Hybrid Educational Methodology for the Cognitive Domain of Built Heritage Protection Interconnecting Secondary with Tertiary Level Education

http://dx.doi.org/10.3991/ijep.v3i4.2761

A. Konstanti and A. Moropoulou
National Technical University of Athens, Athens, Greece

***Abstract*—In the present work, a hybrid educational methodology has been developed for approaching the cognitive domain of Built Heritage Protection in an interdisciplinary and integrated way. This domain was selected as a pilot one, presenting various remarkable characteristics, such as bringing together STEM subjects with social and human sciences, proving concrete concepts, being attractive for youth, and demanding combination of technical solutions with social aspects. The methodology had the scope to interconnect secondary with tertiary level education for the achievement of the best possible results, as the latter possesses the needed specialised knowledge, expertise and infrastructure. The methodology incorporates problem-based learning, aiming at the effective solution of real and extremely complex problems encountered in monument scale, which is combined with traditional teaching methods, such as lectures, as well as contemporary elements, such as class exercise laboratory experiments, in situ field work, promoting hands-on experience of students. The pilot application and evaluation of the hybrid methodology proved to be a valuable experience for students of secondary level education, which needs to be further exploited and optimised in order to meet the expectations of the interested parties.**

***Index Terms*—built heritage protection, hybrid educational methodology, problem-based learning.**

I. INTRODUCTION

The prosperity of each country is associated with the improved performance across all over the spectrum of education. Understanding of science and technology, given their rapid evolution today, is critical for education. Europe needs more scientists and engineers and more qualified personnel in order to achieve competitiveness [1]. Well-educated citizens are the "key" for employment, competitiveness, productivity and social cohesion [2].

In this respect, the interest, engagement and professional orientation of students in science, technology, engineering and mathematics (STEM subjects) play a significant role. STEM subjects are considered crucial for the growth and economic prosperity of each country, contributing to research and development. Their knowledge is a prerequisite for designing innovative products, introducing and utilizing new technologies, supporting industrial production, supporting business development services, providing scientific approach to modern problems, data analysis, decision making, and responding to current developments.

However, the contemporary trend in Europe [3], [4] presents decline in the interest of students in STEM subjects. The percentage of students who were enrolled at tertiary level education in Schools relevant to STEM subjects was reduced from 26,7% (year 1998) to 25,2% (year 2006).

As far as Greece is concerned, according to a European research carried out in the framework of ROSE "The Relevance of Science Education" project [5] among 15 years old students from 33 countries all over the world, it came off that [6], [7]:

- 35% of female and 45% of male students prefer STEM subjects in school
- 40% of female and 50% of male students believe that science and technology are the key for environmental problems' solution
- 25% of female and 35% of male students desire to become scientists
- 30% of female and 60% of male students are professionally oriented towards technology related professions.

Thus, it is made apparent that the traditional teaching methods fail to attract the interest of secondary level students in STEM subjects, and therefore the introduction of innovative educational methodologies is considered indispensable. These methodologies must be attractive to students, provide deep understanding of the relevant issues and concepts, follow an integrated multidisciplinary approach, give emphasis on scientific methods, and interlink technical solutions with social considerations for modern problems [8].

II. PREPARATORY WORK

A. Selection of the cognitive domain of Built Heritage Protection

In the present work, the cognitive domain of Built Heritage Protection is selected as the pilot domain for the application of innovative methodologies for teaching STEM subjects at secondary level education.

This domain composes a complex and broad scientific field, presenting the following characteristics [9]:

interdisciplinarity; bringing together concepts and principles from physical sciences, technology, mathematics, human and social sciences, arts; attractiveness for youth; tangible - concrete concepts; relevance with students' experiences and interests; response to the natural disposition of young people towards science; promotion of technological achievements; demand for combination of technical solutions with social aspects.

Traditionally, the term Cultural Heritage has been associated with art, architecture and archaeology. Built Heritage, in particular, has shifted towards including historic structures, monuments, historic sites, natural landscapes, urban areas, etc. Built Heritage Protection is a crucial factor for local development, Historic Cities' revitalisation, support of relevant professional profiles, and exploitation of tourism [10].

