample opportunities for students if facilitated. Table S3 in the supplemental data online illustrates the contextual assessment through the EDUCATE framework.

Individual teachers have tried to modify the pedagogical approach in their own courses. However, these isolated efforts did not work at bringing about modifications in the pedagogic approach, and neither did a curriculum design based on a different model (Ahsan *et al.* 2012: 335). Therefore, this under-researched area needs much collective effort for modification or reformation.

3.2 Questionnaire

A QDA with a semi-structured three-point Likert-scale questionnaire through interview was used. For a graphical representation of the three-point Likert answers, see **Figure 2**.

A summary of the discussion on responses to the semi-structured questionnaire is presented in **Table 7**.

Table 6: Summary of the major content and their approaches.

	BUET (public)	KU (public)	AUST (private)	UAP (private)	BRACU (private)
Theory courses	•	•	•	•	•
Applied courses	•				
Energy efficiency	•	•		•	•
Thermal control/performance	•	•	•		•
Passive cooling/design/control	•		•	•	•
Alternative solutions	•				
Environmental design	•	•			
Sustainable development/sustainability issues	•				•
Approaches to sustainable education in architecture pedagogy in Bangladesh					
Core value					
Technology domain	•	•	•	•	•
Choice					•
Specialist knowledge					

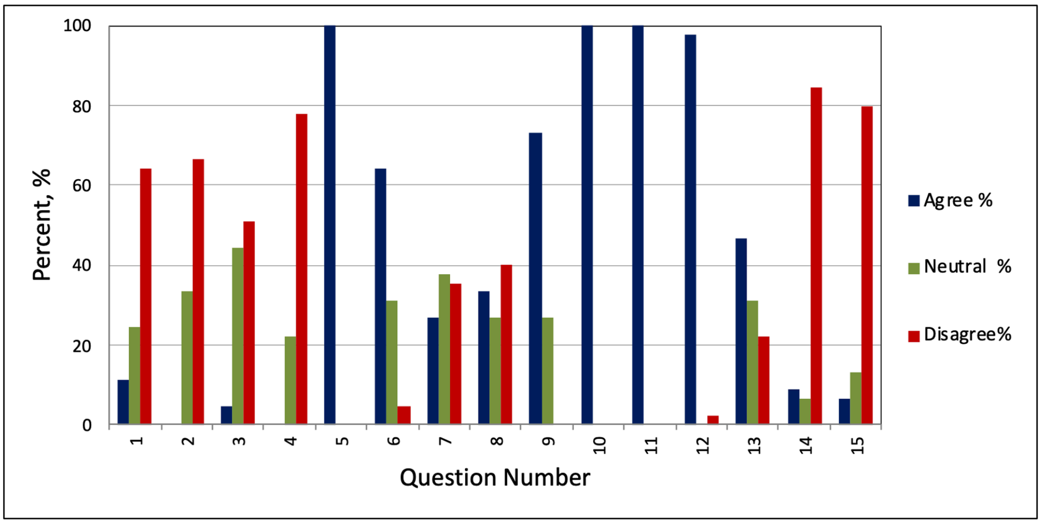

Figure 2: Question and response percentage from the questionnaire survey.

Table 7: Responses to the questionnaire.

