Emphasizing Sustainability Principles in Developing Building Technology Courses: Engineering Educational and Research Collaboration between Egypt and USA

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Abstract – In partnership research with the Department of Technology Systems, East Carolina University, in the USA, the study attempts to explore means of developing Building Technology courses at both undergraduate and graduate levels in the Department of Architectural Engineering at Mansoura University in Egypt. It aims to examine the potential of incorporating sustainability goals, contents, and measures into further architectural engineering curriculum reform. Methods and potentials of using technology to encourage and enable such development are examined, modern and appropriate building technology skills and transferrable knowledge are provided, updated educational measures are followed, and thoughtful exchange about educational development plans is shared. Accreditation emphasis is addressed to reflect the vision and objectives of both the faculty and department programs. In this sense, the systematic technique provided, tracks the scope of Building Technology courses and the overall program competencies. It is formulated to apply to current higher education development projects, and intended to be of benefit to other architectural engineering courses' development.

Keywords: Building Technology, Course Development, Collaboration, Sustainability.

INTRODUCTION

Architecture education can play a major role of the growing public concern about environmental issues and the demand for better approaches to shaping the built world. This can be achieved through engaging with, discussing, and reflecting on issues associated with buildings and planning processes. Therefore, students can gain a deeper understanding of the interconnectedness of the world in which they live, while a number of important cross-curricular issues can be brought to life. These include citizenship, sustainable development, health and employment, as well as social justice, diversity and environmental responsibility. The Egyptian Ministry of Higher Education has announced that an independent monitoring body would be created to oversee the accreditation of educational institutions to ensure they meet acceptable standards [Said, 17].

Science and technology do not automatically produce unmitigated good [Alberts, 2]. Integral to the promotion of worldwide capacity of Science and Technology (S&T) is the need to take potential ethical issues into serious account, as well as to assess the risks and dangers created by the greater ease with which modern capabilities can be misused. Building Technology courses that cover many theoretical and practical issues related to the domains of architectural design and its applicable processes can help promote teaching practical and sustainable values of

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buildings and appropriate technologies that will provide higher living standards for minimum resource consumption. In this regard, the Faculty of Engineering in Mansoura University has decided to pursue accreditation through the Accreditation Board of Engineering and Technology (ABET). Departmental Program Vision and ABET criteria are focused to conclude the points that may foster the accreditation process. The context of this paper challenges the critical and basic advanced architectural competencies delivered to students through Building Technology courses. The current undergraduate and postgraduate educational programs' output is tracked to develop and organize the teaching modules of these competencies amidst ever-changing institutional requirements. Design theories as well as building construction, architectural design, and graduates' professional practice will benefit from the courses' development.

PROBLEM

In the recent academic years, the following problems have been reported and certified on the building technology courses' evaluation delivered at the faculty of Engineering, Mansoura University [Sheta, 19]:

1. The Architectural Engineering Department, as well as most of the similar in the Egyptian governmental universities, lacks enough awareness of the importance of building technology education, and the role it can play in preserving the built environment with more involvement and better understanding of the meaning and concept of sustainable architecture.
2. Compared to similar courses in other accredited architectural engineering programs, Building Technology courses in Mansoura university lack competencies, contents' updates, and year-to-year improvement.
3. Lack of practical or virtual training in all Building Technology-related courses, and poor laboratory equipment for any potential training to be involved in the teaching process [National E-learning Center, 15].
4. Poor classroom facilities, inadequate equipment, and outdated lab software. In the Academic Year 2006/2007, students' enrollment exceeded 120 students; all occupy one studio and one lecture room.
5. Bureaucratic procedures to implement emergent needs.

AIMS

The proposed development aims to work as an interdepartmental program, bringing together the faculty and students from other currently separate educational areas of engineering and science. It aims at providing a foundation for design exploration and communication, offering students new ways to access updated design techniques, model buildings, and environmental present ideas. In this sense, the study strives to explore potentials to achieve the following objectives:

1. Fostering education of sustainability through curriculum reform; a major constituting element of the planning and design strategy for the sustainable campus initiative, endeavored in the collaborative effort by both academic institutions.
2. Fostering the Architectural Engineering Department program accreditation process.
3. Uncovering the barriers to technology transfer by fostering the mechanism of international partnership in technology education development programs.
4. Allowing graduates for better opportunities in the national and international employment segments.