Built Heritage Protection involves a combination of disciplines and demands basic knowledge of scientific and technological aspects, such as [11], [12], [13], [14], [15], [16], [17]:

- Built Heritage values and their complex equilibrium with their surroundings and the Society. It includes the understanding of what is actually considered to be cultural heritage, why it needs to be preserved, its social significance and the possible conflict of values.
- Methodological knowledge of the nature and character of Built Heritage. It includes understanding of the building/monument as an entity (architectural, historic building materials and materials of architectural surfaces) and as part of its surroundings; integration of art, materials and structures in built heritage; comprehension of the necessity-driven (societal, technical, risk related) evolution of historic structural systems, their behavior (functional, dynamic and environmental) and the contemporary methods employed to elucidate past relevant know-how.
- Identification of the interrelationship between physical deterioration of Built Heritage with the environment. This is accomplished through perception of the influence of environment on the decay of monuments, through understanding of the role of atmosphere, gas pollutants, particulate matter and atmospheric and through realization of the importance of water. Diagnosing the prevailing decay is effectively accomplished through state-of-the art non-destructive and instrumental laboratory techniques.
- Importance and basic approaches of preventing deterioration of cultural heritage.
- Basic principles and guidelines, processes, materials and technologies for conservation of cultural heritage. Understanding that the materials and conservation interventions should adhere to certain requirements set to ensure their compatibility with the historic structures, and that the interventions themselves should be performing and reversible.
- Monitoring of the decay state of cultural heritage and assessment of the effectiveness of protection and conservation interventions. It also embodies the concept of preventive conservation as part of an integrated maintenance procedure aiming to minimize the effects of the environment.
- Aspects of management and use of cultural heritage and in particular the sustainable use of monuments as tourism destinations (archaeological sites, archaeological parks, historic cities), while integrating them dynamically into the plans for the socioeconomic development.

Education in the field of Built Heritage Protection aims at the development of engineers (civil, chemical, architects, materials', survey, environment etc.) and scientists (chemists, biologists, physicists, conservators, geologists etc.) with the ability to respond to the contemporary needs, recognised as indispensable for the new professionals profiles in the specific cognitive field, for [18]:

- advanced diagnostics and monitoring of deterioration process in architectural surfaces of historic and traditional buildings
- environmental impact assessment and mapping on real scale - real time production
- selection, application and evaluation of proper, effective and compatible conservation materials and techniques for restoration interventions
- strategic planning of conservation interventions, environmental management for the protection of monuments, complexes and sites.

Built Heritage needs to be preserved utilizing the latest advances in Science, Technology, Engineering and Mathematics. Built Heritage Protection is a research intensive field focusing on the use of the best available technologies for providing the optimum solutions [8].

B. The Greek reality at secondary level education

As far as the curriculum structure of secondary level education for the academic year 2012-2013 [19], the distribution of lessons is depicted in Figures 1, 2, 3 for the three Grades of Lyceum in Greece. STEM subjects represent the percentage of 33%, 36% and 24% among the lessons taught at the 1st, 2nd and 3rd Grade of Lyceum respectively [8].

Additionally, since the academic year 2011-2012, the project idea has been incorporated into the curriculum for students of first and second grade of Lyceum [19]. Projects compose a distinct section of the curriculum, implementing the basic principles of the New School, according to which students are recognised as young "intellectuals", "scientists" and "researchers", working closely in the context of initiatives and options and experience a hands-on approach for obtaining knowledge through interdisciplinary questions, experiments and inquiries [20].

The thematic areas covered concern human and social sciences; art and culture; mathematics, physical sciences and technology; environment and sustainable development; combination of the above. The subjects of the project shall meet the interests of students; involve them in inquiry procedures; exploit the content, the conceptual shapes and the methodological approaches of the courses taught; correlate real situations experienced by students with sections of courses taught [19].

