

Restructuring engineering courses with the help of educational theories

Leda G. Boussiakou† & Efrossini C. Kalkani‡

King Saud University, Riyadh, Saudi Arabia†
National Technical University of Athens, Athens, Greece‡

ABSTRACT: The purpose of this work is to introduce the techniques suggested by educational theories, such as Bloom's Educational Taxonomy and Kolb's Learning Styles, in restructuring the courses *Hydropower Engineering*, *Hydraulic Structures and Dams* and *Renewable Energy Engineering* of the School of Civil Engineering at the National Technical University of Athens in Athens, Greece. The scope of the effort refers to the assessment of the existing situation, the incorporation of educational items according to published research, and the future prospects for testing and evaluating the revised courses. The procedures used in performing the work investigate the contents and structure of each course, introduce new educational techniques in the classroom, and extend the contents into new subjects. The major findings refer to the expansion of the content of the courses to include issues on societal needs and the environment, on all types of structures, on planning and design, on operation and maintenance, and on economics and finance. The restructuring will be successful as long as the revision of the content and experience from the educational literature are implemented and tested in the classroom.

INTRODUCTION

The primary purpose of this work is to introduce educational techniques in restructuring the following courses offered by the Hydraulic Engineering Department in the School of Civil Engineering at the National Technical University of Athens in Athens, Greece:

- *Hydropower Engineering*;
- *Hydraulic Structures and Dams*;
- *Renewable Energy Engineering*.

This can be achieved by applying the educational theories of Kolb's Experiential Learning and Bloom's Educational Taxonomy [1-3].

Regarding Kolb's Experiential Learning theory, the four quadrants and the sequence of abstract conceptualisation, reflective observation, concrete experience and active experimentation are considered and translated in terms such as thinking, watching, sensing/feeling and doing [1][4][5].

Regarding Bloom's Educational Taxonomy theory, the six levels of the cognitive domain are considered, which include the lower level thinking skills of knowledge, comprehension and application, and the higher level thinking skills of analysis, synthesis and evaluation [2][3].

The courses *Hydropower Engineering*, *Hydraulic Structures and Dams* and *Renewable Energy Engineering* have certain characteristics as shown in Table 1. These characteristics refer to the type of course (required or elective), the semester taught, the hours of class or laboratory time, and the number of students registered in each course. The similarities between the courses refer to the fact that the subjects taught describe civil engineering structures that extend over large areas of land, create many environmental problems and enormous conflicts of interest.

Information on the learning styles and personalities of the students is not available in this research since the students did not take the Learning Styles Test and the Personality Type Test [6][7]. However, certain characteristics were assumed for the restructuring of the course, as if the students displayed the visual, active, sensing and sequential learning styles, and the guardian personality type.

In restructuring the courses, the authors incorporated in the teaching process those activities that the students were asked to perform, such as thinking, watching, sensing/feeling and doing. Some of these activities incorporate elements of testing the knowledge, comprehension and application of the subjects, and promote from the part of the students the analysis, synthesis and evaluation in providing solutions to engineering problems and performing design.

Table 1: Characteristics of the courses to be restructured.

Course Title	Semester Taught	Credit Required or Elective	Class Lecture (h)	Lab Practice (h)	Number of Students
Hydropower Engineering	8th	Required	2	2	20-40
Hydraulic Structures and Dams	9th	Elective	2	2	15-30
Renewable Energy Engineering	2nd	Elective	3	0	3X80

RESEARCH PROCEDURE

The research procedure takes into consideration the contents and the structure of each course, and investigates the new subjects and the educational activities that need to be introduced to the course. The new subjects will consider the societal aspects of the projects, as well as the environmental effects, business and entrepreneurial issues, and property or users' rights. The educational activities will refer to the newer applications of Bloom's Educational Taxonomy and Kolb's Learning Styles in modern engineering education.

To restructure the courses, although each course has its own characteristics and is addressed to a different audience, the authors:

- Consider the courses' contents as presently taught;
- Investigate learning theories and their application in the classroom;
- Consider the introduction of subjects on societal issues, the environment, legal issues and entrepreneurship;
- Present the outline of the revised courses;
- Introduce characteristics according to the learning theories;
- Discuss the educational techniques presented in the literature.

The educational techniques from the literature consider the following:

- Introducing experimentation in the classroom;
- Training students in teamwork;
- Developing their oral and writing skills;
- Emphasising innovation;
- Encouraging invention and creativity;
- Assessing the understanding and practicing of students in entrepreneurial issues, environmental concerns, conflicts of interest and complex engineering issues.

