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THE USE OF E-PORTFOLIO IN A LINEAR ALGEBRA COURSE

Judit Taberna Torres[1], María Isabel García-Planas[2], Santiago Domínguez-García[3]

[1]Escola Tècnica Superior d'Arquitectura de Barcelona, UPC, [2]Escola Tècnica Superior d'Enginyeria Industrial de Barcelona, UPC, [3]Universitat Rovira i Virgili

Spain

Judit.taberna@upc.edu, maria.isabel.garcia@upc.edu, soyelsanti31@gmail.com

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Abstract

The use of e-portfolio becomes a standard tool when it comes to learning and student's assessment. This is due to the teachers need for enhancing their students' autonomy. The use of e-portfolio helps students to focus on their own learning process. Lectures should not be limited only to classes, but must foster active learning, and in this regard, the introduction of the e-portfolio is an excellent tool because it stimulates collaborative and cooperative work among students and, in turn, it encourages feedback by the teacher. To apply active methodologies during 2014-15, the e-portfolio was introduced in the course of Linear Algebra. To prepare the work of the e-portfolio the teacher had to define precisely the objectives that must be achieved by the students, and has had to plan in an understandable manner the tasks that the students can work independently outside the classroom. For the realization of the e-portfolio have been used different platforms. Each quarter of the students worked on a different platform, through AteneaLabs that provided templates so that each student make their own e-portfolio, as well as it provide all necessary manuals. The platforms used were: Mahara, Exabis, WordPress and Google Sites. Formative assessment of the e-portfolio had been made from different rubrics defined in the course syllabus and known by students since the beginning of the course.

Keywords – E-portfolio, Linear algebra, Project-based learning, Evaluation.

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1 INTRODUCTION

It is well known that Linear Algebra is fundamental in different areas of sciences. Because of multiple problems can be modeled by means linear systems where linear algebra became essential to obtain and discuss the solution. Nevertheless, one of the main difficulties that first-year university students who have enrolled in scientific or technical degrees other than mathematics is that they do not see the importance that mathematics, in general, and linear algebra, in particular, may have in their fields of interest.

This can seriously affect students' motivation in the course, and prevent their success. This effect appears to be more pronounced in the first year of linear algebra due to its abstract factor while the calculus finds it easier to think that may be more useful.

Since the 90's have been pushing reforms in teaching linear algebra. Concretely, in 1993, the Linear Algebra Curriculum Study Group (ICSG) in the USA wanted to sort out the linear algebra curriculum problem, which did not adequately address the needs of the students it attempted to serve at many schools (Carlson, Johnson, Lay & Porter, 1993). To do so, they published a set of recommendations for the first course in Linear Algebra. With these recommendations, the research on teaching linear algebra was encouraged and provided an extensive list of articles on this topic (see Yildiz Ulus (2013), and Aydin (2009), for example).

Among these studies, it is worth noting everything that several researchers say about the use of ICT, and how it affects both on students' attitudes and their academic achievements.

Following Piaget's psychological theory of concept development, Harel (in Harel (2000)) defends the following three 'principles' for the teaching of linear algebra: the Concreteness, the Necessity, and the Generalizability. Firstly, the Concreteness Principle states, "for students to abstract a mathematical structure from a given model of that structure, the elements of that model must be conceptual entities in the student's eyes". Secondly, the Necessity Principle states, "students must see and need to learn for what they are intended to be taught". Finally, the Generalizability Principle states, "when instruction is concerned with a 'concrete' model, that is a model that satisfies the Concreteness Principle, the instructional activities within this model should allow and encourage students to the generalizability of concepts".

In the search for alternatives to improve the teaching and learning of linear algebra, different experiments have been designed and implemented, concluding that to improve the teaching and learning of linear algebra can be useful to include alternatives such as creation of portfolios, implementing projects both individually and in groups, and the use of new technologies. The objective of this work is to analyze the benefits of the project-based learning (PBL) in the Linear Algebra curriculum by creating e-portfolios in large groups.

We show the results of this study as well as the satisfaction and usefulness of the e-portfolio. The study sample consists of all students from the first year of Engineering in the subject of linear algebra at the ETSEIB of Universitat Politécnica de Catalunya.