HYPOTHESIS

The study is based on the hypothesis that developing a set of competencies and mapping the courses' objectives and outcomes in terms of sustainability and environmental compliance can yield favorable results to the entire program educational objectives. The suggested development criteria can help allocate competencies with emphasis on satisfying accreditation criteria in both the department and faculty educational programs and their measurement.

METHODOLOGY

To achieve its goals, the methodical process of the study is organized in a number of sequential steps:

1. Exploring the appropriate mechanisms of surveying the updated employment requirements and defining the education/training potentials necessary to apply to curriculum reform;
2. Comparing the current program specification to latest ABET criteria, to distinguish immediate reform requirements and priorities.
5. Fostering the mechanism of international partnership in technology education development programs.
3. Develop the Building Technology course in the Architectural Department at Mansoura University, and the program objectives based on the competencies discussed, while allowing for measurement of the outcomes.
4. Exploring the potentials of emphasizing sustainability content in the course developing.
5. Formulating the findings and results into a process that can apply as an enhancing higher education project. Tools include implementation, dissemination, sustainability, quality control and monitoring, and management.

PREVIOUS STUDIES

An integrated, interconnected, multi-disciplinary approach for fostering sustainable development at the Monterrey Institute of Technology was introduced by Lozano et al (2006) [Lozano, 13]. Ferrer-Balas et al (2006) went further by showing that one of the ways to monitor the dissemination of environmental and sustainable concepts in the curriculum is to count the courses that include environmental and sustainability concepts in the official course description using a key-words search [Ferrer, 8]. A building technology course for 4th year students in the School of Architecture at University College in Dublin, Ireland, obligates students to put their theories into practice and build a 1:1 model [Kenning, 12]. The Queensland University of Technology (QUT) blueprint paper set the strategic direction for the university, and clearly spoke of a future of regeneration, engagement and experimentation [Boyer, 3]. The University Vocational Award Council (UVAC) places great emphasis on involving local employers and members of professional bodies in course planning, with employer representatives attending validation events and exam boards. Some programs provide a direct route to professional body membership, either as a consequence of graduating with Honors or by subsequent individual application [Brennan, 4].

Other partnership experiments include a collaborative research adopted at the University of British Columbia (UBC) in Vancouver, Canada. A cooperative, tri-lateral venture involved universities in Canada, the United States and Mexico was initiated. The program curriculum had being cooperatively designed and developed to be used by all the partners. It included a combination of campus-based courses, field study, research exposure, and distributed/distance learning activities in the form of courses, topic specific modules, on-line seminars and discussion groups. Students from the three North American countries formed a community of learners. They obtained a North American perspective on important environmental issues and problems, and alternative ways of approaching them. Language support and inter-cultural training have worked as integral parts of the curriculum design [Kennedy, 11].

STRATEGIC PLANNING TO ACHIEVE INSTITUTIONAL VISION AND MISSION

Mansoura University is currently undergoing a number of educational development projects through national and international-funded programs such as the Higher Education Enhancement Project Fund (HEEPF) and the Tempus. [HEEPF, 10]. Other potential funds could be made available through the US-Egypt Joint Science and Technology Funds [Embassy of the U.S. in Egypt, 7]. These grants provide the opportunity to bring together Egyptian and international experience to work on collaborative educational research projects.