In restructuring the courses, the authors develop the course syllabus with guidelines to students through the whole semester, and make statements separately for the objectives of each course, the weekly schedule, the dates of tests and examinations, the grading system, and the students' expectations.

The objectives of the courses require that by the end of the courses, students will be able to know how to perform the activities summarised in Table 2.

In restructuring the courses, the new syllabi for each course are developed. The syllabus of each course remains the same as long as the internal or external factors do not require its revision. For example, failure of students in completing successfully the course or low retention rates of students may imply a required revision of the course syllabus. Also, societal or environmental needs may require the revision of the syllabus to include new subjects and direct students in developing specific skills.

METHODS EMPLOYED

The methods employed in the restructuring of the courses are the development of guidelines on the requirements for the instructors and students, and the design of the expected outcomes for students.

Table 2: Objectives of the courses.

Course Title	Course Objectives
Hydropower Engineering	- Know how to determine societal needs in hydropower developments - Understand the environmental issues of hydropower developments - Estimate the available water resources - Design the layout of hydropower installations - Make a preliminary selection of the main electromechanical equipment - Design the layout of the waterways, dams and power plants - Design individual structures of the hydropower development - Understand the project management of hydropower projects - Understand the economics and financing of hydropower projects
Hydraulic Structures and Dams	- Determine the societal needs in hydraulic structures and dams - Understand environmental and legal issues - Evaluate the availability of water, as well as storage and flood control issues - Design the layout of structures - Design the river diversion and water conveyance structures - Design water flow control structures, gates and valves - Design different types of dams, foundations and seepage treatment - Understand construction project management - Understand the economics and financing of hydraulic structures and dams
Renewable Energy Engineering	- Understand societal needs in developing renewable energy sources - Understand environmental issues of renewable energy exploitation - Understand issues of hydropower and the design of small installations - Calculate the power and capacity of wind power installations - Calculate the power and capacity of solar power installations - Calculate the power and capacity of geothermal energy installations - Calculate the power and capacity of biomass installations - Design the layouts of renewable energy installations - Understand construction, operation, maintenance and entrepreneurial issues

The guidelines will be developed in four areas, from which the middle two are explained here:

- The rights and responsibilities of the instructor and students;
- The objectives of the courses and the grading system;
- The textbooks, reference materials, homework and group projects;
- The weekly schedule of classes with the titles of subjects taught.

The compilation of the grading system has to be clear and fair to students and give them many opportunities to improve their total grade in the class. The grading system will be according to the distribution included in Table 3. The total points that a student can make are 1000, while the bonus points are 150, and there will be 34 to 42 opportunities for students to perform well. These opportunities are actually the number of problems that students will be asked to answer individually or in groups during the semester and for which they will be graded.

The reference materials for the courses include titles of books and journals, along with the names of the publishing companies. There will be more reference materials and information on case histories that will be distributed in the classroom by the instructor and on which materials students can perform their class writings and projects.

Students can find more reference materials by using the search engines on the Internet, and by searching the catalogues of bookstores and publishing companies on relevant materials. The reference materials regarding books and journals of all three courses is presented in Table 4.

MAIN OUTCOMES ON THE COURSE CONTENTS

The main outcomes refer to the weekly schedule of classes, which includes the subjects taught at every class session. The subjects refer to societal needs and the environment, the different types of structures and their applicability, the planning and design processes, the operation and maintenance stages, the economics of the structures and project management, plus business and entrepreneurial issues.

The courses are taught during the 14 weeks of the semester and the subjects taught are arranged in a sequence that is meaningful to students. The classes usually cover a period of 15 weeks, but the last week is reserved for activities such as additional learning materials, student presentations, short examinations, plus field trips and site visits of interesting projects. Detailed explanations on the courses and the techniques for revisions on the course content are explained in detail elsewhere [8-10]. The weekly schedules for the three courses, which include the theme subject and titles for the detailed subjects taught, are listed in Tables 5, 6 and 7.

The descriptions of the subjects included in Tables 5, 6 and 7 indicate that each subject is described regarding the theory and the characteristics of the variables, and the instructor will continue towards the technology, machinery applied, layout of the development and civil engineering structures. The instruction will include the amount of energy that can be exploited, the main and auxiliary structures, the design and construction issues, as well as project management issues. In all three courses, there will be subjects on the economics and financing of the structures, as well as business and entrepreneurial issues.

