Project-Based Methodology to Lecture on Web Frameworks Applied to the Management of Health-Related Data

Damián Fernández-Cerero(✉) and Alejandro Fernández-Montes

Departamento de Lenguajes y Sistemas Informticos,
Universidad de Sevilla, Sevilla, Spain
{damiancerero,afdez}@us.es
http://www.lsi.us.es

Abstract. The management and processing of the data generated by healthcare systems is getting more and more attention because of the digitalization of a traditionally analogical sector such as healthcare. Various data management frameworks and solutions have emerged to face some of the multiple challenges present in this environment, including: (a) Data privacy and security; (b) Inter-operability between heterogeneous systems; and (c) Usability and readability of health-related sensitive information.

In this paper, the authors share their experience on lecturing on how to address such issues by developing web-based software from several points of views: (a) Healthcare professional needs and requirements in terms of usability, accessibility and easiness; (b) Technical requirements and knowledge required to develop all the layers of a fully functional example of a micro health information system; and (c) Technical requirements to share and distribute the data required by several agents of the healthcare environment, focusing on the adoption of international standards such as HL7; (d) Perform of all operations in a secure, available and reliable way.

It is concluded that the application of Flipped Teaching among with Project-based Learning may have a very positive impact on both in grades and drop rates for late-years (junior and senior) courses within the Health Engineering bachelor's degrees.

Keywords: Project-based Learning · Flipped classroom · Health Engineering

1 Introduction

1.1 Health Engineering Degree

The University of Sevilla and the University of Málaga conforms the so called Andalucía-Tech campus. This is an aggregation of universities with the objective of develop and cooperate in this establishment of new and challenging degrees.

In this context, both universities agreed to offer a novel degree, not present in any other Spanish or European Universities: The Degree in Health Engineering. The main focus of this approach is to instruct students in the disciplines related to the application of engineering approaches to the Health Systems. The novelty of the approach is to incorporate three specializations: Clinic Informatics, Bioinformatics and Biomedical Engineering (which is the one present in several universities).

Clinics Informatics focuses on the application of Computer Science in clinic environments, especially for the interoperability of Healthcare Information Systems and for the definition of the Hospital Information Systems (HIS). In addition, various standards for the codification and transmission of health data are studied in this modality, including Health Level Seven (HL7), Digital Imaging and Communication in Medicine (DICOM). This specialization is only taught in the University of Sevilla.

Bioinformatics focuses on the scientific exploitation of clinic data to expand the knowledge on the relationship between them and the patients' pathologies. Moreover, the most advanced techniques to infer conclusions from patients' clinic data are studied in this modality. This specialization is only taught in the University of Málaga.

Biomedical Engineering focuses on the industrial design and manufacturing of clinical equipment for the various hospital environments, including cardiology units, operating rooms, general equipment, electrocardiogram equipment, and monitoring equipment.

1.2 Normative Context

The following verification files in Computer Science area have been taking into consideration to elaborate the lecturing project:

- The publication of the degree in Health Engineering Bachelor (Grado en Ingeniería de la Salud) present in the State official newsletter (BOE) number 5, 6th of August of 2012[1].
- Verification memory of the Health Engineering Bachelor (Grado en Ingeniería de la Salud)[2].
- Study program of the Health Engineering Bachelor (Grado en Ingeniería de la Salud)[3].

The concrete environment of the subjects taught in the Computing School (Escuela Técnica Superior de Ingeniería Informática) of the University of Sevilla and the working market have also taking into account for the elaboration of the study program.

[1] https://www.boe.es/boe/dias/2012/01/06/pdfs/BOE-A-2012-227.pdf.
[2] https://www.informatica.us.es/docs/estudios/ing_salud/memoria_verificacion.pdf.
[3] http://webapps.us.es/fichape/Doc/MVBOE/226_memVerBOE.pdf.

1.3 Project-Based Learning

Project-based Learning (PBL) is a model which organizes lecturing around projects. According to some definitions found in the literature, the projects are complex tasks based on problems or questions which are challenging. The students must perform design, problem-resolution, decision-making, and exploration tasks. Such tasks give students the opportunity to work with a relative autonomy for a long period of time. As a result, students may elaborate realistic products [1,5].

The characteristics found in the literature which define Project-based Learning include [4,7]:

- Original content.
- Teacher supervision but not direction.
- Clearly defined teaching objectives.
- Collaborative learning.
- Deliberation and incorporation of mature skills.