Development Partners

Central to educational development philosophy should be the commitment to the architectural design excellence that demands not only skillful manipulation of form and function, but also inspiration from a broad body of sustainable building science and technology that can make a significant contribution to the nations' economy [SQA, 18]. The educational experience at the Architectural Department in Mansoura University will be enriched and broadened by close interaction among other resources and experience shared with corresponding accredited programs in international educational institutions. Development may further engage Departments of Civil, Mechanical, and Environmental Engineering from Faculties of Engineering and Science. Backed with their service- and practice-oriented, and flexibility with respect to goals and objectives, College of Technology and Computer Science in East Carolina University (ECU) is expected to share experience and provide an interactive collaboration through the

Global Classroom tools and advances. ECU is a progressive and innovative university that is committed to providing high quality teaching and learning opportunities for its students. It aims to be recognized nationally and internationally for its teaching and learning excellence [Teaching@ECU, 20]. Accredited programs at ECU in the Bachelor of Science in Industrial Technology can help achieve further development in the Sustainable Design which is delivered online as one concentration of the Required Technical Content [Rodenberg, 16]. Examining ways in which use of technology may encourage and enable the development of large-scale virtual learning environments (VLEs), mainly in architecture education, may correspondingly provide the underpinning necessity for successful knowledge-based society [Department of Innovation, 6].

The Global Classroom in the College of Technology and Computer Science (TECS), ECU

The Global Classroom is one of the Videoconferencing and Technology Facilities on ECU that feature a state-of-the-art teaching and learning tool. It supports internet-based and video conferencing for groups up to 100 persons, and can support up to four concurrent groups at one time in a variety of venues [Rodenberg, 16]. Designed to host asynchronous and synchronous online activities, this advance can be further used in sharing up-to-date data and information between the faculty and students in both academies.

Curriculum Reform

Building Technology courses were taken for an example that can be applied on other courses taught in the Architectural Department. Contents, ILOs, and teaching methods are focused on how to be managed, while meeting the requirements set by both the main Department Program Vision and the Accreditation Board of Engineering and Technology (ABET), Figure 1.