Table 3: Grading system for the courses.

Graded Item	No. of Problems or Questions	Points for Each Problem	Total Grade Points (Maximum)	Percent	Extra Work for Bonus Points
Homework	10-12	30	360	36%	2 problems
Class writings	8-10	4	40	4%	
Mid-term examination or Project 1	4-5	30	150	15%	1 extra problem
Mid-term examination or Project 2	4-55	30	150	15%	1 extra problem
Final examination	8-10	30	300	30%	1 extra problem
Total	34-42		1000	100%	

Table 4: Reference materials on books and journals.

References	Book and Journal Titles, publisher
Books	Gipe, P., *Wind Energy Basics: a Guide to Small and Micro Wind Systems*. Chelsea Green Publishing, 122 p (1999) Goldin, A.R., *Geothermal Energy: a Hot Prospect*. Harcourt Brace Jovanovich, 124 p (1981) Kachadorian, J., *The Passive Solar House: Using Solar Design to Heat and Cool your House*, Chelsea Green Publishing, 220 p (1997) Markvart, T., *Solar Electricity*, John Wiley & Sons. 256 p (2000) Messenger, R., *Photovoltaic Systems Engineering*. CRC, 424p (1999) Reed, T.B. and Das, A., *Handbook of Biomass Downdraft Gasifier Engine Systems*. SERI, 200 p (1998) Zagars, A. (Ed.), *Hydropower: Recent Developments*. ASCE (1985)
Journals	*International Journal of Geothermal Research*, IGA *International Journal of Hydropower and Dams*, Aqua Media Int., UK *Journal of Biomass and Bioenergy*, Elsevier Science *Journal of Solar Energy Engineering*, ASME *Journal of Volcanology & Geothermal Research*, Elsevier *Water Power and Dam Construction*, Wilmington Publishers, UK *Wind Engineering Journal*, Multi-Science, UK

Table 5: Overall schedule of teaching subjects in *Hydropower Engineering*.

Week	Theme Subject	Titles of Detailed Subjects
1	Societal needs	Needs in power (capacity and energy); the physics in power production and transport; power consumption
2	Environmental issues	Availability of power production from water; the resources available; capacity and energy possibilities
3	Availability of water	Environmental constraints; main and complementary uses of water; the hydrologic cycle; reservoirs; pumped storage
4	Equipment, machinery	Available hydro machinery for small and large installations; auxiliary equipment
5	Design of layout	Overall design and layout for small and large capacity hydropower installations
6	Design of layout	Design of access roads; the removal of human installations; provision of temporary and permanent facilities
7	Waterways	Design of the diversion tunnels, channels and alternative layouts
8	Design of dam	Design of the dam and the reservoir, the cofferdams, river diversion and reservoir impoundment
9	Waterways	Intakes and headrace tunnels and channels
10	Waterways	Spillways and bottom outlets
11	Power plant	Design of the power plant: underground, semi-covered, above ground
12	Design of waterways	Design of tailraces in tunnels and channels; reservoir shore development; downstream landscaping
13	Project management	Construction stage; management; resources; schedules; temporary and permanent installations; access roads and facilities
14	Economics	Economics and financing hydropower development; business plans

Table 6: Overall schedule of teaching subjects in *Hydraulic Structures and Dams*.

Week	Theme Subject	Titles of Detailed Subjects
1	Societal needs	Societal needs in water for agricultural, industrial and domestic use; single or multiple uses of water
2	Environmental and legal issues	Availability of water for use by humans, animals and plants; resources available; environmental constraints; water rights; legal issues
3	Water storage and flood control	Storage and flow of water; main and complementary uses of water; the physics of the hydrologic cycle; storage reservoirs; flood control
4	Design of layout	Overall layout and design of storage; conveyance structures; irrigation and drainage channels; flow control structures; intersecting structures
5	Design of layout	Design of access roads, land use and landscaping; auxiliary structures of aggregate and concrete production; earth materials provisions
6	Design of river diversion	Design of river diversion with tunnels and channels; multiple diversion structures; multiple stages of diversion; initiation, operation and closure
7	Design of foundation	Design of impermeable layers for hydraulic structures and dams, drainage filters, grout curtains, drain curtains and upstream impermeable aprons
8	Design of waterways	Intakes and headrace tunnels and channels; energy dissipation structures; surge tanks; siphons
9	Design of waterways	Spillways and bottom outlets; combinations of spillways and bottom outlets with diversion tunnels; concrete plugs; irrigation bypasses
10	Design of dams	Concrete gravity dams, buttress dams and arch dams; design methods for stability; grout and drainage structures; instrumentation
11	Design of dams	Earth dams with impermeable cores; rock fill dams; vertical, inclined and surface impermeable membranes; hydraulic deposition; instrumentation
12	Electromechanical equipment	Pumps and motors, gates and valves, hoists and gantry cranes; automatic or manual operations; provision of power and control devices
13	Construction management	Construction stage; project management; resources; schedules; temporary and permanent installations; access roads and facilities
14	Economics and finance	Economics and financing projects of hydraulic structures and dams; operation and maintenance stages of the project

