independent small cities, full of green areas, private gardens for everyone, excellent inner infrastructure and proper connection with London. Also, in order to establish this independency, these City Gardens offered a large gamut of all necessary public services for its citizens from administrative, commercial, educational and sports character. One of the creators of City Gardens, the urbanist Howard Ebenezer was imagining new towns that will have all the positive characters of town and country gathered in one place:" "But neither the Town magnet nor the Country magnet represents the full plan and purpose of nature. Human society and the beauty of nature are meant to be enjoyed together. The two magnets must be made one. As man and woman by their varied gifts and faculties supplement each other, so should town and country…[iv]"

Unfortunately, back here in the Balkans, even if we have progressive minds in the field of urbanism, their ideas are not the priority of current authorities. In fact, in Skopje, the rising number of new constructed buildings is a result of insatiable investors, local authorities and citizens who do not think for the near future. The new constructed buildings are not a real need for build space. The thing is that in those new dwelling buildings, the human conditions are almost everywhere worst, comparing to the old residential areas that existed at the same location. We can unfortunately conclude total absence of urban development politics for the future growth of the capital of Macedonia. The only need is financial profit in each segment of the society.

Only if we could encourage radical changes of the focus for the urban growth politics, we could make progressively better and better town in any way.

Only if the real needs for better human living conditions become the new focus of the local authorities, (they will also assure a stabile position and the people will give more votes for them) then there will be new guidelines for the urbanists and the construction companies. Also, finally the users of the current houses and dwelling buildings will search for something really better to live in! Pollution problem and the increasing number of diseases related with the air pollution, overcrowded build space, traffics jams and parking lack in any part of the city, devastated green zones and more obstacles around the existing buildings ruining the previous city's landscapes views will maybe initiate such a general radical change in the urban politics of the Macedonian society.

That is why the creation of NSSC should become the strategic priority of the current authorities.

The creation of these new settlements could represent a potential risk because of the possible problem of its integration with the parent city. In order to create this kind of urban quarters it is necessary to establish as well new and high quality infrastructures between the city and these new settlements[v].

Other challenge is to convince the future inhabitants of these new settlements to change radically their lifestyle and current habits even if the new settlements guarantees better life conditions in any way.

It doesn't means that these ideas will be abandoned and not supported by the people, but there must be more media campaigns and a big support from the city's authorities. Off course, there should be precisely calculated as more as it could be the estimated costs for those capital projects in a short and in a long term. The price of land plots for the new settlements should be absolutely attractive as well of the NSSC's different contents and its independent character. There should be also governmental subventions for the future inhabitants to encourage them and to support their decision.

Regarding the size of the New Satellite Smart Cities, it depends of the topology and the existing physical condition of the selected areas. But in general, the number of inhabitants should be between 10 000 and 30 000 people. This number could include the number of surrounding population that will become part of the NSSCs.

4. WHY WOULD SOMEONE CHANGE ITS LIVVING SPACE AND MOVE TO NSSC?

Hopefully that the need for nature as a basic human desire will be bigger priority one day and the citizens could finally realize their suppressed dreams[vi].

Therefore, in the following text we are defining a list of needs that will convince the citizens to move in to NSSC:

4.1 The unpolluted air

Air pollution, one of the main current devastation of urban space of Skopje, could be one of the most encouraging factor or changing the location of living[vii]. Regarding the air quality analyses in Macedonian capital and the comparison with the surrounding capitals in the region, Skopje has twice bigger air pollution. And in the European scale of most polluted cities, Skopje is always in the top 3! The recent study concerning the air quality in Skopje observed for a long term was made by the Institute of Health and Welfare of Finland in December 2016 shows that 30-35 % of deceases in Macedonia are caused by the air pollution.

4.2. Cheap price of the building plots

Bigger and cheaper new space instead of expensive house or apartment rents in the city will certainly convinced the citizens, especially those with big number of family members settled under the same roof.

4.3. More human character of the living space and contact with the nature

Overflowing of constructed space in general, devastation of human and urban current conditions, replacing green areas and small parks with constructed blocks etc. are the reasons of dehumanization of current Macedonian cities. The green areas are more and more far from us and seek for nature is getting bigger and bigger. The nature in NSSC will be omnipresent through the big gardens for everyone, park for relaxation and recreation, open sport field etc.