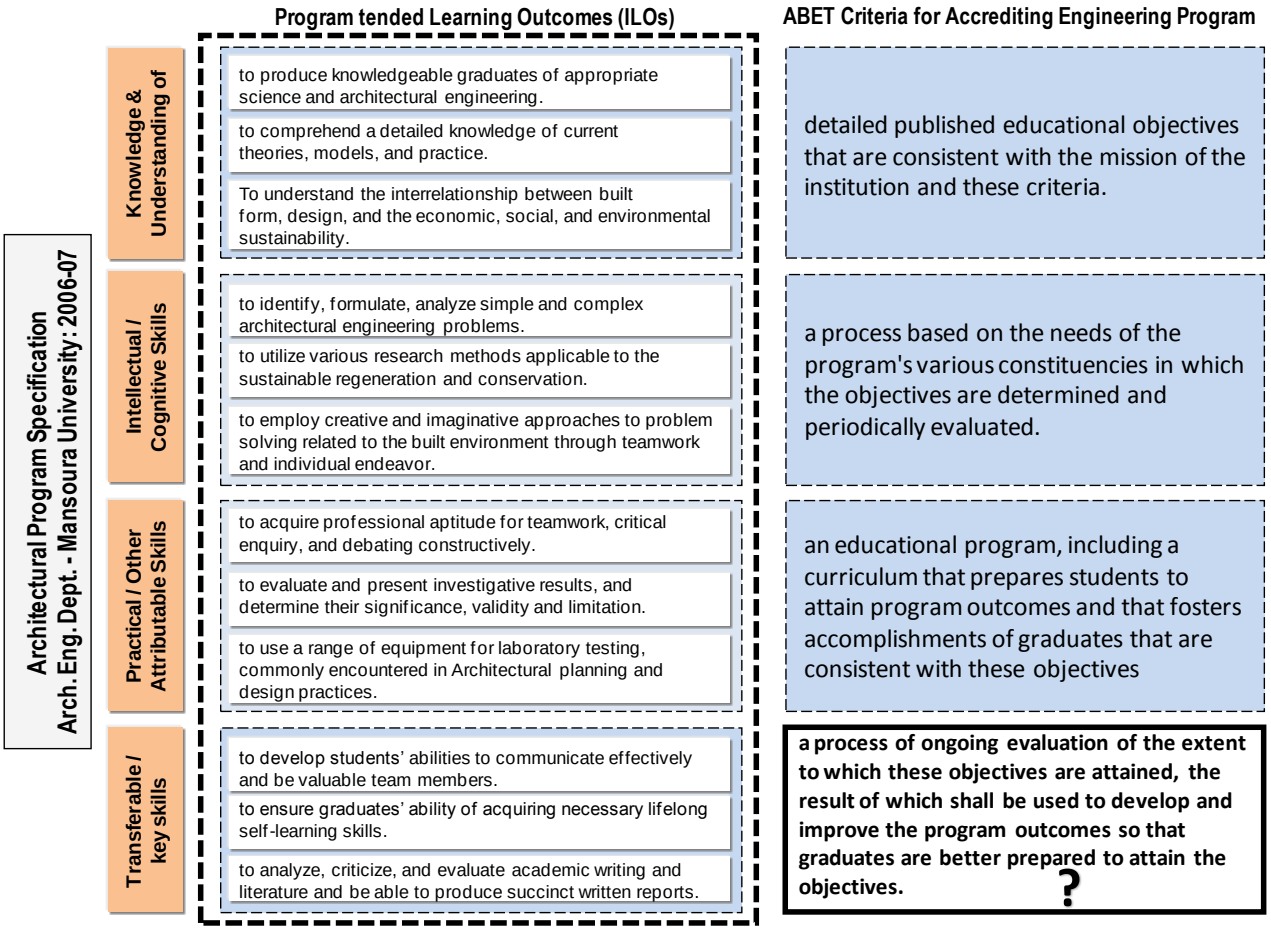


Fig. 1. The Program Educational ILOs in the Architectural Department, Faculty of Engineering, Mansoura University vs. ABET Criteria for Accrediting Engineering Programs [The Authors and ABET, 1].

Mapping Current Course Objectives to ABET Accreditation Criteria

The study adopts a methodical model of working towards sustainable education that looks at the scholarly activities of teaching, discovery, and application as coming together with areas of focused overlap and a central core of scholarly integration. With this model in mind, one of the major parts of the Faculty's current transformative process is the development and introduction of a new suite of certain undergraduate and postgraduate courses to replace the existing ones, Figure 2 [Crowther, 5].