EDUCATIONAL OUTCOMES

The educational outcomes refer to the effective teaching in the classroom, which will include activities to develop the skills of students regarding knowledge, comprehension and application, as well as in analysis, synthesis and evaluation. These skills, along with thinking, observing, sensing, feeling and doing in at the higher or lower degree, depend on the learning styles and personality types of students, and are used in solving engineering problems when performing the design of engineering structures.

The content and educational outcomes should comply with the main objectives set forward in the restructuring process as follows:

Table 7: Overall schedule of teaching subjects in *Renewable Energy Engineering*.

Week	Theme Subject	Titles of Detailed Subjects
1	Society and the environment	Introduction; societal needs; environmental concerns; pollution; remediation; benefits; national policies on renewable energy
2	Hydropower	Hydropower design; availability of water; regulated flow; types of hydro machinery
3	Hydropower	Hydropower installations; small and large power plants; turbines and generators; pumping storage; operation and maintenance
4	Wind energy	Wind energy design; wind intensity measurements; site selection; calculations on installed capacity and energy generation; backup power
5	Wind energy	Manufacturers and available types of wind turbines; operation and maintenance; wind-farms
6	Solar energy	Solar energy and thermal design installations; greenhouse heating; operation and maintenance; parabolic mirrors technology
7	Solar energy	Solar energy, photovoltaic design and installations; power storage, operation and maintenance; backup energy; solar powered instruments
8	Geothermal energy	Geothermal design; geothermal reservoirs; dry and wet wells; reservoir development; installed capacity and power production; siting of facilities
9	Geothermal energy	Geothermal installations; steam processing and transfer; steam turbines and generators; operation and maintenance
10	Biomass energy	Biomass design; collection of biomass; available and thermal energy; installed capacity total energy; biogas generation
11	Biomass energy	Biomass installations; biomass burners of different types; sites of installation; power production; operation and maintenance
12	Economics and the environment	Economics, financing and environmental issues; cost of installations; operation and maintenance; revenues and benefits
13	Construction management	Construction sites; construction management; acceptance tests; delivery to owner; commercial operations; decommissioning
14	Entrepreneurial and business issues	Organisation of the design; construction, operation and removal; business and entrepreneurial issues; conservation; data collection, processing and forecasting

- The issues on the course subjects and related areas to be covered;
- The elements of effective teaching in the classroom to be applied;
- The maximum educational objectives to be pursued.

The issues on the course subjects are included in Tables 5, 6 and 7. The issues on the effective teaching in the classroom are included in Table 8. The effective teaching issues include the activities for the sensing, feeling, and doing of the students, while the lecture section includes the thinking and observing of the students.

The elements of effective teaching and the activities prescribed in Table 8 correspond to the Learning Style Theory [1]. The same activities correspond to knowledge, comprehension and the application of the Bloom's Educational Taxonomy Theory that proceeds further to analysis, synthesis and evaluation [2][3]. Hence, sketching the plans and cross-sections of structures and performing the design belong to the higher levels of thinking in the cognitive domain, which are analysis, synthesis and evaluation.

The activities described in Table 8 will be adjusted according to the content of each of the three courses. In the knowledge section, students will have the opportunity to list and recite information on the subjects taught. In the comprehension section, students will be able to explain and paraphrase information. In the application section, students will be calculating, solving, determining and applying knowledge to engineering problems.

Moving forward to the higher levels of the cognitive domain, students in the analysis section will be able to model, predict, classify, derive and interpret situations. In the synthesis section, students will be creating, inventing, designing and improving plans and cross-sections of structures. In the evaluation section, students will be able to judge, select, justify critique and optimise solutions of the projects that they work on.