4.4. New employments in the NSSC (public and private sectors)

As the result of making new public buildings and new contents for the NSSC, the new possibilities for the employments will be open as well. In fact, the future inhabitants could find

new jobs in their new settlement and this will be another possibility to encourage the migration to these new cities.

4.5. Individual housing with own garden

This issue is very important for those who prefer a close contact with the nature. The private gardens represent not only place of repose, it also represents a place for a constant physical activity which is recommendable for everyone.

4.6. Attractiveness of the dwelling area

A pleasant big picture of the detached or attached houses with no more than two levels is always attractive and tempting for the future possible inhabitants. Equally important is establishing pleasant views towards the surrounding areas in order to strengthen the overall quality of the new smart satellite cities.

4.7. Reach spectrum of activities and public contents

NSSC's new contents and activities will certainly establish the independent character of it. There must be introduced new independent public centers within the NSSC. Public administrative buildings (local authorities, police, post office, banks, cultural facilities (cinemas, theatres, museums), commercial center-shopping mall, sport facilities and open sport fields (sport halls, swimming pool, fitness etc.), hospital center (for local citizens and for all citizens of Skopje), are representing a strong magnet for the future inhabitants.

4.8. High quality infrastructure and transport network

HQ infrastructure means quality internal communication and good network of public transport and connections with Skopje. Inside infrastructure that provides quality connections with the inner contents has to be an essential and integral part of the NSSCs[viii].

Another major element of the NSSC will be the new Transport center situated in the center of the new town. This center will be the starting point of the future transportation link with Skopje. That will include several bus lines and a city railway system[ix].

5. CONCLUSION

Transformation, as the definition of this term represents a marked change in form, nature, or appearance. From the previous analyzes of this paper we could make the following logical conclusion. In order to achieve positive urban transformations in the Macedonian society, first of all it is necessary to establish a prepared terrain in a bigger scale of the society. The whole mechanism of schools, media, social networks, etc. should be involved in those preparations of the system so we can enable any kind of progressive ideas or projects for better future.

The only path that will allow any kind of changes is to have open minded authorities who will initiate "fertile soil" for "growing" and realizing the progressive ideas. Therefore, we need to make positive transformation in our minds, before we make other positives transformations.

The idea of New Satellite Smart Cities and remodeling the existing city quarters in order to achieve a high quality living space would be very welcomed only if the society and the citizen himself will change its priorities and its focus of interests. Only if we accept new life

priorities defined for a long-term period, any kind of smart ideas regarding the improvement of our environment and our living space could find its way.

So, there is still hope for the Macedonian capital to improve its urban condition and to offer proper human living space to its citizens. And we, who are thinking about the positive urban transformations, we should never stop to remind about the benefits of those changes until the society will accept it.

At the ends, why we are appropriating the title “New Satellite Smart Cities” to the new proposed settlements?

Why New? : Because it is difficult to reorganize the existing city’s urban areas.

Why Smart? : Because those new towns are conceived to be a smart solution for those citizens who are planning to get away from the Macedonian capital evading from all of its problems.

Why Satellite? If we are not speaking about astronomy, satellite means object that is subordinate to another authority or by influence of it. Satellite cities in our research perspective represents new towns that will be however part of Skopje, and the towns that will be by the strong influence from the Macedonian capital. But it in the same time NSSC will have a strong independency as a separate town regardless its subordinate character.

Why Cities? We are proposing the name “City” as a part of “NSSC”, and not the terms like “quarter”, “district” or “neighborhood”. Why? : Because the total concept and the general idea is to design a new city with all necessary elements that makes that settlement a real City.

REFERENCES

[i] Bruce Mau. An Incomplete Manifesto for Growth - Lessons for Architecture, University “Ss. Cyril and Methodius” –Faculty of Architecture, Macedonia, pp. 17-18, 2001.

[ii] Piers MacNaughton , Usha Satish , Jose Guillermo Cedeno Laurent , Skye Flanigan , Jose Vallarino , Brent Coull , John D. Spengler a , Joseph G. Allen , The impact of working in a green certified building on cognitive function and health, Building and Environment, Vol. 114, pp. 178-186, 2017.

[iii] Anne Steinemann , Pawel Wargocki, Behzad Rismanchi, Building and Environment, Vol. 112, pp. 351-358, 2017.

[iv] Renata Paola Dameri, Camille Rosenthal-Sabroux. Smart City How to Create Public and Economic Value with High Technology in Urban Space, Springer International Publishing Switzerland, pp.7-10 2014.