2 METHODOLOGY

We are fully convinced that teaching in large groups does not have to limit itself to the master class only. Under this conviction, we decided to combine master classes with PBL. To do that, and for the first time, we have introduced during the academic year 2014-15, the e-portfolio in a core subject in the first year of an engineering degree. In addition, students displayed their e-portfolios in a common space on University virtual campus so that students can view each other's e-portfolios.

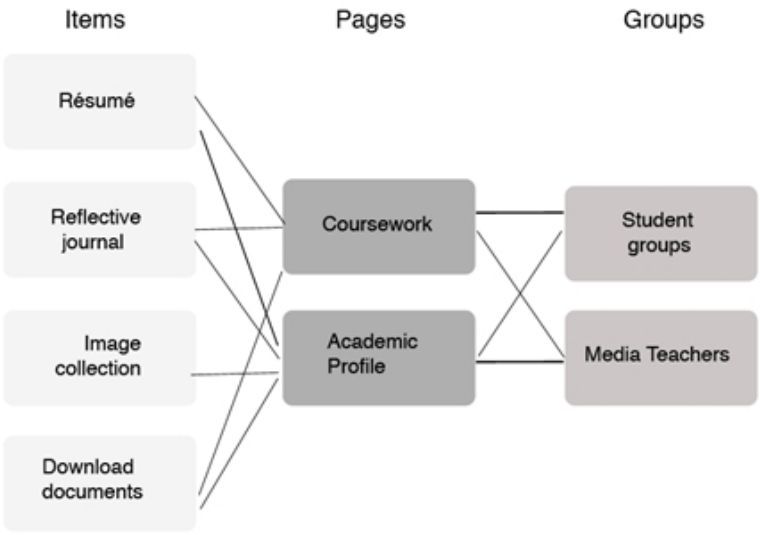

Figure 1. Organizing a portfolio: Schema

2.1 E-portfolio

E-portfolio is a valuable tool for teaching, learning, and assessment. An e-portfolio is a digitized collection of pieces of evidence joined and managed by a user, usually on the Web. Such electronic evidence may include entering text, electronic files, images, multimedia, blog entries, and hyperlinks, among others. E-portfolios are both a process of showing off the user's abilities and platforms for self-expression, and, if they are online, they can be maintained dynamically over time.

In order to clarify the structure of an e-portfolio, we show in Figure 1, a schematic overview of the artifacts constituting the portfolio, as well as pages that integrate it and the groups that should compose it.

In our particular setup, the e-portfolio has the sense of “assessment folder” or a broader form of “learning portfolio”. More specifically in the context of this work, the e-portfolio is a method of teaching, learning and assessment of different types of productions by students through which they can evaluate their abilities in the context of a discipline or field of study. Moreover, staff reviews the student productions with evaluation criteria previously established, allowing the student (and others) to see their efforts and achievements into the learning objectives.

2.2 E-portfolio for a Linear Algebra course

In the context of teaching and learning of the subject of linear algebra, the e-portfolio can be used as a repository of learning experiences as through the teachers and students work the teaching and learning activities from the Internet.

More specifically:

- The students use the e-portfolio for:
  - Collecting systematically achievements in learning,
  - Self-evaluating how to acquire and develop the skills required in the subjects they are studying,
  - Self-evaluating their learning results.
- The teacher uses the e-portfolio for:
  - Collecting and place the work done by students in their courses
  - Evaluating the acquisition and development of skills of students through the implementation of activities (with the tutor, with the peer group, independently, etc.)
  - Assessing the outcome of learning.

Thus, a clear interaction between teacher and student is obtained.

2.3 Software for creating e-portfolio

Many online platforms allow creating your personal e-portfolio in general and educational e-portfolio in particular. Several authors (see Diana Bri, García, Colls and Lloret (2009), for example), analyze some of these educational platforms in order to facility the decision about the platform on which to choose.

The platform models chosen for our experience were Mahara, Exabis, WordPress and Google Sites. We divided all the students into groups of four, and we assigned to each group a different platform. We wanted also to analyze which platform was more understandable and easy to work with from the students' perspective.

Mahara is an open source web application to manage e-portfolios and social networks. This application is more centered on the learner in contrast to most Management Systems that are more focused on organizational learning. Exabis is also an open source platform, which allows the users to create and to administrate personal e-portfolios. Students can collect documents, notices, news and links in their e-portfolio and if pertinent may publish reports. Mahara and exabis only works on the platform of AteneaLabs. WordPress is a free and open-source tool and a management system of contents. The characteristics of this platform include an architecture plugin and a template system. Upcnet provides a username, and URL and five different models to all the students that are going to use WordPress platform for their e-portfolios. Finally, Google Sites is a free online application offered by Google Company. This application allows the users to create a website in a simple editing a document. Both teachers and students can gather in one place and quickly texts, images, and other materials. It also allows easy sharing personalized information publicly or across the network. The problem with this platform is that there is a limit of size for saving documents in the site.