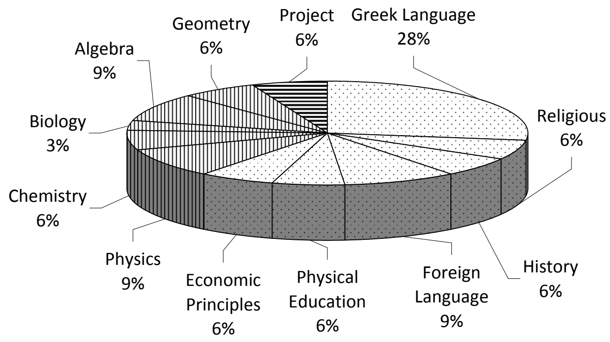

Figure 1. Curriculum structure for the 1st Grade of Lyceum in Greece

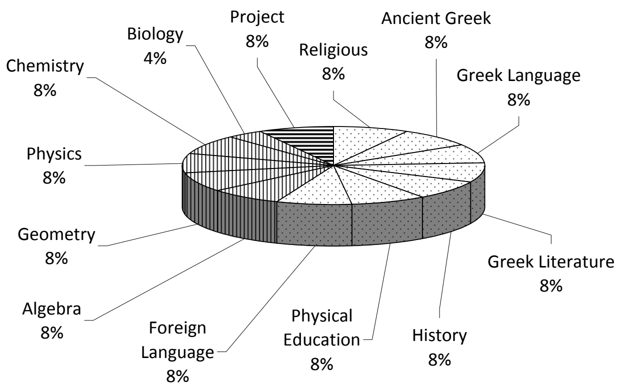

Figure 2. Curriculum structure for the 2nd Grade of Lyceum in Greece

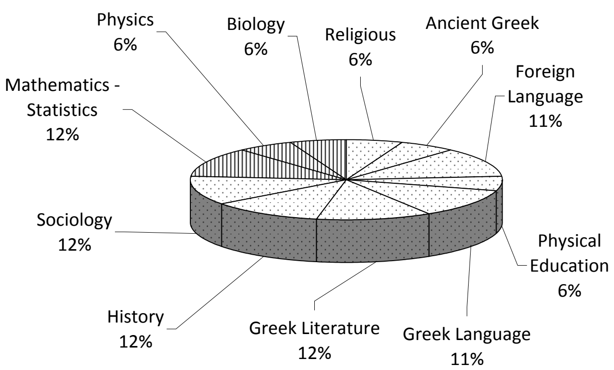

Figure 3. Curriculum structure for the 3rd Grade of Lyceum in Greece

Despite its significance, the cognitive domain of Built Heritage Protection is not apparent in the curriculum of secondary level education as a separate lesson or as a discrete subject. On the contrary, fragmentary concepts are taught through other lessons and an integrated and interdisciplinary educational approach is absent.

These lessons basically represent human sciences (History, History of art, Religious, Literature, Greek language) and less physical sciences (Chemistry, Physics, and Biology).

Built Heritage Protection presents remarkable interdisciplinarity, interconnecting STEM subjects with social and human sciences [8], as depicted in Figure 4.

The specific cognitive field should not be dealt as an obligation of the society for preservation linking the past with the future, but as a vehicle for educating youth towards the relevant technological advancements, research and innovations of the past and the relevant methodology developed.

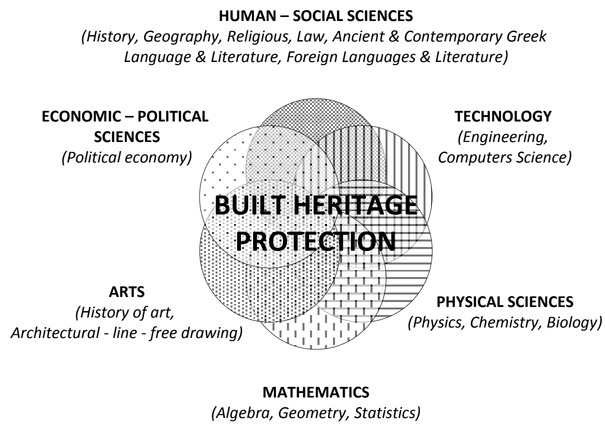

Figure 4. Interdisciplinarity of Built Heritage Protection domain

C. *Key competences and Built Heritage Protection*

Recently, the concept of key competences has been incorporated into national curricula of several European countries. Key competences represent a transferable, multifunctional package of knowledge, skills and attitudes that all individuals need for personal fulfillment and development, inclusion and employment. These should have been developed by the end of compulsory schooling or training, and should act as a foundation for further learning as part of lifelong learning [21].

The basic competences defined at EU level, which represent a combination of knowledge, skills and attitudes, considered indispensable for personal fulfillment and development, active citizenship, social inclusion and employment concern: communication in the mother tongue; communication in foreign languages; mathematical competence and basic competences in science and technology; digital competence; learning to learn; social and civic competences; sense of initiative and entrepreneurship; cultural awareness and expression [22].