[v] Stanley Buder. Visionariess and Planners - The Garden City Movement and the Modern Community, Oxford University Press, New York, pp.26-37, 1990.

[vi] Danica Mitkovska, Live births, deaths and migration by urban and rural areas, by regions, 2015, State Statistical Office of Republic of Macedonia, Skopje, No: 2.1.16.26, pp. 5, 2016.

[vii] Howard Ebenezer. Garden Cities of Tomorrow, Swan Sonnenschein & CO. , Ltd Paternoster Square, London ,pp. 17-18, 1902.

[viii] Lewis Mumford. The Culture of Cities, Harvest/HBJ Book Harcourt Brace Jovanovich, Orlando-Florida, pp. 407-416, 1970.

[ix] Andrew L. Dannenberg, Howard Frumkin, and Richard J. Jackson, Making healthy places : designing and building for health, well-being, and sustainability, ISLAND PRESS, Washington, DC, pp. 33-47, 2011.
[x] Eran Sher. Handbook of Air Pollution from Internal Combustion Engines Pollutant Formation and Control, Academic Press, San Diego, pp. 42-64, 1998.
[xi] Konstadinos G. Goulias, Transportation systems planning : methods and applications, CRC Press LLC , Boca Raton, 2003.
[xii] White, Peter, Public transport : its planning, management and operation, Routledge, Abingdon, Oxon, 2009.

IBU International Journal of Technical and Natural Sciences 1 (2020) 63-76

Assessment of Teaching Effectiveness in Engineering Education

J. Glassey[1], E. Schaer[2], A. Porjazoska Kujundziski[3], L. M. Madeira[4], M. Polakovic[5], N. Kockmann[6]

[1]jarka.glassey@ncl.ac.uk, [2]eric.schaer@univ-lorraine.fr, [3]aporjazoska@ibu.edu.mk,

[4]mmadeira@fe.up.pt, [5]milan.polakovic@stuba.sk, [6]norbert.kockmann@bci.tu-dortmund.de

[1]Newcastle University, Newcastle upon Tyne, United Kingdom,
[2]Université de Lorraine, UL Nancy, France,
[3]International Balkan University (IBU), North Macedonia,
[4]Faculdade de Engenharia da Universidade do Porto, Porto, Portugal,
[5]Slovak Technical University, Bratislava, Slovakia,
[6]TU Dortmund University, BCI, Dortmund, Germany

ABSTRACT

A framework for evaluation of effectiveness in teaching and learning of core knowledge and professional skills in chemical engineering education has been developed by iTeach EU project (http://www.iteach-chemeng.eu/) consortium, involving six partner institutions from different countries (UK, France, Germany, Portugal, Slovakia and Macedonia). Initial testing of the framework included two teaching units, chemical reactor engineering and design project, as part of the core courses in undergraduate chemical engineering curriculum. Evaluation of six different metrics, such as strategic nature of the course/discipline, relevance of the proposed formation, pedagogical relevance of the teaching approach, perception of relevance of the pedagogical approach, evaluation of acquisitions and evaluation of transfer, being integral parts of the framework, allows easy assessment and comparison of efficiency in teaching among different institutions, as well as easier recognition of the areas of improvement in specific pedagogical methodologies. Moreover, one of the goals of the project has been to establish a tool that could be used in assessment of delivering the core knowledge and employability competences in the education of different scientific disciplines. After some adaptation and improvements, the framework was subjected to a wider testing including stakeholders groups with different educational and professional experiences. The effects of this testing concerning variety of teaching approaches will be elaborated and discussed.

Keywords: ***lifelong learning, teaching effectiveness, higher education***

INTRODUCTION

Educating engineers is a very challenging process evolving and changing with time to satisfy the requirements of the society in which the engineers will work. The rapid technological development brings benefits to the society such as easier access to the needed information and market globalization, but also imposes many obligations particularly in the area of engineering education [1]. The market globalization demands appropriate technological expertise along with the cultural

and economic familiarity with the society. Also, technological expansion erases the recognizable disciplinary boundaries in engineering branches. Whilst 20-30 years ago differentiable proficiency has been recognized in diverse engineering disciplines, but today an engineer needs to show multidisciplinary knowledge and problem-solving skills [1]. Furthermore, the industrial drive is no longer focused solely on greater production and profits, but also on so called social corporate responsibility, which is customer focused and aims to decrease or eliminate environmental pollution, moves towards renewable resources as well as occupational health and safety [2, 3]. All these facets increase the demand for adaptation of engineering training process providing modern curricula consistent with updated technological applications.