2.4 Subject Planning

Under learning e-portfolio point of view, to prepare the e-portfolio is imperative to define the goals, which we want students to achieve as well as the topics, that we consider basic to overcome objectives.

Figure 2. Subject Planning

The issues in our particular case are the basic in a linear algebra first-year course. Specifically, these topics include system of linear equations, vector spaces, matrices, linear maps, a matrix of a linear transformation, change of basis, eigenvalues and eigenvectors as well as applications in the field of discrete linear systems. Obviously, all these topics must be in a place accessible to all students, in our case we use the Moodle platform that is available from the University for students and teachers.

We planned, as can be seen in Figure 2, the different projects that must be solved by the students through the different weeks of the course. We also included in each student e-portfolio a tutoring schedule and evaluation thereof. Moreover, the students are asked to create their curriculum vitae and to include all the digital information that they have required for doing the work.

This planning is reviewed every semester. However, there are very few variations in the timing because the duration of the semester is the same (15 weeks). The total time for this project is 150 hours, a 49% of this corresponds to work in the classroom and a 60% to homework. The master class time is a 25% of the time class, the rest of time class is for tutoring and solving problems in a collaborative form.

2.5 Projects

During the academic year 2014-15, we conducted a pilot test of the project-based collaborative learning by means e-portfolios in a core mathematical subject, for undergraduate students of the "Escola Tècnica Superior d'Enginyers Industrials de Barcelona, (ETSEIB)" at the "Universitat Politècnica de Catalunya, (UPC)".

The objective of these projects is that students understand the concepts of linear algebra and through practical cases; they create the need to learn this subject.

As we have seen in subsection 2.3, during the first week of the course, we explained comprehensively what is an e-portfolio and the projects that students had to perform both individually and collectively.

During the first semester course, two projects were proposed that we will detail below. All the groups have the same project but with different numerical data to test the model, so all of them will have different results to study and to analyze. Project 1 has a duration of 5 weeks and Project 2 of 8 weeks.

- Project 1: Leontief economic open model

  This work tries to describe a simplified model of Leontief by linear algebra techniques then, to resolve a case.

  - Step 1: Find information about the problem of Leontief, (important: do not forget to put all the references used). Individual work.
  - Step 2: Ask the resolution of open Leontief model theoretically. Fully explain and put all the references used (books, websites, comments with other groups...). Individual work.
  - Step 3: Solve the case study applying the theoretical results indicating at all times the theoretical side being applied and why use. Teamwork.

  During the second and fifth week were tutored and resolved all doubts raised by the different groups through the Moodle platform in its version adapted by UPC: AteneaLabs. The delivery of the project was carried out during week six.

- Project 2: Newton's law of heating and the heat equation

  From week seven the second project starts, as prior knowledge of linear algebra requires the knowledge acquired in the project one and its achievement requires the rest of the course syllabus. This work was performed in its entirety on the group. This task is to study the distribution of heat through a thin bar made of a homogeneous material discretizing bar in n equidistant points. Specifically, it is to analyze the evolution of the temperature in each of the points with the passage of time.

  - Step 1: Modeling the evolution as a discrete linear dynamic system
  - Step 2: Explain in detail the linear algebra information required to solve the equation, such as:
    - Analyze the type of matrix describing the system
    - How to calculate powers of a matrix
    - Obtaining of eigenvalues and analysis of stability study
  - Step 3: Solve a case applying all theoretical results indicating at all times the theoretical side being applied and explaining why.

  It is important in all stages of the project to put all the references used (books, websites, and comments with other groups, ...)

  This project has spent more time (week 8 to 14) as the first one, since the resources of Linear Algebra are superior to those required for the first project difficulty and need further mentoring.

  The delivery took place the last week of the course. In this final phase, students also delivered the share of e-portfolio your resume, your overview of the subject and references.

  During the second semester course, we proposed the performance of a single project, which was divided into two sub-projects. Sub-project 1 has a duration of 5 weeks and sub-project 2 of 8 weeks.