Project-based learning is considered the best tool to achieve multiple instructional goals. Among them: (a) Proposition and resolution of real-life challenges; (b) Students' involvement in the presentation of their projects, methodology and proposals; (c) Focus on the critical aspects of a project and prioritization of tasks; (d) Development of team-managing and communication skills to solve challenging issues; (e) Creativity, reflection, critique and revision on the project execution are some of the required collaborative skills to achieve a successful goal.

This combination of the aforementioned aspects of this teaching model provides students with the tools needed to successfully face the challenges that they will meet in the future in the working market.

In this environment, students are asked to perform a project which final goal consists on the development of subsystems of a Hospital Information System (HIS), including: clinic management system, administration system, and interoperation systems.

PBL can be very useful in the context of the bachelor's degrees taught in the School of Computing (ETSII), and that is why it is proposed as one of the learning techniques available to teachers that lecture subjects in the aforementioned degrees. Specifically, for Computer Science subjects, several studies have validated its effectiveness [6], showing many of the benefits obtained. Among these benefits, we highlight: (a) students are able to apply their knowledge; (b) acquisition of practical skills in programming; (c) involvement in teamwork processes; and (d) understanding of the factors that influence project management.

One of the most influential elements on the success of the use of PBL is the origin of the project idea. Three of the most commonly used scenarios include: (a) the students propose the topic of the project with complete freedom (requires validation by the faculty, which evaluates the complexity, viability and fulfilment of the teaching objectives); (b) the students choose from a set of projects proposed by the faculty; and finally (c) A single project is proposed for all the students.

Each approach has its own advantages and disadvantages: when students have the option to choose it, that decision usually translates into greater motivation. However, this decision freedom requires a highly involved teacher with a great ability to adapt to changing problems. In addition, this option requires also more complex evaluation and validation techniques. Plus, students can sometimes perceive that the difficulty, supervision and evaluation processes among students and projects are not homogeneous. On the other hand, when a single project is proposed to the students, such heterogeneity in terms of evaluation is minimized and requires less effort on the faculty side, since they only require knowledge on one problem domain and on one set of determined solutions. However, this approach presents a risk of lack of motivation from the students caused by the proposed project, meaning that apathy may grow, and the results could be less satisfactory.

Students may be oriented to carry their project out in groups or individually. The choice will depend on the teaching objectives, fundamentally if the faculty is eager to promote the group skills, and if the typology of the proposed projects is usually faced as a team or individually in the professional environment.

The orientation and the period of time given the students to complete their projects also marks the difficulty and extension of the projects, and therefore the teaching staff must propose or validate projects that are viable and at the same time hard enough for the objectives set.

The specific characteristics of the PBL that will be implemented in the course will be determined by: (a) the teaching objectives of each subject; (b) the size of the class groups; and (c) teaching staff and resources available.

1.4 Flipped Teaching

Flipped Teaching is a model that swaps the traditional lecturing process, where the teacher is the central source of knowledge which is spread among the students following a lecturing style. Students are not usually highly engaged nor motivated, since their role is framed within the absorption of the knowledge and asking the lecturer for some guidance on the lessons. The teacher can also suggest students to perform some activities and to solve problems/tasks in an autonomous way that could be corrected during following lessons in order to reinforce the knowledge transmitted.

In Flipped Teaching, unidirectional learning activities are moved to outside class hours thanks to online resources, forums, and personal research [3]. On the other hand, activities usually classified as homework are pushed into the classroom to have the real-time support and guidance of the teacher [8]. In this model, the learner become the center of the learning process, since he can adjust the knowledge-acquisition rate and depth and can enquiry lecturers when the knowledge is already present, strengthening the learning process. The guidance provided by teachers in this model is usually more personalized and interactive, achieving higher rates of motivation and engagement [2].

Flipped Teaching can optimally fit into the final courses of bachelor's degrees taught in the School of Computing (ETSII), where students need to be put as

the center of the learning process to reinforce important skills before arriving to work market. Among these skills, flipped teaching include: (a) autonomous research; (b) self-management of time; (c) collaboration to achieve difficult goals; and (d) understanding of the importance of continuous work and organization.

Even if the most important factors for a successful learning process in Flipped Teaching falls on the students themselves, some decisions made by teaching staff may highly impact on the results. Among them: (a) the quality of the supporting material; (b) the quality of online resources for collaboration, communication and research; (c) the type of activities proposed in the classroom; and (d) the willingness of the teachers to go beyond of what's expected.

