Advantages, Disadvantages and the Viability of Project-Based Learning Integration in Engineering Studies Curriculum: The Greek Case

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INTRODUCTION

The ongoing evolution of scientific and technological applications increase the need for a change in the Hellenic educational system and the way in which knowledge is passed on efficiently, in order to better accommodate those developments and pave the way for the future generations to proceed to further improvements. Students of the Aristotle University of Thessaloniki (AUTh), from various technological and scientific fields of studies, convened with academics and professionals to discuss, in line with current research, on Project-Based Learning (PBL) as a suggested pedagogical method as well as its potential application to the University curriculum. Particular attention was drawn to some already existing and active project teams hailing from various disciplines which presented how they add value to their education through the

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practical application of knowledge they have accumulated through classes. The issues addressed during this session were in reference to the definition of PBL, its pros and cons, the soft skills that one can develop through it, and the requirements for it to be suitably applied in the University curriculum.

1 PROJECT – BASED LEARNING: DEFINITION AND CHARACTERISTICS

Project-Based Learning (PBL) is defined as the teaching method in which students learn new information and acquire new skills while tackling for an extended period of time a complex question or problem, within the context of a certain course [1]. It is considered a learner-focused teaching approach, shifting from the classic paradigm where the teacher repeats the information, towards a path where the teacher acts more as a facilitator, allowing the students to research, question and later apply what they learnt in order to suggest a viable solution to an ill-defined problem.

John Dewey, who promoted the philosophy of “learning by doing”, introduced the term PBL in 1897; however, it was only applied in practice during the 1960’s in Health Sciences Education [2]. The most frequent pattern relies on students deciding on the approach they are going to take regarding the problem they are presented with, then searching for a solution based on previous knowledge or on the courses taught in parallel as the project advances. Working in teams or individually, students have to find relevant sources to gather information and then analyse and synthesise it to form a solution, acquiring additional knowledge in the process.

PBL engages students in developing their collaborative and investigating skills with regards to real world problems, thus adding value to their learning [3], though the skills that students actually set in motion vary, depending on the course and the question. In many cases, the content of the projects is not specifically bound to a certain curriculum; therefore, students have the possibility to explore different disciplines and integrate their principles in the solution they suggest [4]. The problems themselves are mostly designed in a way that gives the participants ample space to demonstrate the wider knowledge they have acquired from previous years of merely theoretical studies.

Although there have already been several studies defining and describing the PBL methodology, only a handful of those are investigating students’ or professors’ opinions and perceptions when using PBL. To the best of the authors’ knowledge, no similar study has ever been conducted in Greece; this is the reason why this effort is considered a “first attempt” to monitor the reactions of the parties involved, within higher education. The AUTh has not yet implemented PBL officially in its curriculum, but it has rather allowed its use by professors in case they wish to do so. In view of these aspects, the aim of this paper is to examine the students’ attitude towards PBL and to explore how the academic community perceives the PBL, in relation to the experiences of existing project teams and in correlation with the demands of the current job market. Finally, the wider goal is to provide the competent academic authorities with suitable and targeted incentives in order for them to examine the possibility of a PBL curriculum, thus meeting the requirements of European Engineering Education.

2 METHODOLOGY

Initially, when discussing the methodology to be followed, a working team was put together by the Local BEST Group (Board of European Students of Technology) of AUTh. The team was responsible for a one-day event within the framework of a Local Event on Education (LEoE) organised by BEST Thessaloniki. The organisation of the event included several aspects such as the topic preparation, the event structure and the discussion coordination.

In order to achieve the knowledge aimed at as well as the skills range relating to the nature of the topic, there was an effort to involve different perspectives and parties and enhance the communication between them. Therefore, among the delegates, there were representatives of the academic community and of the job market, student teams involved in projects and students from different engineering and science departments of the AUTh.

The methodology used included 3 stages:

- Preparation (prior to the event): Aimed at providing students with knowledge related to the topic examined. Several days before the event, preparatory material was given to them in the form of handout papers, in order to help them familiarise themselves with the concept, while reflecting on PBL.
- Presentation (during the opening session of the event): Consisted of conventional presentations on PBL definition and applications, PBL projects run by student teams and examples of engineering courses inside the AUTh that apply the PBL method.
- Discussion as the main part of the event: Included interactive discussions among the parties involved. Firstly, a round table was arranged in order to discuss the four main points of PBL application; namely the advantages and disadvantages, the skills acquired by students, possible ways of implementation within the AUTh as well as the requirements and facilities needed. Following the round table, the discussion groups formed focused on four specific sub-topics; i) student-to-student and student-to-professor relations, ii) the profile and skills that a professor needs in order to successfully facilitate PBL projects, iii) student research with regards to the projects and iv) job market expectations from PBL.