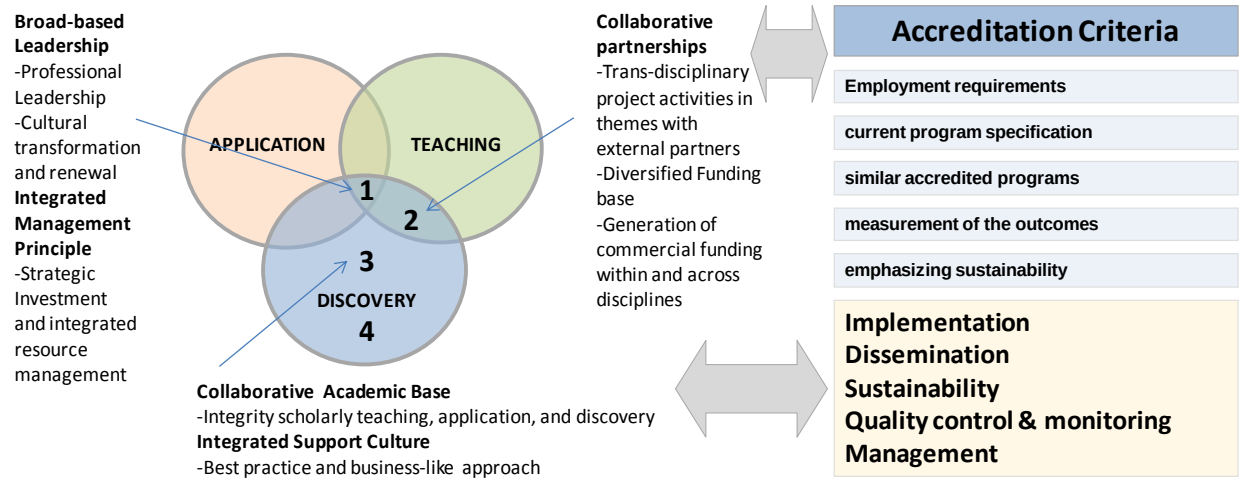
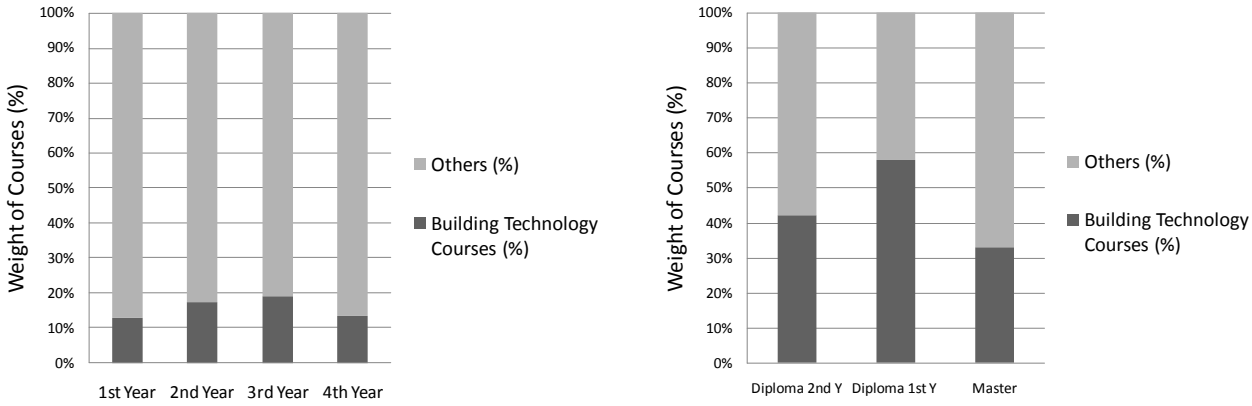


Fig. 2. "Teaching-Application-Research" as the core issues reshaping new educational development.

The Department of Architectural Engineering in Mansoura University is rich in diversity and creativity, and yet lacks efficiency and quality. Through close interaction with faculty in small studios and classes, students gain experience in contemporary design issues and an in-depth understanding of theory and history. In its postgraduate curriculum, the department further provides opportunities for advanced study and research in these fields and in such areas as advanced building techniques and materials, environmental design of buildings, and advanced structural systems. For evaluating purposes, statistics for currently studied courses relates to building technology are calculated. In the first academic year, building technology is attributed to curriculum only through the building construction course that represents 13 percent of the overall structure. The percentage jumps to one fifth in the second year. In the third and fourth year of the undergraduate level, an average percentage of 13 percent of Building Technology courses are optional. The postgraduate courses are more concentrated in their building science and technology content as appears in Figure 3.



Undergraduate Program *Graduate Program*

Fig. 3. Rational weight of Building Technology courses in the Architectural Engineering Programs, Mansoura University.

THE PRINCIPLE IDEA

Through the modern and appropriate building technology skills transferred to architecture students, better utilization of international and local building techniques could be realized, and thus, a better living standard can be attained. Academically, dealing with the issue of building technology in a more modernized and intensified trend is very important in order to bridge the current gap in teaching such a topic in Egyptian universities. Focused processes and developed modules helped to formulate four Building Technology courses for the undergraduate and postgraduate programs, Figure 4 and 5.