DISCUSSION OF RESULTS

The main outcomes and results are the restructuring of the courses, with the goal to make the courses compatible to the educational requirements in higher engineering education by introducing societal and environmental concerns, as well as by developing the teaching structure in a way so that learning will be effective for students. The results are based on the following:

- The main items of restructuring the courses (application of the educational theories and introduction of modern materials);
- The educational items to be applied according to the published research in the engineering-education literature;
- The future prospects for the evaluation and testing of the revised course.

The main restructuring of the courses is included in Tables 5, 6 and 7, while the application of the educational theories is included in Table 8. The theory of Bloom's Educational Taxonomy is incorporated in the tables as activities that will create knowledge, comprehension, application, as well as analysis, synthesis and evaluation. The theory of Kolb's Experiential Learning is incorporated in the tables as activities that will create thinking, observing, sensing and feeling, and doing, which address all the learning styles of students.

Table 8: Activities in class that create concrete experiences and encourage active experimentation.

No.	Knowledge, Comprehension and Application	Analysis, Synthesis and Evaluation
	Sensing and Feeling	*Doing*
1	Time series of variables in hydropower, wind, biomass, geothermal, solar energy (thermal and photovoltaic)	Calculations of installed capacity/energy based on water, wind, biomass, geothermal, solar (thermal and photovoltaic)
2	Lists of the values of variables, evaluating regulated quantities, mean, standard deviation, extremes	Developing graphs of variable quantities versus time, chronological, sequential, cumulative, histograms
3	Slide and video shows of types of structures, lists of site characteristics, topography, geology, required building materials	Sketches of layouts and structures, line diagrams of conduits, positioning of structures, foundation considerations, materials handling
4	Sketches of individual structures, approximate dimensions	Preliminary structural stability, stress-strain evaluation, hydraulic, geotechnical design
5	Layouts of access roads, power lines, facilities at the development site	Plans of access roads, positioning of power lines, buildings and facilities at the site
6	Slide show and lists of human-made and natural features that need to be removed	Lists of actions to be taken for each feature, costs and durations of removing and replacing
7	Slide show and lists of costs and benefits of one or more structures	Cost benefit analysis, benefit from revenue or avoiding losses, study of alternative cases
8	Slide show and lists of electromechanical equipment	Positioning electromechanical equipment on a floor plan and in cross-sections
9	Slide show and list of control structures, gates and valves	Positioning of control structures on a conduit line diagram and on cross-sections
10	Slide show of diversion schemes, seepage and flow nets	Sketches of diversion channels and tunnels, diversion stages, calculation of seepage flow
11	Slide show of foundation treatment activities, remediation measures	Sketches of remediation measures, materials to be used, dimensioning and scheduling
12	Slide show and list of environmental problems created because of the project	Remediation measures, cost analysis, overall effect or benefit to the environment
13	Lists of legal issues at a site to be developed, water rights, air pollution	Cost of each issue is taken care of during or after project construction
14	Field trip to installations in their construction or operation stage	Report writing on the items observed on the field trip and on the materials collected

Researchers have used several theories to analyse student learning [11]. These include the following:

- Knowledge structure;
- Piaget's concrete and formal operational stages;
- Myers-Briggs intuitive versus sensing;
- Perry's model of college student development;
- Deep versus shallow approaches to learning.

The researchers found that if the teaching is restructured in order to address students' learning styles, then the instruction is made in a way to benefit students [12]. Students learn better with active experimentation in multidisciplinary teams that include students from different university departments [13].

The enhancement of introductory courses may use educational theories and the experience of the instructors [8][14]. The use of paper materials for engineering structures is commonly used to test the organisation, rules and performance of teams in engineering classes [15]. Regarding more complex engineering structures, such as renewable energy structures, the application of educational theories is a basic tool in restructuring the courses [8].

Regarding the development of a course on hydraulic structures and dams for engineering students and professionals, the theoretical and practical aspects are introduced in the course [9]. The restructuring of an engineering course in hydropower may use international educational standards to comply with the needs of an international audience [10].

The courses of *Hydropower Engineering*, *Hydraulic Structures and Dams* and *Renewable Energy Engineering* refer to complex layouts and the construction of a series of large structures over an extended area of different interests for which several disciplines in engineering have to cooperate for the final project. Researchers have found that courses on complex structures have to begin with an intense design challenge that exposes students to multidisciplinary projects [16]. Civil engineering projects usually require extensive cooperation with the stakeholders of the project and dealing with difficult engineering problems due to a lack of information on design parameters. As such, instructors should teach students in a variety of active learning styles by using individual and group writing, group design and role-playing [17].