- Project 3: Application of Markov chains to the study of the optimum number of beds in ICU, intermediate care in a hospital room for decision making in hospital management.

  In the sub-project 1, the students should do a short-term planning and in the second one, they should do a long-term project, that is to say, the study of the stability of the system.

- Sub-project 1
  - Step 1: Find information about Markov chains, (important: do not forget to put all the references used). Individual work.
  - Step 2: Matritial description and in linear algebra terms, of Markov chains of first order with constant coefficients. Fully explain and put all the references used (books, websites, comments with other groups, ...). Individual work.
  - Step 3. Modeling the evolution of a discrete linear dynamic system.
  - Step 4: Solve the case study applying the theoretical results indicating at all times the theoretical side being applied and why use. Teamwork.

  During the second and fifth week were tutored and resolved all doubts raised by the different groups through the Moodle platform in its version adapted by UPC: AteneaLabs. The delivery of the project was carried out during week six.
- Sub-project 2

  From week seven, the sub-project 2 starts.

  Since the description of the Markov chain, obtained in the first subproject, is the basis for the realization of the second one. This work was performed in its entirety on the group.
  - Step 1: Describe the order k state of the discrete linear dynamic system obtained in the subproject 1.
  - Step 2: Explain in detail the linear algebra information required to solve the equation, such as:
    - Analyze the type of matrix describing the system
    - How to calculate powers of a matrix
    - Obtaining of eigenvalues and stability study
  - Step 3: Solve a case applying all theoretical results indicating at all times the theoretical side being applied and explaining why.

  It is important in all phases of the project; to put all the references used (books, websites, and comments with other groups, ...)

  This sub-project has spent more time (week 8 to 14) than the first one since the resources of Linear Algebra are superior to those required for the first project difficulty and need further mentoring.

  As in the first semester, the delivery took place the last week of the course. In this final phase, students also delivered the share of e-portfolio your resume, your overview of the subject and references.

2.6 Evaluation of e-portfolios

One way to tell if students have acquired the required training skills to ensure that they have achieved the learning objectives is by means an evaluation. E-Portfolio Evaluation Criteria should take into account operational, appearance, the pieces of evidence and the reflection Indicators.

Considering all these aspects and in order to respond to such needs, we have chosen to create a rubric to assess.

As it is well known, rubrics are descriptive scoring schemes that are developed by teachers or other evaluators to guide the analysis of the results or the efforts in the processes of students, (see Brookhart (1999) and Koh (2013), for more details about rubrics).

For the linear algebra course, we proposed two rubrics, the first one for the student self-assessment as well as for peer assessment, and the second one for the assessment of student work from the teacher.

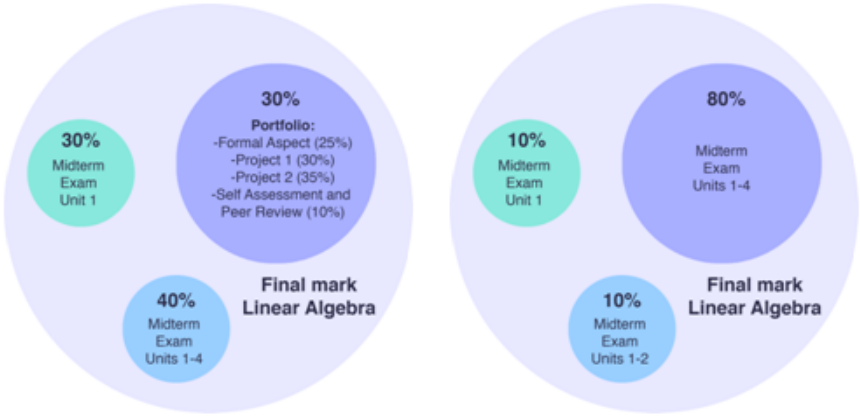

Figure 3. Evaluation scheme

In Figure 3, two different systems of the final mark for the students of Linear Algebra are showed, in the right one we observe that the evaluation is made by means three different exams, depending on the units; this was the system used during the academic years before. In these midterm exams, students had to solve different problems.

In the scheme of the left, belonging to the school year 2014-15, we decided to change the importance of the last midterm exam and include the e-portfolio as a 30% of the final mark. We evaluate different aspects of the e-portfolio, the ones related to the formal appearance of the site, the solving process of the various projects and the self-assessment and peer assessment of the student work. We evaluated the formal aspect concerning the assigned platform (Mahara, Exabis, Google Sites or WordPress) because we knew that all the platforms had different limitations.