	Focused Process	Code	Course Title *(*=optional course)*	Developed ILOs: competency
	Undergraduate Level	Undergraduate Level		Undergraduate Level
Setup	ORGANIZE & SETUP	7113	Building Construction (1)	Understanding of the fundamentals
Setup	ORGANIZE & STARTUP	7122	Building Construction (2)	Content knowledge, skills, and resources
Database	DESIGN CRITERIA	7211	Computer Applications in Architecture (1)	Collaborative design (using CAAD tools)
Database	DESIGN CRITERIA	7213	Building Construction (3)	Appropriate technology understanding
Database	DESIGN CRITERIA	7222	Building Construction (4)	Creative sustainable construction
Database	DESIGN CRITERIA	7224	Building Physics and Environmental Control	Basic sustainability understanding
Database	DESIGN CRITERIA	7226	Computer Applications in Architecture (2)	Collaborative design (using CAAD tools)
Projects	BUILDING PERFORMANCE	7316	Environmental Design*	Knowledge of the environmental design
Projects	BUILDING PERFORMANCE	7326	Advanced Building Technologies*	New techniques and technologies
Projects	APPLICATION	7416	Advanced Architectural Design*	Advanced sustainability understanding
	(Diploma)	Postgraduate Level (Diploma)		(Diploma)
Professional Practice	BUILDING CONTROLS	4513	Building Technology (1)	Arch. Sustainability practices
Professional Practice	BUILDING CONTROLS	4530	Advanced Building materials and Methods	Building materials & const. methods
Professional Practice	BUILDING CONTROLS	4532	Environmental Control of Buildings	Sick buildings – EAQ
Professional Practice	ASSESSESMENT	4635	Advanced Construction Methods	Advanced sustainability practices
Professional Practice	ASSESSESMENT	4636	Building Technology (2)	Building assessment methods (measures)
Professional Practice	Master	Postgraduate Level (Master)		Master
Professional Practice	BUILDING CONTROLS	4716	Environmental Effects on Arch. Design	Arch. Sustainability practices
Professional Practice	ASSESSESMENT	4717	Advanced Building Technology	Building assessment methods (measures)

Fig. 4. Focused processes (modules) organized by ILOs, courses sequential occurrence, and suggested competency.

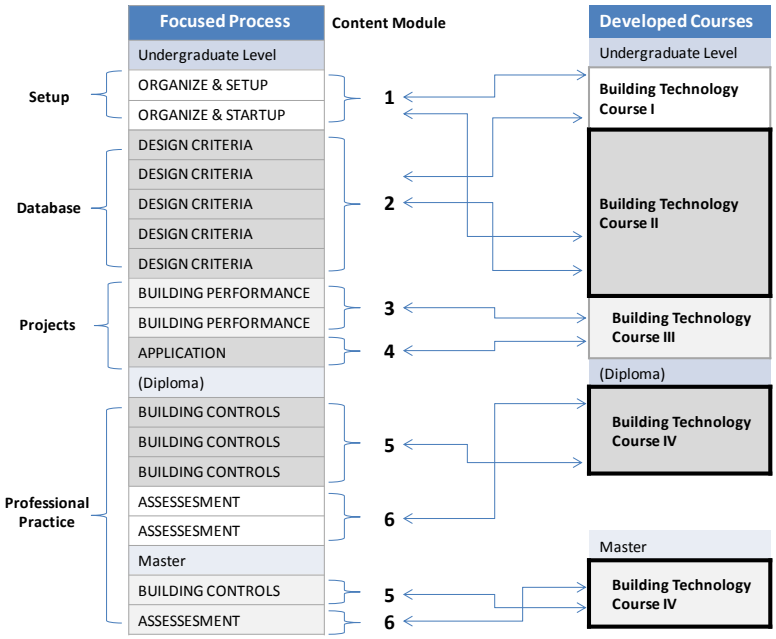


Fig. 5. Six organized content modules for the undergraduate and postgraduate programs.

Building Technology courses and their learning objectives based upon competencies illustrated in this exercise can ensure that students gain the skills to qualify for better opportunities in the national and international employment segments. Such methods give validation to the competencies upon which course objectives should be based in the Construction Technology context. By benchmarking curriculum content, changes to courses' contents can be easily tracked and monitored. It has been proved by Hannon (2006) that Modularization can also benefit the accreditation process as the sections can be labeled and weighted with accreditation criteria [Hannon, 9].