As far as the Greek educational system is concerned, the closest terminology existing for key competences concerns intellectual and physical capabilities. According to Greek Legislation [23], the main aim of secondary education is to contribute to the complete, harmonious and balanced development of the intellectual and physical capabilities of students in order to enable them to evolve into well-rounded personalities able to lead creative lives. The general aims of education are classified into: knowledge and methodology; cooperation and communication; interrelation between science or art and everyday life. All subjects (Greek, mathematics, physics, religious, education, history, physical education, environmental education and art) are taught so as to be in line with the three above-mentioned general aims [24].

Specializing in Built Heritage Protection, the disciplines composing the specific cognitive field shall respond to the following competences [8]:

- *Communication in foreign languages*, responding to the multi-lingual dimension of cultural heritage and intensifying the intercultural communication among countries

- *Mathematical literacy*, responding to the need for problems' solution met in monuments' practice, which demand complex mathematical computations (such as mathematical modeling of salt decay deteriorating monuments' building materials)
- *Competence in science and technology*, responding to the need for interpretation of natural or man - made phenomena affecting built heritage (such as environmental factors deteriorating cultural heritage), as well as to the need for proper utilisation of high measuring techniques (as non destructive techniques for performing decay diagnosis in situ at monuments - historic buildings)
- *Digital competence*, responding to the need for use of ICT in Built Heritage protection (such as GIS applications for environmental management of monuments, complexes and sites)
- *Learning to learn*, responding to the need for critical and creative thinking for solving problems met in practice through hands-on and active engagement (such as laboratory experiments performed by students for decay diagnosis)
- *Interpersonal, intercultural and social competences*, responding to the need for awareness raising regarding societal and cultural aspects and understanding of the intercultural dimension in societies at international level
- *Cultural expression*, responding to the need for awareness raising regarding cultural heritage at global level, cultural diversity and cultivation of the sense of identity.

D. Interconnection of secondary with tertiary level education

Although nowadays contemporary teaching methods and techniques exist, they have not really been incorporated into Greek school reality and traditional "passive" methods are prevailing. The application of innovative methodologies utilizing "active" learning procedures is time consuming and demands the relevant education and culture of the transmitter and receiver, as well as specialised knowledge and expertise of the teacher.

Built Heritage Protection, when introduced through innovative educational approaches into School curricula, can raise students' interest and knowledge in STEM subjects. Indeed, Cultural Heritage is successfully protected and conserved when the qualities of scientific reasoning, and the transversal competences of critical thinking, problem-solving, creativity, teamwork and communication skills are all merged together and effectively applied. An approach which encompasses a continuing learning process and promotes research and development bounded by problem-solving requirements is considered preferential.

Additionally, the cognitive domain of Built Heritage Protection fulfills the criteria set for projects within the Lyceum curriculum and therefore presents an appropriate potential thematic area for project application in school.

However, teachers at secondary level education rarely do dispose the specialised knowledge for an interdisciplinary approach demanded for: effective and integrated teaching of the specific domain; awareness raising of students about cultural heritage protection; adequate attractiveness of students' interest and professional orientation; successful guidance and implementation of a related research project taking into account the multidisciplinary nature of the field.

The interconnection between secondary and tertiary level education has nowadays a new and substantial character, given the recent reform of educational curricula, the introduction of projects, and the use of information and communication technologies [25].

The transfer of knowledge and expertise from tertiary to secondary level education is a contemporary requirement for the modernization of the educational system, linking science with society. Especially for the cognitive domain of Built Heritage Protection [17], [26], [27], tertiary level education can provide:

- the required expertise and specialized experience from teaching and research in this field of knowledge, and the application in real situations and problems encountered in practice in monument scale
- the laboratory infrastructure to practice and consolidate the theoretic framework and the equipment required to implement on-site hands-on experience students through open workshops (monuments, sites, industry)
- knowledge about the skills and qualifications needed by future professionals in this field of science in order to meet the modern challenges
- good command of the problems encountered in practice in Monuments and integrated, efficient and compatible ways of resolving problems, taking into account national legislation, international charters, historical, social, environmental factors etc.

III. DEVELOPMENT OF THE HYBRID EDUCATIONAL METHODOLOGY

For the design of the methodology, the general characteristics taken into consideration followed the recent trend towards the incorporation of Science in Society and their fruitful cooperation. Students shall realize the importance of the effect of science and technology in their lives and learn to find effective solutions to problems based on scientific knowledge.

