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The Experience of Developing a Module on Energy-Efficient Buildings for Architecture Students

Prof. Ahmed S. Muhaisen

Abstract— This paper presents a practical experience of developing a module on energy-efficient buildings for architecture students. The module was developed by a team of staff from the Islamic University of Gaza (IUG) and Vienna University of Technology (TU Wien) as part of an academic partnership project funded by APPEAR program and Austrian Development Cooperation (ADC). The study highlights the various steps followed by the teams to develop the module and then integrate it into the curriculum of the architecture department at IUG. The development of the module contents, including the theoretical and practical parts, was also presented. In addition, the paper focuses on the evaluation processes carried out by different bodies at IUG to find out to what extent the module development and implementation were successful. The results clearly indicate that the developed module contributed considerably to promote energy-efficient approach of building design and construction. And significantly succeeded to increase the students' knowledge and improved their skills in creating such type of buildings.

Index Terms—Energy efficiency, building design, architecture education, curriculum development.

I. INTRODUCTION

Energy efficiency in buildings is proposed worldwide as part of an overall strategy to reduce energy consumption and consequently the adverse effects on the environment. This is due to the fact that buildings use a considerable part of energy in the world and contribute to the global warming through the greenhouse gas emissions [1]. Therefore, many architecture and engineering schools have started to take practical actions to incorporate the subject of energy-efficient buildings into the curricula of relevant programs as a way to change the traditional approach of building design and construction. This is seen as an important step towards promoting this subject and finding well-educated and trained architects and designers who are able to create more sustainable buildings and make a change in the traditional trend of building related industries.

Many previous studies have examined the importance and experiences of incorporating energy efficient and sustainable buildings into the curricula of architecture and engineering programs. Loftness (2005) [2] reported that the 21st century of architecture students should take a leadership role in management of global environment. This can be achieved through providing such students with technical knowledge necessary for precise and wise architectural actions. Rashed-Ali, et al. (2014) [3] focused

on the importance of integrating environmental issues in architectural education. They reported that there are three different approaches to integrate energy efficiency into the curricula of architecture. These approaches include the use of published literature materials, the use of performance simulation software and hands-on experiments. Alawin, et al. (2016) [4] reviewed existing study plans of engineering courses in Jordanian universities and questioned engineering students to figure out energy efficiency related modules. They concluded that there is a general lack of awareness and knowledge about energy efficiency among engineering students. Goldman, et al. (2010) [5] assessed the state of energy efficiency services sector in the USA to identify high priority training needs. The study concluded that most professional roles related to energy efficiency require at least a four-year degree. It also recommended that energy efficiency related interdisciplinary programs should be supported. Olweny (2013) [6] conducted a study on architectural education in the region of East Africa with the aim of finding out to what extent the architectural education is responding to contemporary challenges, especially those related to environmental sustainable design and energy efficiency. He concluded that there are some limitations to integrate these subjects into the curricula of architecture programs in East Afri-

ca. The main limitations were found to be the lack of experience and experts at many architectural schools, in addition to the lack of information and local examples.

This study presents a practical experience of developing and teaching a module on energy-efficient buildings for architecture students at IUG. It highlights the different steps of developing the module and then the evaluation processes carried out to examine its success. It is concluded that incorporating such a module in the curriculum of the architecture program was considerably successful and contributed to increase the students' awareness and skills in creating energy-efficient buildings.

II. THE ENERGY SITUATION IN GAZA

The Gaza Strip Has almost no conventional energy sources, wherefore it is almost totally dependent on the electricity and fossil fuel imported from abroad. As a result of the combined effects of the unstable political situation, blockade, and weak economic situation, the Gaza strip has been suffering from a severe energy deficit and a worsening balance between supply and demand in recent years [7].

As a result of the electricity load shortage, the electric current is cut off at least eight hours per day, causing disruptions in economic activities and all aspects of life. The distribution of the total annual electricity consumption in the Gaza strip among various sectors clearly reveals that the domestic and residential sector consumes the main bulk of electricity; about 70% of the total consumption [8]. This indicates that domestic sector should be the focus of any plan to reduce the per-capita electricity demand in Gaza in the future.