ABET Criterion 3: Program Outcomes

The proposed objectives of the developed courses are compared to ABET Criterion 3 on Program Outcomes, Table 1 and 2.

Table 1. ABET Criterion (3): Program Outcomes [ABET, 1].

Criterion 3. Program Outcomes	
a	ability to apply knowledge of mathematics, science, and engineering
b	ability to design and conduct experiments, as well as to analyze and interpret data
c	ability to design a system, component, or process to meet desired needs within realistic constraints such as sustainability
d	an ability to function on multidisciplinary teams
e	ability to identify, formulate, and solve engineering problems
f	understanding of professional and ethical responsibility
g	ability to communicate effectively
h	understand the impact of engineering solutions in a global, economic, environmental, and societal context
I	recognition of the need for, and an ability to engage in life-long learning
J	knowledge of contemporary issues
K	to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Table 2. Developed courses' objectives vs. ABET Accreditation, Criterion 3 on Program Outcomes.

No.	Courses Objectives	ABET Criterion 3 [ABET, 1]										
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	Building Tech. I (organize, setup, initiate design criteria)	-	√	-	√	-	-	√	-	-	√	√
2	Building Tech. II (developing design criteria)	-	√	-	√	√	-	√	√	√	√	√
3	Building Tech. III (understand building performance)	√	√	√	√	√	√	√	√	√	√	√
4	Building Tech. IV (building controls and assessment)	√	√	√	√	√	√	√	√	√	√	√

BUILDING TECHNOLOGY COURSES' DEVELOPMENT PROCESS: A PROJECT SEQUENCE

Developing the current insufficient and obsolete curriculum of building technology in Egyptian Universities is a potential approach to pave the way for the latest, as well as most appropriate building technologies to replace traditional systems. If efficiently equipped with enhanced educational program in the field of Building Technology, reflections on students design concepts and their ability to merge technology within architecture will be exposed widely to many different approaches of design and trends of building technology from around the world. Together, they may introduce students to innovative issues and trends in contemporary architectural design. Hence, the graduates will be more aware of what architecture can bring to the built environment [Ferrer, 8]. The project sequence is an extended application of the curriculum reform prototype that can be experimented and interlinked by other architectural engineering departments in the Egyptian universities. With respect to the project sequences provided by the Ministry of Higher Education, the overall development tools and their goals discussed below include implementation; dissemination; sustainability; quality control and monitoring, and management.

1- Implementation

Development Goal: Enhance Building Technology courses with new modern contents that include computer animations, video presentations, specialized software, modern reference and text books, and the infrastructure for e-learning potential.

a) Enhancing Courses with Updated Contents

- Get and review current courses and similar courses from other universities through on-line searches, emails, calls, and visits/invitations within Egypt.
- Arrange meetings between Egyptian and international experts to enhance the contents of courses followed by team meeting to approve changes and decide on implementation plan.
- Implement changes and get new reference/text books and journals to have the new courses ready.

b) Adding interactive educational online materials

- Establish a faculty team with proper equipment to search on available online educational data and decide on suitable data involvement in each building technology course level.
- Implement the new changes to developed courses.

c) Virtual electronics lab with trained faculty and staff, equipped with proper equipment and software

- Establish a medium computer lab (get faculty, staff, a place, and proper equipment) .
- Purchase and install specialized software for new teaching tools.
- Train staff and others through workshops on using lab.
- Examine the potential to connect to the Global Classroom in the College of Technology and Computer Science (TECS), ECU.

2- Dissemination

Development Goal: Make the courses known and available to others through an e-learning environment, regular publications (inc. e-version), open days, planned visits and invitations, and publish papers in conferences.

a) Special website & on-line Learning Management System (LMS) to offer further developed courses

- Set up website and selected LMS and gradually add contents of new courses with animations.

b) Create an inclusive database on all Egyptian experts and interested people in the Building Technology field, with regular communications to exchange information and latest updates

- Prepare database of the interested organizations in modern building technological theories, make direct communication on a regular basis, and acquire their acceptance to participate in this experiment.
- Arrange meetings to decide contents of open days, places, times of visits, who and when to invite, which conferences to attend, where to do hard copies of publications, and the selected materials to be published.