On the other hand, we are all faced with rapid technological changes so that the “new” technology taught in the engineering courses during the educational period becomes outdated and sometimes useless for the graduates. In addition, there have been some criticisms of employers about the lack of communication skills, low level of teamwork skills as well as absence of professional perception in graduates of engineering [4], implying that engineering education requires not only strong knowledge in natural sciences, mathematics and engineering fundamentals, but also needs to offer development of communication, teamwork skills and lifelong learning, facilitating the adaptation of graduates to changes and challenges of the future [5].

Beside industry, the accreditation bodies in higher education exert some pressure on universities in terms of the design of engineering study programmes that will offer adequate quality of education and, at the same time, will make them attractive for future generations of engineering undergraduates [1].

These issues have raised additional concerns among university professors about the feasibility of traditional teaching approaches in engineering education and have led towards alternative methods of teaching. Some of the teaching styles promoting active learning are suggested to be: practical problem-solving methods, using visual presentation of material being taught (pictures, graphs, schemes, films, etc.), organizing brainstorming sessions, using computer-aided instruction, application of drill exercises, self-learning method, etc. [6-9]. Yet, many instructors hesitate to implement methods different than traditional ex-cathedra teaching. Some of them do not accept alternative approaches considering the switch to alternatives time consuming and that such a switch might distract them from research projects they are involved in [1].

However, in the last two decades there have been some signs of change [10]. Engineering professors started to consider different techniques in order to make their teaching, and thus students’ learning more effective. Logical question is how the teaching effectiveness can be measured and what criteria may be established for such evaluation [11-13]?

Most of the studies concerned with teaching effectiveness have been related to evaluation of academic staff and their rating based on the surveys carried out among students at the end of each semester and / or academic year [14]. International and national university rankings have been mostly related to research criteria [15]. Higher education accreditation agencies evaluate study programmes mostly, based on the learning outcomes explained through Bloom taxonomy domains [16] without taking into account the effectiveness of applied teaching methodology.

Thus, the aim of the iTeach project (www.iteach-chemeng.eu) as a part of Life Long Learning Programme of the European Union was to develop a robust framework for effectiveness assessment

of various pedagogical methodologies, especially those designed to develop important core competencies associated to the employability of graduates in chemical engineering.

After some modifications, the framework was subjected to a wider testing including teaching units that are also part of engineering disciplines other than chemical engineering curricula and some of the results are presented in this study.

What is the assessment framework tool and what does it do?

Our previous studies have been related to the analysis and review of learning outcomes [12] necessary for the establishment of the framework for the assessment of a whole formation in chemical engineering [13]. A framework tool devoted to a single teaching unit effectiveness evaluation has been also developed by iTeach consortium.

The tool is a free and easy-to-use instrument for higher education institutions and organizations to asses, compare and communicate results related to the teaching efficiency of a single course.

The tool provides answers to key questions such as:

- What influence does a certain pedagogical approach have on the learning process?
- How do employers assess the relevance of a certain course?
- What are the students' perceptions about a given pedagogical approach?
- Does a certain pedagogical approach improve the learning process?
- Do the graduates and students agree on the relevance of the formation and pedagogy of a certain course?
- Do academics and employers agree on the strategic nature of a course?

The framework enables easy calculation of six metrics to assess the efficiency of teaching a given course. The six metrics taken into consideration are:

1. Strategic nature of the course – Deals with the importance of a course for the global learning outcomes of the study programme.
2. Relevance of the proposed formation – Concerned with the content of the teaching unit.
3. Relevance of the proposed pedagogy – Oriented toward the form of the teaching unit, it is clearly related to the chosen teaching method.
4. Perception of relevance of the pedagogical approach – Related to the perception of the course by the students from a qualitative and organizational point of view.
5. Evaluation of acquisitions – Deals with the knowledge acquired by students that is measured by assessment after finishing the teaching unit.
6. Evaluation of transfer – Asses not only a single teaching unit, but the whole formation as well.

DATA ANALYSIS METHODOLOGY

Several teaching units, and among them, Physical and chemical phenomena, attended by 2nd year students of chemical engineering, and Physics I, as part of almost all engineering curricula in the 1st year curricula at International Balkan University in Skopje , have been used to test applicability of the iTeach framework in the academic year 2016/2017. The teaching method evaluated for both courses is problem-based learning.