Improving energy-efficiency in buildings as far as possible is proposed as part of an overall solution to the energy problems in the Gaza strip. Applying energy conservation and efficiency measures in residential buildings is highly recommended to improve the overall energy situation in the Gaza strip. Energy-efficient buildings are expected to contribute to minimize the dependence on inadequate conventional energy sources in Gaza, reduce the adverse environmental effects caused by burning fossil fuels, as well as help easing the energy crisis.

III. PEEB PROJECT

The project of "Promotion of Energy-Efficient Buildings towards Developing Sustainable Built Environment in the Gaza Strip-Palestine" (PEEB), is an academic partnership project implemented by the Architectural Engineering Department at Islamic University of Gaza (IUG) and Institute of Architectural Science at Vienna University of Technology (TU Wien). It is funded by the Austrian Partnership programme in Higher Education and Research for Development (APPEAR) and Austrian Development Cooperation (ADC).

The main aim of the project is to promote energy efficiency in buildings as a strategy to achieve sustainable built environment in the Gaza strip – Palestine. The project seeks to develop an approach to sustainable building design and construction that contributes to reducing the energy consumption of buildings and its adverse environmental impacts.

The main objectives of the project are as follows:

- Facilitating a transition towards more environmentally sustainable development in Palestine.
- Establishing a research cluster in the field of energy efficiency.
- Increasing public awareness of the importance and methods of reducing energy consumption in buildings.
- Capacity building for local organizations in the field of energy-efficient buildings.
- Incorporating energy-efficient building design into the curricula of the architectural programs.
- Developing collaborative relations between Palestinian and Austrian institutions.

IV. DEVELOPMENT OF A MODULE ON ENERGY-EFFICIENT BUILDINGS

As mentioned above, integrating the subject of energy efficiency in buildings in the curricula of architecture is one of the main objectives of PEEB project. It aims, particularly, to promote this approach of building design, and to facilitate building the capacity of the architecture department at IUG to take a further step towards saving the environment and contributing to ease the energy problem in Gaza, through creating more energy-efficient buildings.

Accordingly, the project teams collaborated in an effective manner to develop the module syllabus and contents, and then integrate it into the curriculum of the architecture program at IUG. The development process lasted for about three months, and included various activities to ensure an optimum outcome, as follows:

A. Developing a plan of work

Throughout various meetings and long discussions between the members of the teams, a plan of accomplishment was developed. It included few steps, starting with reviewing the curriculum of the architecture department at IUG and TU Wien, then developing the syllabus and contents of the module, and ending with evaluating the module development and integration into the academic plan of the architecture program at IUG.

B. Review the curriculum of the architecture department at IUG and TU Wien

This step included reviewing the contents and description of the academic plan of BSc degree in architecture offered by IUG. It aimed to find out to what extent the existing curriculum covers the subject of energy efficiency in buildings, and to explore the possibility of adding a new module, especially in terms of academic and administrative requirements. The review process showed the following results:

- The curriculum does not include any specific module about energy efficiency in buildings.
- Available relevant modules do not cover the subject in a sufficient and advanced way.
- To develop such a module, the academic plan should be first adapted to contain a module with the title of "Energy-Efficient Building Design" which requires approvals of the architecture department, the academic affairs and then the admission and registration department at IUG.

In addition, similar modules available at TU Wien were also reviewed to find out common subjects and to benefit from the contents and organization of such modules.

Based on the aforementioned results, IUG team took the responsibility to carry out the academic and administrative procedures to adapt the academic plan of the architecture degree at IUG to include the new module. This process was done successfully as an important step

towards developing the module and ensuring a systematical incorporation into the curriculum of the architecture program.

C. Developing the contents of the module

Depending on the previous steps, the team members started to develop the main contents of the module. The following considerations were taken into account in the development process:

- The architecture students do not have, generally, sufficient background about energy efficiency in buildings, although they are very good in science related subjects such as physics, chemistry and Math.
- The new module should generally cover most subjects related to energy efficiency in buildings, to serve as a background for students who will be interested to study more advanced modules in the same field.
- The new module should include a relatively adequate practical part to facilitate understanding and implementing the technical aspects of energy efficiency.
- The practical part should be based on computer simulation techniques.

Accordingly, the module contents were developed in line with the previous considerations and the academic rules applied at IUG. The module contents were categorized under five main topics, as shown in table (1). The topics cover generally the main subjects related to energy-efficient buildings. Each topic is planned to be covered throughout a specific period of time, taking into consideration that the full academic term at IUG is 14 weeks. Details of the module contents can be shown in Appendix (1).