2 Subject and Student Population

The subject where the previously mentioned teaching methodologies were applied is a third course subject from the Degree in Health Engineering. The subject title is "Codificacin y gestin de la informacin sanitaria" (Codification and management of health data) and is included in one of the three specializations of the degree: Mencin en Informática Clínica (Clinic informatics).

The student population under study covers students from five academic courses, which sum up 57 students. Demographic information about students was not included as part of this study, but gender, age and other demographics were similar between both populations. Academic courses of 2013 and 2014 a project-based learning methodology was applied, mixed with conventional lessons conducted by academic staff. A total of 27 students participated during these courses. Academic courses of 2015, 2016 and 2017 a flipped teaching methodology was applied, and no conventional lessons were conducted by academic staff. A total of 30 students participated during these three courses.

Figure 1 shows the individual scoring for each academic year. The period of time under consideration comprises the following years: 2013, 2014, 2015, 2016 and 2017 (which sum up a total of 5 academic years). Academic courses of 2013, 2014 a project-based learning methodology was applied mixed with a more conventional lessons conducted by teachers. By the academic courses of 2015, 2016 and 2017 a flipped teaching + project-based learning methodology was applied (no conventional lessons conducted by teachers).

3 Statistical Analysis

Results from these five courses are presented in Table 1. In this section we performed various statistical analysis in order to check the goodness of the proposed teaching methodology based on flipped teaching.

It can be noticed that the proposed teaching methodology based on flipped teaching achieves its goals of putting the students as the core and center of the learning process, method and activities. As a consequence of this new approach several Key Performance Indicators (KPI) were improved in the three academic years where the flipped teaching methodology was successfully applied. This Key Performance Indicators include:

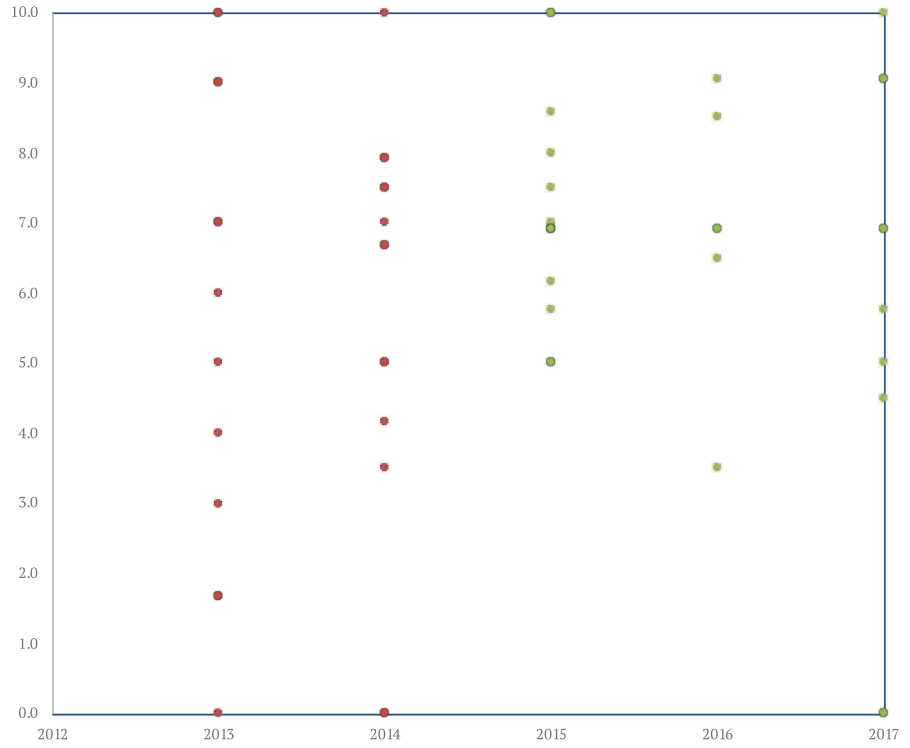

Fig. 1. Individual scoring grouped by academic year. (Red: no flipped-teaching, Green: flipped-teaching)

- **%passed.** Ratio of students that passed the subject.
- **%failed.** Ratio of students that failed the subject.
- **%drop-out.** Ratio of students that abandoned the subject.
- **Average score.** Mean value of the scores (from 0 to 10) achieved by students.
- **Variance.** Variance of the scores achieved by students.

From these results and comparison between the two groups we notice that the ratio of students that passed the subject was increased by 20% and at the same time the ratio of students that decided to drop-out the subject was decreased.