3- Sustainability

Development Goal: Increase sustainability content into all contributed courses, allow each course to sustainable development, especially after the fund ends (if any), and mitigate all potential risks.

a) Develop a new interdisciplinary Master's programs in Sustainable Architecture (expected to be approved after two Academic Year).

- Increase positive coverage of the College, and particularly of its current programs in Architectural Engineering by at least 10% in the local and national media and in specialized publications.

b) Develop best project prizes and graduate fellowship award every year

- Announce project prize and graduate fellowship, accept applications, decide winners, and announce result.

c) Increase and stress on the courses' sustainability content

- Develop all Building Technology courses' contents to include updated sustainability data on sustainable architecture and its connection to building science and technology with a year-to-year content advancement.
- Subscribe to on-line materials, training courses, and agreements with other departments both ion the local and international scale.

- Define potential risks and suggest different ways of mitigation based on scenarios.

4- Quality Control and Monitoring

Development Goal: Conducting continuous monitoring of progress to guarantee high quality control over the development process, required by [Egyptian NQAAC, 14].

a) Design evaluation sheets to get feedback from team members, online users of services, and virtual lab users
- Arrange meetings to decide on suitable evaluation sheets, use it, get feedback, study results, modify sheets, and test again to reach better performance.

b) Conduct intermediate reports that show current status of development process vs. preplanned and proposed schedule to overcome any potential delay
- Collect data about quality of services, discuss results, and plan how to improve performance, publish your findings, and implement these plans.

c) Final report to show final status of development process and plans continuity after fund consumption (if any)
- Collect data about quality of services, process them, and implement changes to guarantee continuity of funds after end of project.

5- Management

Development Goal: Regular management meetings to review overall progress of project and emergency meetings to confront problems as early as possible.

a) Scheduled weekly management meetings
- Arrange scheduled time/location for meetings, remind members, and send proposed agenda quite enough before the meeting date to review and get better results and feedback.

Beneficiaries and Anticipated Outcomes of the Building Technology Courses' Development

Building Technology Courses' development can help achieve the following outcomes:

1. Enhancing graduates employability in a globalised market, while meeting the demands of global firms. Qualified graduates will enhance the efficiency of labor as a factor of productivity and will thus improve the competitiveness of building industry and overall sustainability measures.
2. Enhancing techniques and ways of transferring new concepts with using the state-of-the-art educational and training equipment, new computer simulation programs, and foreign expertise in this field.
3. Raising the teaching skills of the academic staff. This pertains initial training of the staff and their assistants.
4. Initiating continuous courses training and development mechanisms, e.g. periodical workshops in qualified Virtual Learning Environment (VLE), locally and internationally.
5. Fostering sustainability in the educational process, expected that the project will cover first two undergraduates courses and may sustain for the next two practical undergraduates courses.

CONCLUSION AND RECOMMENDATIONS

Much reform is needed - if progress is to be achieved - in curricula, teaching methods, and instructors' skills. In addition, educational administration should be decentralized; a culture of scientific research must be supported; services for special needs students should improve; and the university system should be revamped, either by creating new facilities or restructuring the largest ones into smaller, more specialized campuses. The following procedures describe principal requirements' capture and analysis:

1. The baseline document for curriculum standards, assessment strategies, instructional strategies, prescribed learning outcomes, and recommended learning resources should be addressed.
2. Existing Architectural Engineering courses' contents and teaching tools should be emphasized with more sustainability principles to achieve better learning outcomes.
3. Input from field-based consultants and employers should be tracked and addressed in a regular-base development process.
4. Levels of foreign instructional connectivity and updated technology access have to be solicited.

5. Building Technology courses may engage delivering projects that employ sustainable guidelines at the end of each academic level.
6. Alternate assessment and instructional strategies have to be considered.

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Biography

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