One main factor that requires the restructuring of the courses and the integration of business and entrepreneurship in these courses is the deregulation of the electricity market in the European Union (EU). This deregulation has created new opportunities for civil engineers upon graduation and requires a more hands-on active learning experience on the part of students [18]. Also, from research performed on a survey of former students in the workplace, researchers have found that students should be encouraged to practice and develop their oral and written technical communication skills [19].

Educators in engineering schools found it necessary to introduce business and entrepreneurial subjects in the course description because after graduation, students will need to work as professional engineers in different projects independently and in cooperation with others. The introduction of engineering to entrepreneurship has included promoting collaborative activities, and engaging faculty in teaching and research on entrepreneurship [20]. The researchers have designed a two-semester course sequence to introduce students to entrepreneurship with the goal to develop teambuilding, cooperation with other team members, and production as deliverables of a business plan and a prototype product [21].

The restructuring of courses taught at engineering schools is considered necessary due to the constantly changing job-market. Researchers have found that restructuring curricula required a strategic plan from the administration of the university [22]. Regarding instruction and curriculum reform, researchers have found that the intellectual development of students and their academic abilities has to be evaluated before the reform [23].

Since the National Technical University of Athens has only engineering departments, students do not have the opportunity to cooperate with students of other professional disciplines, such as business or law. Researchers have found that cooperation between students of different departments can lead to education in innovation and product development, as well as the learning of entrepreneurial activities like patent law, product liability, business, sales, marketing and venture capital [24].

The introduction of environmental issues in the three courses can be justified by the work performed by other researchers regarding environmental education. There may be two main directions: learning to define how environmental processes work and learning how to value and feel concern for the environment [25]. The need of environmental and sustainable development considerations to be included in the engineering education has been analysed by researchers along with the requirements of the accreditation board of engineering criteria [26].

Environmental literacy is required in the education of civil engineers and starts from the very first year of their education. Researchers found that an environmental course enables students to make informed decisions in the context of environmental issues, describe the content of such a course and discuss the assessment of the effectiveness of the course in promoting environmental literacy [27].

The courses under restructure refer to complex environmental projects that have extended damage to the environment. Researchers found that to enhance student learning of complex environmental systems, modelling systems should be presented by using multimedia educational materials, which provide experiential learning opportunities to students [28]. Further, researchers have used interactive simulation software packages to present an environmental engineering design project with the goal to supplement the theory of complex and relevant design projects, and incorporate current research findings and experimental techniques into the course outline [29].

The restructured courses will be taught in the subsequent academic years. The implications for further research will be to test in the classroom the efficiency of the changes and evaluate the feedback from students and instructors towards finalising the implementation of the educational changes of the restructured courses. If the restructuring proves to be successful, then the syllabus of each course will be established as the one leading to successful results for students.

CONCLUSIONS

The primary objective of this research is to introduce the techniques and activities suggested by educational theories, namely Bloom's Educational Taxonomy and Kolb's Learning Styles, in the restructuring of three courses offered by the School of Civil Engineering at the National Technical University of Athens. These courses are *Hydropower Engineering*, *Hydraulic Structures and Dams* and *Renewable Energy Engineering*.

The research procedure investigates the contents and structure of each course as it is taught today, and proceeds to the introduction of educational techniques in the classroom and the extension of the contents into new subjects. The methods employed refer to the development of guidelines on the rights and responsibilities of the instructors and students, course objectives, grading system, reference materials and weekly schedule of classes.

The main outcomes of the research refer to the expansion of the content of the courses to incorporate issues on societal needs and the environment, different types of structures and their applicability, planning and design processes, operation and maintenance issues, economics and the financing of projects, as well as business and entrepreneurial issues. The educational outcomes refer to effective teaching in the classroom and in developing students' skills in knowledge, comprehension, application, analysis, synthesis and evaluation, as well as in thinking, observing, sensing and feeling.

The discussion of the results refers to the main items of restructuring the courses, the educational items according to the published research in the engineering education literature, and the future prospects for the testing and evaluation of the revised courses. The conclusions drawn from the research outcomes and the discussion consider that the restructuring will be successful as long as the main outcomes on the revision of the content, the educational activities indicated by the educational theories and the experience from the educational literature are implemented and tested in the classroom.

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