No	Questions	Responses
(a) Climate change, low-carbon development and sustainability awareness		
1	You are aware of the climate change, sustainability, and low-carbon development issues	64% responded that they were unaware of the fact of climate change, sustainability and low-carbon development issues. The reason they mentioned is lack of education and practice
2	Our built environment professionals are aware of the climate emergency and low-carbon development policies	0% agreed, 33% were neutral and 67% expressed they were not aware
3	You are equipped to respond to sustainability challenges.	Only 4% (2/45) replied they were ready to face sustainability challenges; 51% of respondents disagreed and 45% were neutral
(b) Content in the current curricula		
4	Low-carbon study is present in architectural education	0% agreed, 22% were neutral and 78% disagreed that low-carbon issues are present in the architecture curricula
5	Low-carbon studies should be included in the curricula of architectural education	All the respondents agreed that they need education and training (*e.g.* at pre- and post-professional level) on low-carbon issues. It has been suggested by a few of the respondents that long-term training or workshops would be helpful for professionals rather than a day-long continuous professional development (CPD) course
(c) Curricula revision and execution		
6	Education and training can be rapidly modified to ensure the creation of low-carbon built environments	65% agreed, 31% were neutral and 4% expressed that it would be quite difficult to execute
7	This transition can be implemented successfully	Only 27% think that this transition can be implemented successfully; 33% think positive examples can help in this aspect, while 40% disagreed and gave a different opinion
8	Positive examples and models can be drawn upon or adapted	33% agreed, 27% were neutral and 40% disagreed
9	Creative investigation (design projects) and technical science (structure and other technical courses) both have a potential to be explored by the low-carbon built environment	73% think that creative investigation (*e.g.* design projects) and technical science (*e.g.* structure and other technological courses) have the potential to explore the low-carbon built environment; 27% were neutral and 0% disagreed
(d) Professional training and support		
10	Low-carbon education and training should be facilitated at pre- and post-professional levels	100% of respondents agreed
11	Providing a low-carbon investigation scope through industrial/professional application	100% of respondents agreed that direct communication with the industry will open up a vast scope for learning and investigation of low-carbon emission/design parameters
12	CPD and certified training (on sustainable design/low-carbon development) for educators and practitioners by professional bodies	98% agreed that CPD and month-long certified training (on sustainable design/low-carbon development) for educators and practitioners should be organised by professional bodies and that it will bring much opportunity for them. Only 2% disagreed
13	Competence in sustainable low-carbon design as a requirement for professional membership	47% respondents agreed, 31% were neutral and 22% disagreed with this issue. A few suggested that it may inspire many professionals to build their awareness willingly. It was greatly appreciated that a minimum requirement of sustainability knowledge during the professional registration examination will enhance their awareness about low-carbon development
14	Regulations in your country adequately supports the practice of sustainable design/low-carbon development	9% agreed, 7% were neutral and 84% disagreed that the practice of sustainable design and low-carbon development is supported by building regulations in Bangladesh
15	Your clients consider sustainability as an opportunity beyond legislative requirements	Only 7% agreed, 13% were neutral and 80% of respondents disagreed with the fact that their clients show support for sustainability issues. They argued that very often clients disagree due to lack of funds or additional expenditure for addressing sustainability issues

4. Recommendations

Environmental awareness, low-carbon issues and sustainable education should be integrated as a *core value* and commitment in Bangladesh's architecture education. Early semesters are crucial to let students grasp the knowledge conceptually. Kim & Ringdon (1998) also agreed that it is much easier to instil an environmental consciousness at the formative stage of education than in later stages.

Hands-on training could include small-scale live projects and be arranged through class projects or internship with the help of industry, practitioners and other stakeholders. Fieldwork, measurable tools, *etc.* could be very helpful as a part of hands-on training. The scope to integrate live projects or fieldwork and software facilities could cater for a tangible result towards a low-carbon pedagogy. Architectural courses in other countries have successfully used advanced software for the design approach. This would allow a creative investigation to be supported by technical tools to provide students with a clearer understanding of how design strategies impact resources and internal conditions. In addition to theory courses, certified training seminars and workshops could be arranged. Inter- and intra-departmental 'design charrettes' can be used to stimulate creative thinking on the climate emergency, sustainability, energy-efficient built form and low-carbon-emission initiatives. Sustainability training must be fully embraced at various stages of the curricula, and also be acknowledged by the institutional bodies (Altomonte 2009).

4.1 Organisational issues

The implementation of change depends on the agreement of a diversity of stakeholders and institutions. A three-layered framework is proposed as an interface between three key groups of organisational stakeholders in architecture: academia, professional practice and policy-making (**Table 8**). The first tier (core group) consists of faculty members from the same department. The first tier will prepare a yearly evaluation report (*i.e.* content and syllabus review and modification), which is then sent to the second tier that consists of members from the first tier, other departments, local accreditation bodies (*i.e.* ASIAB), local research organisations such as the Bengal Institute (2020) and Centre of Urban Studies (CUS) (n.d.), *etc.*, and other built-environment professionals and alumni. The second tier will send yearly feedback to the first and third tiers, and arrange training/seminar/dialogue (similar to CPD) for the first tier. The third tier, consisting of representatives from the first two tiers and relevant global agencies' (*e.g.* Higher Education Sustainability Initiative, Aga Khan Development Network—AKDN) policy-makers, related departments from government, *etc.*, will send feedback to the other two tiers along with arranging training/seminar/dialogue every two or three years. This interface will enable:

- the OBE to become aligned with the CLO and national agendas regarding climate change/mitigation and low-carbon development objectives
- a more extensive syllabus review aiming to accommodate the current environmental context and global sustainability challenges
- knowledge-sharing with other departments, universities and international agencies.