A survey conducted among four target groups, academics, employers, graduates and students was used for data collection. Online questionnaires were distributed via e-mail, using contact

channels of iTeach consortium members and associate partners in Macedonia (two higher education institutions, accreditation bodies, employers, and graduates). For the course Physics I, surveys have been sent out to 63 academics (which were specifically asked to disseminate / send to other colleagues), 35 industrialists and 53 graduates (who finished the degree between 2012-2017), while in the case of the course Physical and Chemical Phenomena, the questionnaires have been distributed to 50 academics, 46 industrialists and 108 graduates. In order to increase number of responses from students, the printed versions of questionnaires were distributed among them (50-55 students for both courses), and the answers were inserted into the online questionnaires available on the iTeach official web site. All metrics, except metric 5, have been quantified through a series of Likert-type scale questions. For metrics 1-4 and 6 applied scale to rank individual statements is: (5) strongly agree, (4) agree, (3) neutral, (2) disagree, (1) strongly disagree, while for metrics 5: (5) very good, (4) good, (3) average, (2) bad, (1) very bad. The resulting data have been entered into this iTeach tool to calculate metrics, except metric 5, using formulas [13, 17] presented in Table 1.

Table 1. Metrics considered in the framework

Metric	Formula
Strategic nature of the course/discipline	M1 = (2A+G+2E)/5
Relevance of the proposed formation	M2 = (2A+G+E+S)/5
Pedagogical relevance of the teaching approach	M3 = (2A+2G+S)/5
Perception of relevance of the pedagogical approach	M4 = S
Evaluation of the acquisitions	M5
Evaluation of transfer	M6=(A+2G+2E)/5
A, G, E and S stand for **A**cademics, **G**raduates, **E**mployers, and **S**tudents, respectively.	

Metrics 5, calculated according Eq.1, is based on the students' courses and cohort average grades and standard deviations and it is independent of the grading system used.

$$M5 = \left(\left(\left(AM_y^{course} \middle/ AM_{y-1,y-3}^{course}\right) \middle/ \left(AM_y^{cohort} \middle/ AM_{y-1,y-3}^{cohort}\right)\right) \middle/ \left(\left(SD_y^{course} \middle/ SD_{y-1,y-3}^{course}\right) \middle/ \left(SD_y^{cohort} \middle/ SD_{y-1,y-3}^{cohort}\right)\right)\right) \cdot 3 \qquad (1)$$

where, AM_y^{course} and AM_y^{cohort} are average marks (grades) of the students obtained for the evaluated course and cohort, respectively, in the current academic year; $AM_{y-1,y-3}^{course}$ and $AM_{y-1,y-3}^{cohort}$ are average grades obtained for the evaluated course and cohort, respectively, in the three previous years; SD_y^{course} and SD_y^{cohort} are standard deviations of the average marks of the students, for the evaluated course and cohort, respectively, in the current academic year; $SD_{y-1,y-3}^{course}$ and $SD_{y-1,y-3}^{cohort}$ are standard deviations of average grades for the evaluated course and cohort, respectively, in the three previous years.

Measures of central tendency (M, SD, Min, Max) and frequency counts were calculated for all Likert-scale type questions.

For both courses, more than 80% of students invited to participate in the survey submitted their answers, while for the other stakeholders' groups the number of the responses was significantly smaller (5 to 20 times). Therefore, in the next section the attention will be paid mostly on the results obtained from students' surveys.

FRAMEWORK TESTING RESULTS

iTeach framework was previously implemented for the course Chemical Reaction Engineering [17] that is one of the core courses in the chemical engineering formation, applying different teaching methodologies (traditional lectures, problem-based learning, work-based learning, recorded lectures, practical instruction via labs).

In this study we made efforts to test the applicability of the tool for different courses, in this case Physics I and Physical and chemical phenomena assessing the effectiveness of the problem-based teaching approach.

Predominant teaching method used in delivering both courses was the traditional teaching ex-cathedra where students passively listen (or not) to teacher' explanations. Occasionally professors ask questions, and only self-confident students try to answer. At the end of each topic passed, professors usually assign problems similar to those solved during classes.