The contemporary trend imposes interdisciplinarity and innovative approaches, taking into consideration the parameter of environment at a great extend. Critical thinking and scientific support to decision making are promoted, according to STES (Science-Technology-Environment-Society) approach [28].

The hybrid methodology combines educational methods and techniques. More specifically, it concerns the pilot introduction of a problem-based approach, along with traditional "passive" techniques, such as theoretic class lectures and contemporary "active" techniques, such as hands-on experience through class exercises, laboratory experiments, in situ field work at selected monuments, historic buildings and archaeological sites.

The use of tangible examples and real problems met in everyday practice, along with visual and audio material, renders the learning procedure and the educational content more understandable and realistic.

The idea for the introduction of the problem-based learning approach for the cognitive domain of the Protection of Built Heritage arises from the fact that:

- the method has been initially used in medicine and medical sciences in general, which "borrows" a lot of terms in the selected field, such as diagnosis, prevention, prolepsis, therapy, ultrasounds, endoscope, leading to associative correspondences
- the method is applied nowadays in the field of engineering and STEM subjects in general (science-technology-engineering-mathematics) and the cognitive domain of "Built Heritage Protection" belongs in them and is integrated by human and social sciences. This is exactly the case for problem-based approach, according to which the technical solutions must be combined with social aspects
- the problems that need to be resolved in the selected cognitive field present the same characteristics with the ones dealt in the problem-based approach, concerning real cases, met in everyday practice, presenting complexity, needing interdisciplinary approach, demanding teamwork and hands-on experience for facing them.

The hybrid methodology utilizes the experimental "conservatory" introduction of problem-based educational approach in the secondary level education and does not concern a "pure" problem-based methodology, according to which the teacher sets the problem and leaves the initiative to students to proceed with its solution without providing the relevant theoretic background and/or hands-on approach, assuming that students already possess the needed background to do so [29]. The decision on the hybrid methodology is made based on the following facts:

- until today, the problem-based learning approach has been applied only in the tertiary educational level
- the students within the Greek school reality are not familiar with the approach and are not educated towards this direction
- the selected cognitive domain does not represent a specific lesson within the curriculum, but its teaching concerns fragmentary references in various lessons
- the students are not familiar with the information search in such an extend so as to be directed to the problem solution exclusively by themselves, without having been taught the relevant theoretic framework.

The educational methodology [8] is schematically presented in Figure 5.

As far as the educational content of the methodology is concerned, it is structured so as to incorporate four scientific disciplines interconnected with three levels of interventions [30], as presented in Figure 6.

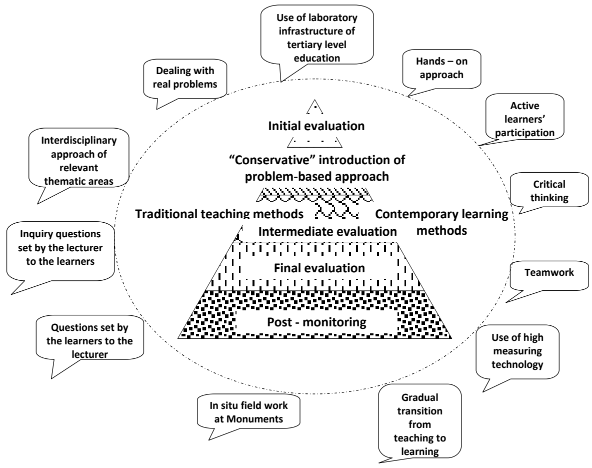

Figure 5. The hybrid educational methodology

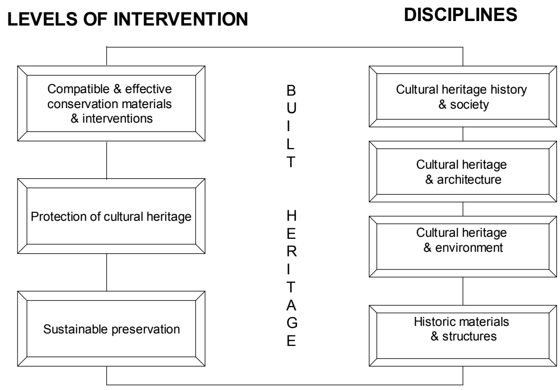

Figure 6. Educational content of the hybrid problem-based educational methodology