It should be mentioned that the theoretical part of the module contents included 18 lectures (1.5 hrs. each) to be given during 9 weeks, whereas, the practical part is planned to take five weeks (36%) of the module period.

Table 1: Content topics of the developed module

	Topics	Weeks
1	Climate, Sustainability, and Energy	2.5
2	Thermal Comfort	2
3	Basic Design Strategies for Energy Efficiency	3.5
4	Assessment of Energy Effi-	1

	ciency in Buildings	
5	Lab Practice on Thermal Simulation	5
Total number of weeks		14

D. Preparing the module teaching materials

Based on the developed contents, which were revised and adapted many times, the team members prepared the PowerPoint presentations of the various lectures, and selected a list of text books and references. The prepared teaching materials were also made available to the architecture students at IUG through the Moodle e-learning platform.

V. EVALUATION OF THE MODULE

The module was evaluated through three different evaluation processes carried out separately by the teacher (author), the architecture department and the academic affairs at IUG. The evaluations aimed, generally, at finding out the degree to which the developed module succeeded to achieve the stated objectives, in a proper way, and in accordance with the overall aim of the project and general academic rules applied at IUG. Details of the different evaluations can be summarized as follows:

A. Teacher Evaluation

An evaluation of the module was carried out by the teacher at the end of the course, in June 2016, based on a questionnaire, which was filled in by the students. About 80% of the students studied the module (40 students) participated in the evaluation process through filling in the questionnaire and answering relevant questions. The students were mainly asked to answer some questions related basically to five main fields as follows:

- **The benefit of the module**

The majority of students expressed that the module was beneficial and helped them to understand the basics of energy-efficient building design and construction. They indicated that the module was beneficial with an average of 87%. They also agreed that the module was a good opportunity to explore a new approach of building design that they were not fully aware of before. However, some of them indicated that one module is not enough to cover all parts and subjects of this new approach of building design.

- **The suitability of the contents**

The results showed that the students were satisfied with the module contents with an average of 89%. They indicated that the majority of contents are suitable and in line with the main aim and objectives of the module, and cover the related subjects in a good and organized way. In addition, the module contents are new and not repeated in any of the other modules offered in the architecture program. However, some of the students indicated that the course was very intense and full of new theoretical information, that maybe enough to be offered in two modules.

- **The practical part**

A considerable number of students mentioned that the practical part of the module was not enough to acquire fully the required skills. This is mainly referred to the fact that they had to take a considerable amount of theoretical information to serve as a background before they start applying the new techniques practically, since it is the only module related to this new approach of building design. This consequently resulted in, from the students' point of view, imbalance between the theoretical and practical parts, in terms of time and attention.

- **The time of offering the module**

A considerable part of the students mentioned that offering the new module in the last term of their study (second term of the fifth year) was not suitable. This is because they are usually busy in the last term in the graduation projects. They preferred to have it in the fourth year because they are relatively less busy, and also to have more chances to apply what they learnt on their building design projects offered subsequently as parts of the other modules, including the graduation projects.

- **The general satisfaction**

Most of the students expressed their overall satisfaction with the developed module, in terms of contents, methods of teaching, and acquired information and skills. They indicated that they are contented with the developed module in general with an average of 86%. This indicates the success of the first time of teaching the module, according to the scale of satisfaction applied at IUG which requires at least 70% of students' satisfaction for the success of a module.

- **Suggestions for improvements**

The following recommendations were suggested by the students to improve the quality of the new module and to ultimately benefit from it in the coming years:

- Offer the module to architecture students who are in the fourth year.
- Concentrate more on the practical part of the module.
- Adding an advanced optional module for students interested to continue in the same field.
- Using more attractive teaching methods.

B. Evaluation of the architecture department

The architecture department at IUG carried out an evaluation to find out the general acceptance of both the students and professors at the department to offer the newly developed module as part of the study plan of the architecture degree. Online and hardcopy questionnaires were distributed to the staff, and registered architecture students at the fourth year, who have not yet studied the module. All the targeted fourth year students (103 students), who constitute about (35%) of the total number of students at the department, responded and filled in the questionnaire. In addition, the total number of permanent staff members at the department, who are 13, responded positively and filled in the questionnaire. The respondents from both sides were asked to choose the most preferable six modules, out of 16 available modules, to be offered for studying and to be part of the curriculum of the architecture program. The archived results showed the following:

- The developed module was the most preferable by the students, as it was chosen by 65% of the respondents, which is the highest percentage achieved for a single module of the selected ones.
- Also, it was the first in the staff list of selected preferable modules, with 54% of the staff chose it, which made it the most frequently chosen module.