For the academic year 2016 / 2017 academicians, delivering both courses being evaluated (Physics I and Physical and chemical phenomena), were asked to implement the problem-based teaching method in their classes, as a dominant means of delivering knowledge. The instructor explains what is going to be learned at the beginning of each session, assigns a problem and divides students in smaller groups leaving them some time for their interpretation about the related problem. In this way, the professor identifies what the students already know, and what are the other facts, observations, rules, theories, etc., that should be explained.

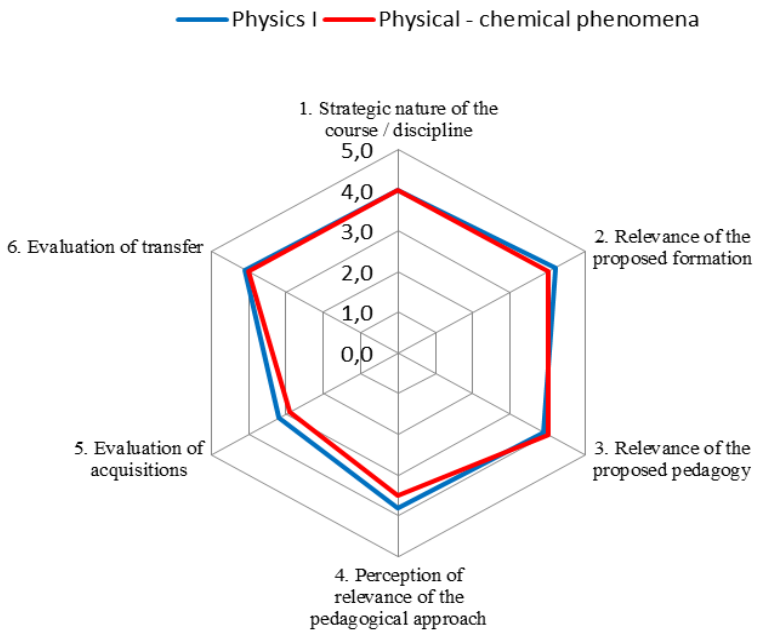

Fig. 1 Assessment framework radar plot for the courses Physics I and Physical and chemical phenomena applying problem-based learning as teaching approach.

Assessment framework in the form of radar plot and overall results for both courses are presented in Fig. 1 and Table 2.

Table 2. Framework metrics for the teaching units Physics I and Physical and chemical phenomena; applied pedagogy is problem-based learning

Metric	Physical and chemical phenomena / Physics I				
	Academics	Graduates	Employers	Students	Overall grade
1. Strategic nature of the course / discipline	3.9 / 3.9	4.4 / 3.9	3.8 / 4.2	-	4.0 / 4.0
2. Relevance of the proposed formation	4.1 / 4.6	4.3 / 3.7	4.1 / 4.2	3.6 / 3.8	4.0 / 4.2
3. Relevance of the proposed pedagogy	3.9 / 4.5	4.4 / 3.5	-	3.4 / 3.8	4.0 / 3.9
4. Perception of relevance of the pedagogical approach	-	-	-	3.5 / 3.8	3.5 / 3.8
5. Evaluation of acquisitions	-	-	-	2.9 / 3.2	2.9 / 3.2
6. Evaluation of transfer	3.8 / 4.2	4.4 / 3.7	3.7 / 4.4	-	4.0 / 4.1

The data presented in the Table 2 indicate that all stakeholder groups concerned (academics, graduates and employers), providing grades between 3.8 and 4.4, agree with the strategic nature of both courses (metric 1), Physical and chemical phenomena and Physics I. Relevance of the proposed formation (Metric 2) is supported by academics (M=4.1), graduates (M=4.3) and employers (M=4.1) for Physical and chemical phenomena, as well as academics (M=4.6) and employers (M=4.2) for Physics I. Students (M=3.6) and graduates (M=3.7) show slight concern about the content of the teaching units (M2) Physical and chemical phenomena and Physics I, respectively. Evaluation of the relevance of the proposed pedagogy (metric 3) resulted with the highest scores given by graduates (M=4.4) for Physical and chemical phenomena, and academics (M=4.5) for Physics I. But, students (M=3.4) for Physical and chemical phenomena, and graduates (M=3.5) for Physics I, show some doubts about the significance of the proposed teaching method. Metric 4 (perception of relevance of the pedagogical approach) and metric 5 (evaluation of acquisition), with the smallest grades of all metrics considered, depend only on students' evaluation (for M4), as well as students' average grades for the courses and cohorts and their standard deviations (for M5). Transfer of knowledge and skills (metric 6) of the two disciplines Physical and chemical phenomena, and Physics I, by all concerned parties, academics (M=3.8 for Physical and chemical phenomena; M=4.2 for Physics I), graduates (M=4.4 for Physical and chemical phenomena; M=3.7 for Physics I) and employers (M=3.7 for Physical and chemical phenomena; M=4.4 for Physics I) is supposed to be effective. It could be noticed that the evaluation of almost all metrics in which students' responses were involved, resulted with smaller overall grades. Besides, as previously mentioned regardless the efforts to get as many responses to the survey as possible, a small number of replies were received from the stakeholder groups, with the students being