It is important to notice that the variance between the scores achieved by students was also decreased (from 9.23 to 5.81) which indicates that there was a more homogeneous subject understanding by students.

The p-value test was performed to demonstrate the significance of the improvement in the score results between students grouped by the learning methodology. The one-tailed study is described below:

Table 1. Statistical analysis summary results.

Measure	Traditional method	Flipped teaching	Diff
Total Students	27.00	30.00	3.00
Passed	18.00	26.00	8.00
%passed	0.67	0.87	0.20
Failed	9.00	4.00	−5.00
%failed	0.33	0.13	−0.20
Drop-out	3.00	2.00	−1.00
%drop-out	0.11	0.07	−0.04
Average	5.64	6.64	1.01
Mode	7.00	6.92	−0.08
Deviation	3.10	2.45	−0.65
Variance	9.23	5.81	−3.43

Difference Scores Calculations

Subset 1 (no flipped teaching method):

$$N_1 : 27$$

$$df_1 = N - 1 = 27 - 1 = 26$$

$$M_1 : 5.64$$

$$SS_1 : 248.69$$

$$s_1^2 = SS_1/(N-1) = 248.69/(27-1) = 9.56$$

Subset 2 (flipped teaching method):

$$N_2 : 30$$

$$df_2 = N - 1 = 30 - 1 = 29$$

$$M_2 : 6.64$$

$$SS_2 : 173.45$$

$$s_2^2 = SS_2/(N-1) = 173.45/(30-1) = 5.98$$

T-value Calculation:

$$s_p^2 = ((df_1/(df_1+df_2)) * s_1^2) \ + \ ((df_2/(df_2+d_f2)) * s_2^2)$$
$$= ((26/55) * 9.56) \ + \ ((29/55) * 5.98) = 7.68$$

$$s_{M_1}^2 = s_p^2/N_1 = 7.68/27 = 0.28$$
$$s_{M_2}^2 = s_p^2/N_2 = 7.68/30 = 0.26$$

$$t = (M_1 - M_2)/\sqrt{(s_{M_1}^2 + s_{M_2}^2)} = -1/\sqrt{0.54} = -1.36$$

The t-value is −1.35515. The p-value is .090455. The result is significant at $p < 0.10$.

4 Conclusions

Authors shared their experiences on lecturing on how to address issues related to healthcare information management and codification by developing web-based software from several points of views: (a) Healthcare professional needs and requirements in terms of usability, accessibility and easiness; (b) Technical requirements and knowledge required to develop all the layers of a fully functional example of a micro health information system; and (c) Technical requirements to share and distribute the data required by several agents of the healthcare environment, focusing on the adoption of international standards such as HL7; (d) Perform of all operations in a secure, available and reliable way.

Evidences made us conclude that the application of Flipped Teaching among with Project-based Learning may have a very positive impact on both scores and drop rates for late-years (junior and senior) courses within the Health Engineering bachelor's degrees. It is shown that flipped teaching reduced the number of drop-outs from students, and at the same time reduces the differences between the scores achieves by them.

References

1. Davcev, D., Stojkoska, B., Kalajdziski, S., Trivodaliev, K.: Project based learning of embedded systems. arXiv preprint arXiv:1606.07498 (2016)
2. Herreid, C.F., Schiller, N.A.: Case studies and the flipped classroom. J. Coll. Sci. Teach. **42**(5), 62–66 (2013)
3. Jinlei, Z., Ying, W., Baohui, Z.: Introducing a new teaching model: flipped classroom. J. Distance Educ. **4**(8), 46–51 (2012)
4. Kokotsaki, D., Menzies, V., Wiggins, A.: Project-based learning: a review of the literature. Improv. Sch. **19**(3), 267–277 (2016)
5. Larson, J.S., Farnsworth, K., Folkestad, L.S., Tirkolaei, H.K., Glazewski, K., Savenye, W.: Using problem-based learning to enable application of foundation engineering knowledge in a real-world problem. In: 2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), pp. 500–506. IEEE (2018)
6. Pucher, R., Lehner, M.: Project based learning in computer science-a review of more than 500 projects. Procedia Soc. Behav. Sci. **29**, 1561–1566 (2011)
7. Savery, J.R.: Overview of problem-based learning: definitions and distinctions. In: Essential Readings in Problem-Based Learning: Exploring and Extending the Legacy of Howard S. Barrows, vol. 9, pp. 5–15 (2015)
8. Xinglong, Z.: The design of teaching mode based on knowledge construction in flipped classroom. Mod. Distance Educ. Res. **2**, 55–61 (2014)