This clearly indicates that the students and staff believe that the developed module is important, and should be certainly included in the curriculum of the architecture program. The results also show that the students and staff are aware of the benefits of such new module, and expect that it

will contribute to make a difference in their normal way of building design and construction, which will be also reflected positively on the students' chances to find jobs after graduation. Taking into consideration that the respondent students have not studied the new module yet, this indicates that the general promotion activities carried out by the project team to promote energy efficiency in buildings achieved their purposes and contributed significantly to increase the students and staff awareness of such a new approach of building design.

C. Evaluation of the academic affairs

As part of the normal and regular evaluations of academic modules, the academic affairs at IUG carried out an evaluation of the developed module. The evaluation is based on an online questionnaire, which is automatically forwarded to all students studied and passed the module. About 32% of the targeted group responded and filled in the questionnaire. The questions of the questionnaire were grouped in five main categories, each of them focuses on a specific competence. The results are summarized in table (2) as follows:

Table 2: Results of the academic affairs evaluation

	Competence	Result (%)
1	Staff mastery of the course	89
2	Teaching methods	86
3	Personal characteristics	80
4	Management of the module	90
5	Methods of students evaluations	83
	Total Evaluation	86

The results of the evaluation indicate a very good general satisfaction of the students with the developed module. This clearly demonstrates a success of the project team in developing the module contents, and a proficiency of the teacher in teaching and managing the module. It should be mentioned that these results match those achieved by the teacher evaluation, which indicates a reliability of the results and validates the outcomes of the evaluations. The results also correspond with those achieved by the architecture department in terms of the students' preference to study the new module. Considering that the three evaluations targeted architecture

students in the fourth and fifth levels, who constitute more than 50% of the students in the department, this demonstrates a considerable achievement in the module development process and in promoting the new energy efficiency approach of building design.

VI. CONCLUSION

As part of PEEB project the Palestinian and Austrian teams succeeded to develop a module on energy-efficient buildings and incorporate it into the curriculum of the architecture program at IUG. The study showed that developing such a module for architecture students is an effective way to promote energy efficiency approach of building design and construction. This is expected, on the long term, to result in a generation of architects who are aware of the environmental and sustainability related concerns associated with the building industry. Accordingly, this will contribute to create more environmentally-friendly buildings in Gaza that require less energy to run, and consequently ease the prevalent energy crisis.

The development of the module was shown to be a collaborative process that requires the involvement of a team of experts and considering various academic and administrative aspects. This was done successfully by the participating teams who collaborated in a professional way to ensure the success of the process. It should be mentioned, that this could not have been possible without the cooperation of the responsible bodies at IUG and their pre-acceptance of any actions to develop the academic programs, in addition to their conventions of the new energy efficiency approach of building design.

The evaluation process of the developed module revealed that the architecture students are considerably satisfied with the module, in terms of contents and acquired information. Also, the module contributed to promote this approach of building design and improved the students' skills. In addition, the staff of the architecture department became aware of the importance of energy efficiency in buildings, and its incorporation into the curriculum of architecture.

Accordingly, the study recommends paying further attention to developing more energy efficiency-oriented modules for architecture students with special focus on practical parts, and using various teaching methods. The time of offering the module for students should be se-

lected carefully in accordance with the requirements of the other modules, and in a way to ensure an optimum utilization and a smooth integration into the study plan.

ACKNOWLEDGMENT

The author would like to thank IUG and TU Wien team members who participated in the development process of the module as part of PEEB project, namely, Prof. Ahmed Muhaisen, Dr. Omar Asfour, Mrs. Asma Naim, Dr. Kristina Kiesel, Dr. Milena Vuckovic, and Prof. Ardeshir Mahdavi. The author and all the project team members are very grateful to APPEAR program and Austrian Development Cooperation (ADC) for funding the project and all associated activities, including developing the module. Thanks are also due to the architecture department at IUG for facilitating developing the module, and providing the author with the required information about the module evaluation.

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