During the discussions and in order to create a secure environment for the students to be able to express their ideas, the parties involved took their place around a U-shaped table, promoting a sense of equality and trying to dissolve any bonds of hierarchy between students and professors. The minutes of the round table and the discussion groups, which were further summarised and translated, constituted essentially the source of our conclusions.

A questionnaire was also produced as an additional tool to the discussions and it was distributed on site to the attending students. The purpose of the questionnaire was to collect their opinion, stir some new ideas and boost the students' motivation participating in the discussion. Given the very positive reaction to this effort, it was decided to approach a larger number of students. Therefore, following the event, 59 students from 6 Departments of the Faculty of Sciences and 7 Departments of the Faculty of Engineering answered the same questionnaire. The population under study does not allow us to proceed to secure conclusions, but it is considered sufficient to provide a general aspect and tendency among students.

3 RESULTS

During the Discussion part of the event, we collected the opinions of the participants which were then processed; several topic sub-sections presented here emerged from the conversation flow the conversation flow during the round table and the discussion groups.

3.1 Soft skills expected and provided

During the sessions, students and professors discussed on the soft skills any student ought to have in order to successfully complete the projects assigned to them as well as the skills they could acquire and/or further develop during the process. A strong

point that was raised from the discussion was that the job market should set the qualifications and skills their potential employees should have in order to be hired. The reason that led to this suggestion is that employers have practical experience on the profile a future employee should have; thus, they can contribute in teaching those necessary skills to students, either by just declaring the desired qualifications or by proposing methods to achieve them without, however, actively interfering in the pedagogical process.

Regarding the actual soft skills implicated in the process, the majority of the participants agreed that team spirit is the most crucial skill one should develop when taking part in a team project. Each member of the team learns how to cooperate with the others - an attribute particularly useful in cases when it is the professor who forms the groups - as well as how to communicate and adjust to the personality and working methods of their teammates. Moreover, every student develops ways of managing their time while on the same time being flexible; working under pressure while being productive; receiving and implementing the professor's feedback.

Throughout a project, different roles are likely to emerge and be undertaken by the team members. One such example is the role of the leader, who needs to interact with every member on a daily basis, in order to both effectively manage team members and further develop her/his leadership skills. However, this is not the only or the most important role in a team. Many people who may not be directly linked to the result production process do have significant tasks to accomplish, like providing the resources and setting the appropriate context for the team to work. Although some of these roles can be difficult to be evaluated properly, all members have the responsibility to fulfil their task adequately, a valuable quality that can help them seize opportunities later in life.

One of the participants' main concerns was that the workload might be unequally shared among the members of the team, with some people tending to benefit from their teammates' work thus earning equal praise and recognition with them. These occurrences demonstrate how demanding it is to develop moral standards and ethics which will help students act in honesty and work hard to the benefit of the team. During the project, every member should focus on the procedure that produces the result and not on the result itself.

Finally, students, professors and company representatives all agreed in conclusion that only when the students' minds are freed from the stress of scoring high marks, will they be able to embrace all these skills and qualities and the fact that, as they themselves stated, in order to improve ourselves, we have to improve society first.

3.2 Advantages of PBL

Discussing PBL advantages, participants stressed the fact that it is an experiential and empirical procedure which helps students to better understand the information they gather. It is easier to understand something working on a specific project, rather than just be an often passive receiver of messages during a lecture. Moreover, students can combine in one project all the knowledge they have obtained from different courses they have attended. According to Greek students, one of the greatest advantages of using PBL is the motivation to learn, since they admit they understand easier the information they get through this hands-on approach; it provides them with the incentive to seek information themselves and not to passively expect it from professors, thus transcending the limitations of the classic teaching methods and gaining time to dedicate to the project at hand.