The proposed steps to be followed within the methodology [8] are presented in Figure 7. More specifically, *Step 1* concerns the introduction of the problem by the teacher to the students. The problem is described briefly and certain data useful for problem solution are provided. In *Step 2*, the teacher in interactivity with students sets the learning goals, providing the guidelines and specifications. The problem is recognised and identified in order for its shaping to be initiated. In *Step 3*, the basic concepts concerning the problem are clarified and through the use of inquiry questions, the teacher investigated the initial relevant knowledge of students and therefore proceeds with the procedure of the learning process. In *Step 4* the lecturer proceeds with traditional theoretic lectures, which are familiar to students, provide them with the necessary theoretic background and reduce the anxiety presented to students due to unknown situations and techniques, such as the problem-based approach. In *Step 5*, hands-on experience is utilized for the consolidation of knowledge. Students are acquainted with contemporary laboratory and non destructive techniques and through their use students learn what and why they measure it. In Step 6, students proceed with problem solution, working in teams and distributing roles. In *Step 7*, students' teams make the final synthesis and present the final integrated "product" in front of the teacher. In *Step 8*, evaluation takes places at initial, formative and final level, made by the teacher as well as the students themselves.

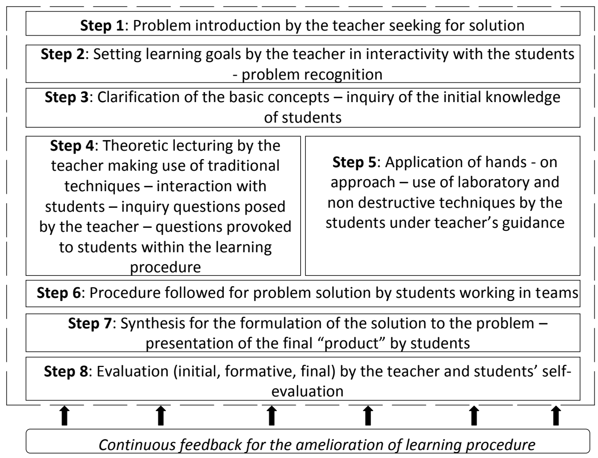

Figure 7. Steps followed within the hybrid problem-based educational methodology

IV. EXAMPLE OF APLICATION OF THE HYBRID EDUCATIONAL METHODOLOGY

The developed educational methodology was applied to students of secondary level education, representing a non-specialised audience in the specific field. The thematic areas of application concerned the whole educational content, as represented in Figure 6.

More specifically, the application of the methodology within the thematic area "Values, awareness and Built Heritage Protection" involves the following [8]:

- *Initial evaluation*

The starting point is the initial questionnaire of perception distributed and answered by participants without any prior experience and relevant knowledge. They are asked to recall any relevant information and knowledge deriving from previous knowledge in other lessons taught in school or based on their personal experience. The questionnaire comprises questions, such as: giving the definition of Cultural Heritage; writing down categories of objects and concepts belonging in Cultural Heritage; identifying the meaning of Built Heritage; giving certain paradigms of World Cultural and Built Heritage; writing down the values which are present in Cultural and Built Heritage in particular, providing certain paradigms for supporting their claims.

- *"Conservative" introduction of problem-based approach*

The problem for solution is set to students: "Assume that you are engineers specialised in the field of Built Heritage Protection, employed in the Ministry of Culture of your country. You are asked to hierarch a list of Monuments, which need to be protected and preserved. The list includes a historic building in the centre of the capital, attracting a remarkable number of tourists; an industrial building placed in a remote rural area, for which immediate interventions, mainly of structural nature, are crucial for its safeguard; an archaeological site of great historic value, close to the capital, threatened by industrial pollution; a monument with high aesthetic value, built close to the sea, deteriorated by salt crystallisation".

The learning goals are set in cooperation of students with their lecturer, the "problem" is recognised and students try to identify at primary stage the factors that should be taken into consideration for problem solution. Through inquiry questions, the teacher performs intermediate evaluation and has an indication of students' relevant knowledge and perception in the subjects under question.

- *Traditional teaching methods*

PowerPoint presentations are given to students, concerning mainly basic definitions of Cultural and Built Heritage, as well as the values they encompass. The educational material is enhanced with photos and characteristic examples for better clarification of the concepts dealt.