The idea behind this method is that an awareness of such a global concern should be shared with other relevant departments and agencies; therefore, the scope of the multidisciplinary effort is gradually opened in the third tier.

Many architectural schools have not developed a concise methodology for integrating sustainability issues into the curriculum (Shari & Jaafar 2012). Therefore, this proposed broad review panel consisting of the three-tier committee members could provide unbiased and advanced educational feedback towards sustainable low-carbon architecture pedagogy.

Table 8: Activity pattern of the proposed three-tier programme on Low Carbon Education and Training for architecture pedagogy.

Tier	Review panel members	Duration or evaluation	Arrange yearly training and feedback report to ...
T1	Departmental syllabus review panel members (core group)	Yearly	Tier 2
T2	Representative from Tier 1 and interdepartmental members, local accreditation/regulatory bodies (*e.g.* The Accredited Standard of the Institute of Architects Bangladesh—ASIAB), local research organisations such as the Bengal Institute, Centre of Urban Studies (CUS), industry/professional practitioners, alumni, climate researcher, *etc.*	Meeting or workshop for training (may be virtual) every two years	Tiers 1 and 3
T3	Members/representatives from Tiers 1, 2 and faculty members from international universities, relevant global agencies (*e.g.* Decade of Education for Sustainable Development—DESD, The Higher Education Sustainability Initiative—HESI, and Aga Khan Development Network—AKDN etc.) policy-makers, related departments from the government, *etc.*	Virtual meeting, workshop or seminar every three years	Tiers 1 and 2

5. The way forward

A review of the architectural curricula has identified the current trend, challenges and opportunities in Bangladesh to accommodate the 'sustainable low-carbon built environment'. This can be used to improve compatibility with the education and training efforts. Special care is needed to integrate and incorporate sustainable low-carbon education and training through the scope of mitigation (decarbonisation) and adaptation pathways in design, pedagogy and practice. A low-carbon architecture pedagogy must break the barriers in the conventional pedagogical/disciplinary systems and bridge divides between creative investigation and technical science through education and training at the pre- and post-professional levels in a comprehensive manner. This would impart skills and knowledge among the graduates of architecture who would actively contribute to the reduction of global emissions. The approaches proposed by the author are expected to offer crucial guidance to academia and other relevant stakeholders.

Notes

[1] Professor Dr M. A. Muktadir (BArch, University of Florida, US; PhD, Edinburgh, UK) was the former Head of the Architecture Department at BUET, Khulna University (KU) (founder head) and Asanullah University of Science and Technology (AUST) (founder head). For his doctoral thesis, see Muktadir (1975).

[2] Postgraduate courses were not considered because most architects do not pursue further study after a five-year course, and postgraduate education is only available in a limited number of institutions.

Acknowledgements

The author gratefully acknowledges the contributions of Dr Zebun Nasreen Ahmed (Professor and former Dean and Head of the Department of Architecture, Bangladesh University of Engineering and Technology (BUET); BUET alumnus), architect Jalal Ahmed (President IAB; BUET alumnus), architect Saiful Haque (Aga Khan Award Winner 2019; BUET alumnus) and architect Saiful Islam, PhD (Associate Professor and former Chairman of the Department of Architecture, North South University; AUST alumnus) for their support, interview and constructive discussion.

Competing interests

The author has no competing interests to declare.

Supplemental data

Supplemental data can be found at https://doi.org/10.5334/bc.54.s1

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How to cite this article: Afroz, R. (2020). Developing a low-carbon architecture pedagogy in Bangladesh. *Buildings and Cities*, 1(1), pp. 637–649. DOI: https://doi.org/10.5334/bc.54

Submitted: 12 February 2020 **Accepted:** 24 August 2020 **Published:** 23 September 2020

]u[*Buildings and Cities* is a peer-reviewed open access journal published by Ubiquity Press OPEN ACCESS