Furthermore, some projects can have the form of an internship. In particular, there are professors actually inciting their students to participate in research programs, such as the ones offered from CERN, where they can gain valuable experience, which is literally impossible to obtain elsewhere. Participants agreed that these kind of internships could potentially offer them a job in the future within the institution or company in question, while they also deliberated on the common belief that PBL bridges the gap between the university and the job market. Participants explained that students can have a "taste of reality" by experiencing and dealing with real-life situations and problems before and after they graduate. This is particularly true in cases of projects developed in cooperation with a company, as they gain an experience that the university cannot provide them with on its own. Company representatives supported the claim that companies are searching for future employees who have worked on various projects, even if this has resulted on them delaying their graduation date. It is essential for them to see if the candidates are capable of communicating with other members of the team and if they have the soft skills required.

3.3 Disadvantages of PBL

Besides the claims that are in favour of the PBL method, participants have not failed to mention the difficulties related to it. Taking into account the current Hellenic education system, there is already a tendency for students to focus only on their projects, neglecting, therefore, the rest of the courses in the semester. Professors stated that this aspect is further stressed, if we take into consideration the whole structure of the higher education system in Greece. Courses are divided into two semesters per year, with approximately seven courses per semester. Thus, it is natural that students have a hard time to fully follow each of these courses, especially when most of them have extensive and demanding projects.

Furthermore, students considered the allocation of different project topics by professors as a disadvantage. In order to secure the transparency of the process, the professor needs to suggest a different topic per student or per team. This means that not every student in class is learning the same thing. While this might be considered as a positive attribute when obtaining a degree (Ptychion), a possible downside is that future employers will not be able to distinguish the exact knowledge background of each candidate.

3.4 How can this model be applied to AUTh

During the roundtable discussions, professors commented that the application of PBL in the University curriculum is regulated by numerous parameters, with the aim to have maximum impact on the academic process. To begin with, one of the most important aspects to be taken into consideration is the fact that the logistics and the wider management of the projects are both dealt insufficiently within the University. Greek students stated that the projects must be well-defined in all aspects and that they should be able to complete them within the teaching timetable of the corresponding class, while at the same time achieving the respective educational goals. According to the participants, it seems that the high demands of many existing projects, along with an overburdening and inefficient working timetable, act as demotivating factors in choosing a project; to accommodate the demands of such schemes, the courses end up rearranging their overall academic schedule.

When discussing about the integration of projects in the current syllabus, concerns were raised regarding the workload in terms of academic hours. Some departments, such as the department of Electrical Engineering, have a very demanding syllabus that leaves no time for constructive studying or practice after classes. However, the concept

of PBL leads to less theoretical academic hours, therefore it could be possible to integrate the working time for projects in the class schedule.

Students claimed that PBL can introduce real-world problems and scenarios in the class under a safe teaching environment, granting them the opportunity to experiment and bring pioneering ideas under consideration, always according to the subject in question. Two elements that can enhance this experience are multidisciplinarity and industrial aid. The ability to incorporate elements from other disciplines into the curriculum, without derailing from the main course of study, can broaden the students' horizons, introducing them to new fields of knowledge whose principles they can apply again at a later stage, when they are faced with real problems on their own. Joint courses and projects are encouraged too, but they must be applied in the final stages of a suitable curriculum, in order for the students to have the appropriate knowledge level.

The participants claimed also that the industry can provide them with both knowledge, through specialized seminars, and relevant support in terms of logistics and topics to be studied upon for the courses, in cooperation with competent academic authorities. However, during discussion, particular emphasis was put to the extent and nature of the industry's involvement; it was stated that it must be such that it shall not interfere with the actual pedagogical process, which could result into shifting the educational goals to better match the business sector's needs and interests. The University must reach out to the industry and not the other way round, as a case of third-party guided knowledge would arise.

3.5 Materials, equipment and staff

One of the main issues that came up while discussing about the implementation of PBL in AUTh was the materials and equipment required to complete the projects. Students pointed out that it might be difficult to respond to the needs when the scale shifts from a few dozen postgraduate students to several hundreds of undergraduates. The shortage of materials and technological know-how can be partially tackled by having interdepartmental projects. One example for this could be the financial analysis for a project which could be conducted in cooperation with the Department of Economics. Furthermore, all students should have equal access to specialised software; thus projects should require only software from the University. In some cases, students can use software that is not very specialised, but can provide them with a simulation of the working environment.

Should the PBL be successfully introduced in the University, it could be easier, later on, to have Master and PhD students serve as mentors for the younger students, since they will have already been familiarised with the methodology of projects through their studies. Another interesting approach, already implemented in the Department of Mathematics, is to have a team of 10 – 15 experts, instead of just one mentor for each team.