- *Contemporary learning methods*

Other contemporary hands-on methods are used, which are attractive to students and help them understand what they have been taught, such as in situ field campaigns, comprising for example free drawing sketching or application of in situ non-destructive techniques for decay diagnosis in historic buildings and archaeological sites.

- *Teamwork for problem solution*

Students, after having obtained the relevant background, they come back to the problem working in teams and distributing roles among them. For their convenience, relevant references are provided by the lecturer for further studying. For example, students write down the values which according to their personal estimation are encompassed in each monument - historic building and try to make the relevant hierarchy. A linear function could be used for the pseudo-quantification of the set of values, setting weighting factors for each parameter. The teams work together for the final synthesis and the production of the outcome, that is the final list of monuments.

- *Final evaluation*

At the end of the educational procedure, students are asked to fill in the same questionnaire as at the beginning, so as to calculate their learning gain. Additionally, the methodology and the procedure followed are evaluated through questionnaires of evaluation, comprising questions such as: comprehensibility of the educational material; fruitfulness of the laboratory and in situ fieldwork; attractiveness of the teaching activities and the lecturers; awareness raising in the specific cognitive field; interest for future professional orientation in Built Heritage Protection.

V. CONCLUSIONS - PERSPECTIVES

The developed educational methodology for approaching the cognitive domain of Built Heritage Protection in an interdisciplinary and integrated way was applied at selected students of secondary level education [8]. The evaluation of this educational experience proved to be a valuable experience, managing to interconnect successfully tertiary with secondary level education and to raise significantly students' gain in the subjects dealt. As an example, at the thematic area "Values, Awareness and Built Heritage Protection", students' gain reached the percentage of 82 % [9].

The introduction of the problem-based methodology raised students' interest, activated them to participate and urged them to deal with real and complex problems that could be possibly encountered in their professional life. Additionally, students had the chance to realise that there is not necessarily a single answer for problem solution and that a combination of parameters shall be taken into consideration for an integrated and thorough study.

Additionally, the problem-based learning approach proved to fit the cognitive field of Built Heritage Protection, as several case studies encountered as complex ill-structured problems need to be resolved, considering a set of parameters and applying creative and critical thinking.

Further optimization and application of the methodology is within the perspectives of the present work, aiming to promising results as far the interest and professional orientation of students in STEM subjects in general and in Built Heritage Protection in particular, making use of problem-based approach and hands-on experience, which were evaluated by students as the most appealing parts of the applied educational methodology.

REFERENCES

[1] OECD, "Better performance and successful reforms in education - Recommendations for the educational policy in Greece", *ISBN 978-89-26-411958-1, 2011*

[2] Council Conclusions of 12 May 2009 *On a strategic framework for European cooperation in education and training (ET 2020),* 2009/C 119/2

[3] ECB – European Coordinating Body for Maths, Science and Technology, *ECB - WP2 D2.1 Observatory Methodology*, Report delivered to EC in the framework of the ECB Project, 2011, Contract number 266622

[4] European Commission, *Science education now: a renewed pedagogy for the future of Europe,* 2007, ISSN 1018 – 5593

[5] Website of the research project ROSE "The Relevance of Science Education": http://roseproject.no/

[6] ERT, *Mathematics, Science & Technology Education,* 2010, School-Business Cooperation

[7] S. Sjøberg & C. Schreiner, "Young people, science and technology. Attitudes, values, interests and possible recruitment, Selected results from recent research", *ERT Event, Brussels, 2008*

[8] A. Konstanti, PhD Thesis "Educational approach for the protection of Monuments", National Technical University of Athens, School of Chemical Engineering, 2013, in process

[9] A. Konstanti, A. Moropoulou, and A. Lobovikov - Katz, "Evaluation of a problem-based "hands-on" educational approach applied for cultural heritage protection in engineering education", *European Journal of Engineering Education, 2013, accepted for publication*

[10] European Commission, Directorate General for Research, "Report Preserving our heritage, improving our environment", Vol. 1, 20 years of EU research into cultural heritage", M. Chapuis (Ed.), Brussels, 2009

[11] ICOMOS - International Council on Monuments and Sites, "Guidelines for education and training in the conservation of monuments, ensembles and sites", *Colombo, Sri Lanka, July 30 - August 7, 1993*

[12] ICOMOS - International Council on Monuments and Sites "International Charters for Conservation and Restoration – Monuments and Sites - I", *Paris 2nd Edition, 2004*