exception. Therefore, further analysis concentrates on the students' assessment of three framework metrics (2, 3, and 4).

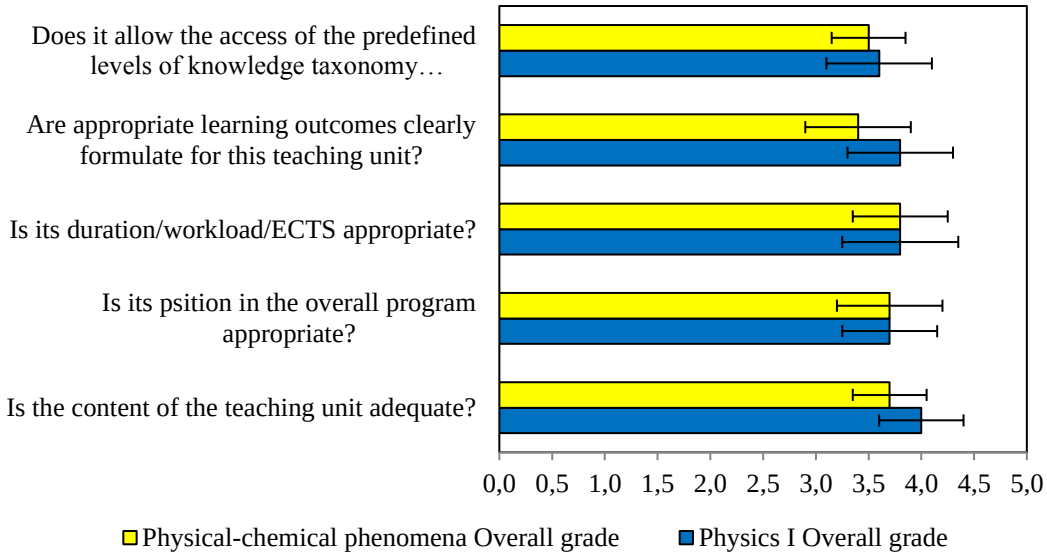

Fig. 2 Metric 2 - Relevance of the proposed formation, mean values and standard deviations for both courses tested.

As far as the relevance of the proposed formation for the course Physics I is concerned, the general score provided by the students is 3.8, and for Physical and chemical phenomena it is slightly lower, 3.6 (Fig. 2 and Table 2). Students attending the course Physics I agree that the content of the course is adequate (M=4.0, SD=0.8). The access of the predefined level of knowledge taxonomy was rated with a smaller score (M=3.6, SD=1.0), which was confirmed by the answers to an open-ended questions where one student wrote "*The material learned in Physics I is not appropriate and it won't be needed later in life, except if you study Physics.*", while the other student did not share the previous opinion: "*In my opinion, this course is very appropriate to start with in the computer engineering department. As I experienced, we learned some basic things in physics.*" On the other hand, students consider the duration / workload of Physical chemistry is appropriate (M=3.8, SD=0.9), but there is some level of disagreement about the learning outcomes in this course being clearly formulated (M=3.4, SD=1.0).

With an overall score of 3.8, the students agree that the proposed pedagogy in Physics I is relevant (M3), but the score of 3.4 indicates that there are some students that disagree with the relevance of the pedagogy (problem-based learning) used in delivering the course Physical and chemical phenomena. Results related to the questions exploring the relevance of proposed pedagogy (metric 3) are given in Fig. 3. Students learned something valuable (M=4.0, SD=0.9) in both disciplines Physics I and Physical and chemical phenomena, but they have doubts about appropriateness of the pedagogy to different learning styles (for Physics I M=3.2, SD=1.1; for Physical and chemical phenomena M=3.1, SD=1.0), and they do not completely agree that applied teaching style in Physics I promotes group interactions (M=3.2, SD=1.3).