In conclusion, before bringing PBL to the University it is of the utmost importance to verify that the infrastructure is operational, the required equipment is well maintained by the competent personnel as well as to determine how many people can work on it, how many students can professors supervise and finally to reach a consensus and arrange the working hours.

3.6 Student to Student and Student to Professor relations

Moving on from the roundtable to discussion groups, participants went on to discuss more specific topics. When asked about the factors that influence a team's success,

professors participating in the event stated that these include proper distribution of tasks, the number –and its stability thereof– of its members and the facilitated interaction. While preparing a project, frequent and open discussions between professors and team members ensure better communication, a healthy cooperation and a fruitful feedback process, thus maximizing the pedagogical quality of the course to which the project is related and of the educational outcome. Professors claimed, from experience, that there is a need for the teams to present their different working methods and learning styles from the very beginning; they also have to set clear objectives, deadlines and requirements. The professor should be mostly facilitating the class, rather than setting the rules and showing the path that has to be taken.

Starting from a different perspective, students stated that there is a need to repel a certain feeling of antagonism that may exist among team members. Possible solutions include: i) teammates having a variety of skills and knowledge, ii) being well informed on the purpose of the projects and iii) understanding the importance of both personal contribution and of teamwork. They commented that friction between them usually emerges during the early stages of forming and norming. On the other hand, competition between different teams is acceptable and, at times, beneficial. Professors and students suggested that self-assessment is also a way of ensuring functional group dynamics, because students tend to be stricter when assessing themselves. In addition, oral examination of the projects by the mentors and midterm evaluation presentations also help with brainstorming and team bonding.

3.7 Professors' critical skills for effectively supporting PBL

When assessing PBL from a professor's point of view, an important factor arising is their pedagogical knowledge. According to Greek students, typical pedagogical competences include creativity, a sense of humor, the ability to comprehend the needs of the students, a certain flexibility while teaching, etc. Supporting this opinion, professors added that in order to be able to handle PBL, they also need to have basic knowledge of project management, team building and team leadership. Students further suggested that professors should be open in personal assessment, be receptive to feedback and correct mistakes.

By accepting that there are skills professors need to have in order to successfully integrate the PBL method in teaching, participants automatically put emphasis on the issue of them receiving appropriate training and pursuing specific teaching approaches and educational practices. The profile of a professor able to manage the PBL method effectively includes a broad educational background, the ability to inspire and stimulate young minds into expanding their way of thinking and further developing their talents, as well as the ability to help them surpass the various difficulties that they may face. Workshops and seminars, along with informal learning are some of the ideas suggested to familiarise themselves with the procedure, while the presence of consultants might be helpful when in need of assistance or of changing the project. To that effect a cooperation between the Faculty of Human Sciences and the Faculty of Engineering or Sciences may prove extremely helpful in terms of didactics and pedagogy.

Professors stated that the Hellenic education system can become quite counter-productive because of the selection criteria set when choosing a professor to take a teaching position. These are mostly based on the number of published papers or on their research rather than on their pedagogical knowledge. Publishing in scientific magazines takes time that is required for developing appropriately oriented teaching methods. To overcome this problem, many other educational systems separate the role of a teaching professor from the role of a research professor, the former achieving

the pedagogical status by attending various targeted seminars; however, in Greece no such distinction applies. It is quite common though that postgraduate students assist in the process, thus aiding their supervising professor and gaining teaching experience. Their role is to facilitate the class, rather than set the rules. However, they are assigned with loads of paperwork and research work that interfere with their ability to help in the teaching process when, at the same time, the ratio between students and professors is uneven as a result of understaffed universities.

3.8 PBL and student research

When facing student research as a topic, participants commented that treating students as future scientists is a key factor when promoting PBL. Incentives for them to engage in the process may include publications in magazines or conferences. When a project is properly structured, students think that they are able to work and pursue their research, even when faced with gaps or unsolved problems in theories and practices. These real-life projects are the first steps in developing skills, while achieving to connect the universities with society. However, professors are not of the same opinion, as they think that the project-related results should be tested and reevaluated, in order to establish feasibility and not just to serve an educational purpose.