[13] European Network for Conservation-Restoration Education, "ECCO Professional Guidelines I", *Brussels, March 1, 2002*

[14] European Network for Conservation-Restoration Education, "ECCO Professional Guidelines II", *Brussels, March 7, 2003*

[15] European Network for Conservation-Restoration Education, "ECCO Professional Guidelines III", *Brussels, April 2, 2004*

[16] A. Moropoulou, A. Konstanti, and Ch. Kokkinos, "Education and training in cultural heritage protection: the Greek experience", in Conference and Brokerage Event The Construction aspects of Built Heritage Protection, Dubrovnik, Croatia, Oct. 14 - 17, 2006

[17] A. Moropoulou, A. Konstanti, A. Labropoulou, and K. Labropoulos, "Adoption of a project approach in engineering education for cultural heritage protection", in PAEE 2013 - International Symposium on Project Approaches in Engineering Education - Closing the Gap between University and Industry, Eindhoven, The Netherlands, Jul. 8 - 9, 2013

[18] A. Moropoulou, and A. Konstanti, "Master level education on protection of cultural heritage: national experiences and European perspectives", in ICIE'10 5th International Conference on Interdisciplinarity in Education, Tallinn, Estonia, Jun. 17-19, 2010

[19] Website of the Greek Ministry of Education and Religious Affairs, Culture and Sports: www.minedu.gov.gr

[20] H. Matsaggouras, *The innovation of Projects within the New Lyceum*, Book of Teacher, Greek Ministry of Education and Religious Affairs, Culture and Sports, School Books Publishing Organisation, Athens, 2011

[21] European Commission, DG for Education and Culture, "Implementation of "Education and Training 2010" Work Programme, Working Group B "Key Competences"", Key Competences for Lifelong Learning, A European Reference Framework, November 2004

[22] European Commission, EACEA, Eurydice, "Developing key competencies at school in Europe: Challenges and opportunities for policy", Eurydice Report, Luxembourg, Publications Office of the European Union, 2012

[23] Greek Law 1566/1985 "Structure and function of the primary and secondary level education and other provisions

[24] European Commission, DG for Education and Culture, "Key Competencies - A developing concept in general compulsory education", Eurydice, Belgium, 2002

[25] A. Moropoulou, "Inter-connection of NTUA with secondary level education for the professional orientation of students", *Workshop " Inter-connection of NTUA with secondary level education for the professional orientation of students", DASTA, National Technical University of Athens, , Athens, 2013*

[26] A. Moropoulou, A. Konstanti, E. Aggelakopoulou, Ch. Kokkinos, "Historic Cities as Open Labs of Research and Postgraduate Education", in 7th International Symposium of the Organisation of World Heritage Cities, Rhodes, 2003

[27] A. Moropoulou, A. Lampropoulou, A. Konstanti, A. Kiousi, "European master level education on protection of cultural heritage: national experiences and European perspectives", in 8th EC Conference on Sustaining Europe's Cultural Heritage, Ljubljana, 2008

[28] U. Zoller, "Chemistry and Environmental Education", *Chemistry Education: Research and Practice, 5 (2), pp. 95-97, 2004* http://dx.doi.org/10.1039/b4rp90014f

[29] X. Du, E. De Graaff & A. Kolmos (eds), "Research on PBL Practice in Engineering Education", Sense Publishers, Rotterdam, The Netherlands, 2009

[30] A. Moropoulou, A. Konstanti & A. Lobovikov - Katz, ""Hands-on cultural heritage" educational approach interconnecting secondary with tertiary level education", in 6th International Congress "Science and Technology for the Safeguard of Cultural Heritage in the Mediterranean Basin, Athens, Greece, Oct. 23-25, 2013 (accepted)

AUTHORS

A. Konstanti, PhD Candidate, is with the National Technical University of Athens, School of Chemical Engineering, 9, Iroon Polytechneiou str., 15780, Zographou Campus, Athens, Greece (e-mail: akonsta@mail.ntua.gr).

A. Moropoulou, Professor and Vice - Rector of Academic Affairs, is with the National Technical University of Athens, School of Chemical Engineering, 9, Iroon Polytechneiou str., 15780, Zographou Campus, Athens, Greece (e-mail: amoropul@central.ntua.gr).

Submitted 13 May 2013. Published as re-submitted by the authors 11 October 2013.