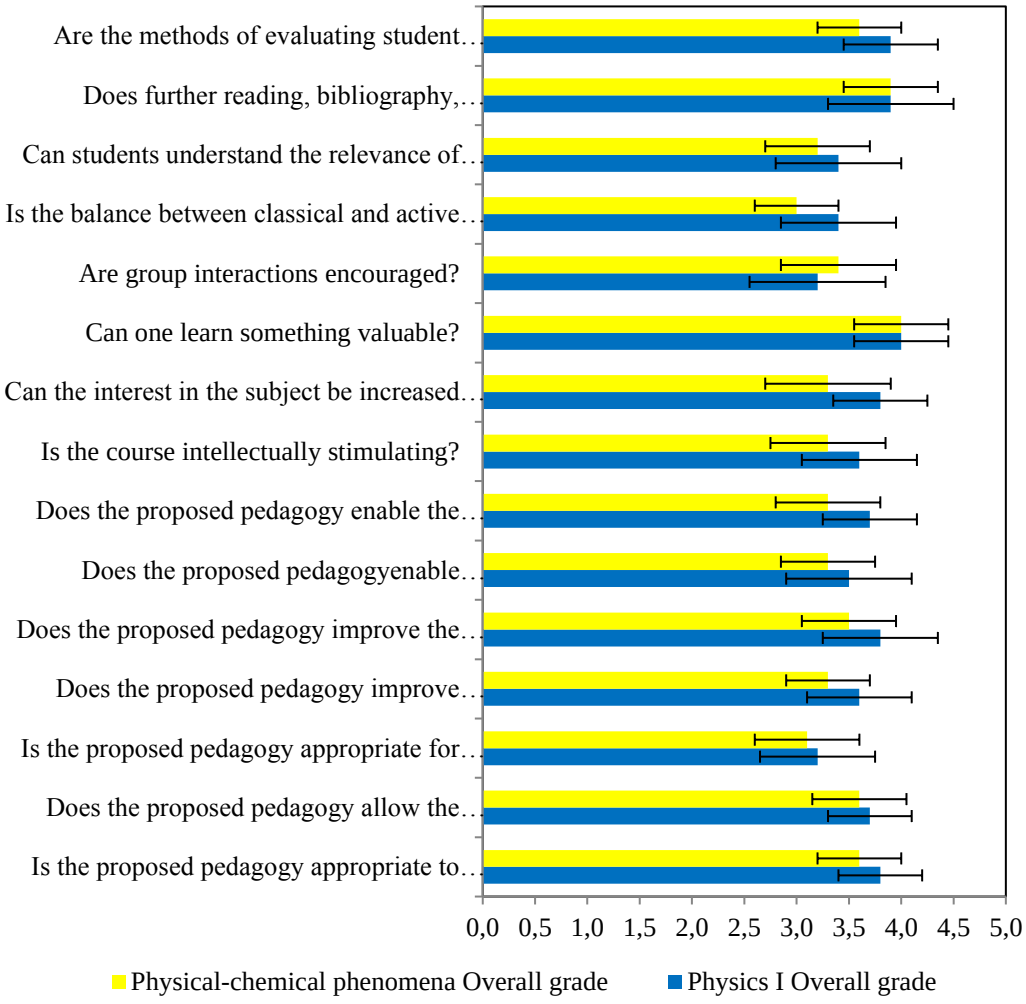

Fig. 3 Metric 3 - Relevance of the proposed pedagogy, mean values and standard deviations for both courses tested.

As far as perception of the relevance of the pedagogical approach is concerned (Fig. 4), students are satisfied with the teacher's explanations (M=4.1, SD=1.0 for Physics I; M=3.7, SD=1.1 for Physical and chemical phenomena). The smallest score delivered for Physics I, which is still a relatively high value (M=3.6, SD=0.9), indicates that some of the students experience increase in the interest in the course Physics I, with the problem-based learning as an applied teaching style. On the other hand, part of the students in the course Physical and chemical phenomena consider that the pedagogical approach, do not entirely improve their interest in the subject (M=3.1, SD=1.1).

Evaluation of the acquisitions, metric 5, calculated using Eq. 1, has resulted in the lowest overall scores for both teaching units, 2.9 for Physical and chemical phenomena, and 3.2 for Physics I. Higher students' marks, above the cohort performance change (if any), would increase the value of the metric. Also, a decrease in the standard deviation is aimed for, indicating a more uniform