3.9 PBL and job market

Discussing on its impact on job market, Greek students claimed that handling projects in universities provides a boost to their résumé and helps decrease the period of adjustment inside a new line of work. Moreover, they acquire a set of abilities allowing them be more competitive in the job market. Nonetheless, students and professors alike agreed that projects do not substitute professional experience; instead, by creating a small-scale work environment, they provide useful job skills, such as, among others, self-presentation, time management, communication and administration skills and creative thinking.

Companies can contribute in various ways too: through company visits which get the students familiarised with the real working environment, providing information in terms of handling projects within working conditions or through offering the actual place for conducting a project. Additionally, it was suggested was suggested that some complementary programs on a voluntary basis or of low salary internships should be created so that students can obtain practical knowledge and experience on the job. These approaches limit the intervention of companies in the education, therefore can be considered acceptable from the academic community. Since education is public in Greece, there is widespread concern that in case the industry is allowed to significantly interfere or even define the projects, then they will sponsor only projects relevant to their interests and the education system and academic research will be coached by the correspondent needs of the market and students will not enjoy a comprehensive curriculum. At the same time, it was not commonly approved to have professionals from companies teach a certain subject and supervise a research project; it was rather suggested that their role should be to train students on practical matters while the latter practice within a regulated internship program.

4 QUESTIONNAIRE RESULTS

During and after the event, the questionnaire was distributed to a number of people in order for them to express their opinions. It attracted mostly students in their senior years of studies, thus providing a more complete overview of the project teaching system in its current form, within the respective departments. To begin with, 84 % of the people asked, claimed that assignments of all sorts are included in their classes

and only 16% claim to benefit solely from lectures. At the same time, 89% of them prefer the combination of lectures and assignments, with the rest being equally divided to those who preferred lectures and those who preferred assignments as their favourite method of learning. Nevertheless, from that group, only 31% responded that they are satisfied by the number of projects in their curriculum, with 86% in total demanding more projects in their course of studies. The academic youth seems to support the idea of PBL, with less than half of those asked stating that this method is extremely helpful for understanding the contents of their courses while about 74% added that it will surely contribute positively to their academic evolution.

Extra emphasis seems to be attached to team spirit and a cooperation mentality, in this survey, with only 23% of the people asked willing to work alone in their assigned projects and the rest preferring to work in teams either organized by a tutor or formed autonomously. Moreover, currently 36% of the students believe that they are adequately graded for their work in the current format, while 57% think that the grades awarded to them in a PBL educational environment, will mirror their work. Additionally, merely 18% from the student pool believe that the academics in the Aristotle University are not capable of supporting PBL, though the current status of cooperation among students and professors can be considered average, according to the questionnaire results. To sum up, an astounding percentage of 73% is of the opinion that a change in the university curriculum, toward a project-centered approach is of vital importance.

5 CONCLUSION

Project – Based Learning is a method that appears to be widely accepted by both students and professors, while companies regard PBL as a valuable teaching method that equips students adequately. However, even though this method is highly appreciated by all parties involved, so far it is not applied to a satisfactory extent within the AUTh and there is an evident need to further include PBL courses in the educational curriculum.

Summing up, it can be stated that the added value for a student, that is the fact of developing both soft and hard skills, during a PBL course, might not be directly reflected in the result of the project or during a job interview, but they are still an important attribute which is much appreciated in the working environment and the constructive role they are called to play within society. While a better link is formed with the job market, Greek universities are not yet ready to accept a drastic involvement of the industry in the curriculum, since there is a shared concern that it will influence the education and the free expression of ideas.

However, despite the restrictions arising, it is hopeful to see from the discussions and the questionnaire results that if faculties decided to apply PBL, there are ways to achieve that, even within the current form of the curriculum. An important advantage of the Aristotle University of Thessaloniki is its multidisciplinarity, which allows for a cooperation and forging of relationships both between professors and students and with professors from different faculties.

Following targeted training, professors can further develop their pedagogical competences, but it seems all the more necessary to distinguish between the two roles of university professors, those of teaching and research professors. Additionally, students can acquire a broader range of knowledge and access to ideas that will allow them to approach projects in a holistic way, allowing them, at the same time, to engage in a procedure characterised by flexibility, versatility and continuous search for new knowledge. A shared feeling among the participants is that the scientist of the future is not only the one who knows, but also the one who can apply this knowledge. As a

result, a new era rises in AUTh, where the need of a reform in the current educational system increases and PBL might serve as a catalytic factor towards this change.

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