3 RESULTS

We have compared the different qualifications of the students during three periods: course 2012-13, 2013-14, and 2014-15, this last one is the period where we have introduced the e-portfolio and the change in the evaluation methodology using the rubrics for the e-portfolio. We show the results of the first semester because it is when we have more new students; in the second semester, the largest amount of students are the ones that have failed the subject in the first semester.

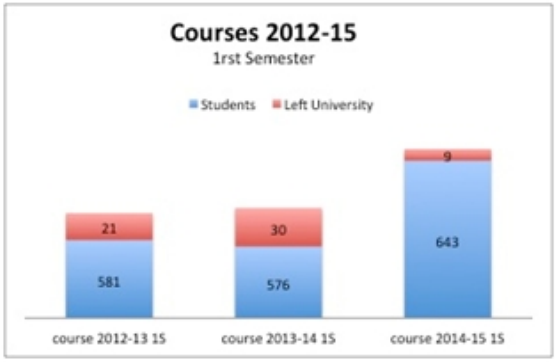

Figure 4. Number of students that left University

As we can see in Figure 4, if we compare the number of students that left Linear Algebra during the first semester of the university over the past three years, we can see that despite the number of students have increased considerably this last year, just nine students have left the course. This last course 2014-15 just a 1.40% of the total amount of students of Linear Algebra left the subject, the years before this average was 5.21% in course 2013-14 and 3.61% in course 2012-13.

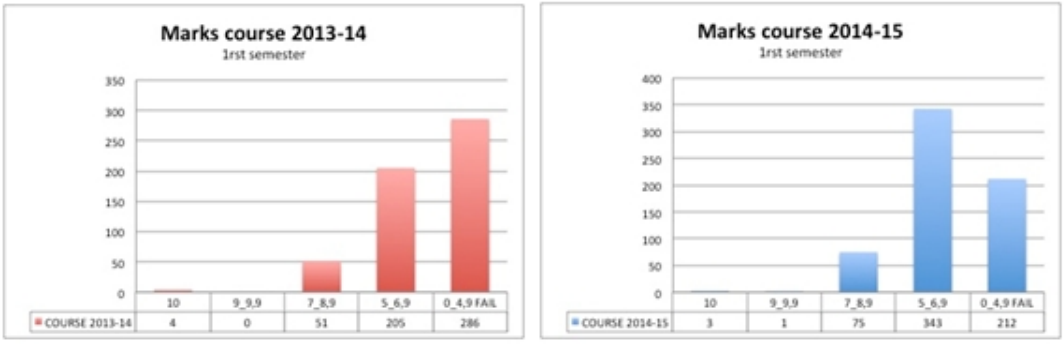

Figure 5. Qualifications course 2013-14 and 2014-15 first semester

We have also analyzed the qualifications between this last year 2014-15 and the last year 2013-14, we can see that the students that failed have been changed from 49.65% in course 2013-14 to a 32.97% in course 2014-15, this is a reduction of the 16.68%. The good marks also have increased in global a 3% this last year.

The previous years to the introduction of the e-portfolio showed that just a 12% of students passed the mid-term exam. However, in the academic year 2014-15, students, who passed it, were a 59%.

4 CONCLUSIONS

Using the e-portfolio we have seen the improvement of the autonomy of the students. They have been working on individual tasks but also in group projects, so they have been able also to cooperate and to work together solving the different tasks.

Is important to create the need to study Linear Algebra to the students, so we decide to do projects related to real life, that fact has motivated the students to ask questions and understand that the subject they were studying had a practical application.

The use of technological tools, the e-portfolio, implies that the professor has to prepare all the material very carefully. We had to prepare templates and manuals for all the different platforms, and also a subject planning with all the structure of the course.

Working with the four different platforms makes us realize that WordPress is the best one for doing e-portfolios for the students and also for the teachers. We want to remark that WordPress is a platform which is easy to access, to design an attractive site and to post files in different formats.

With this new experience, the qualifications of the students have improved. What is more, students have achieved the concrete and general skills of Linear Algebra. Thus, the e-portfolio has helped students to improve their comprehension of the subject through solving practical projects, while it also helps them to structure, organize, communicate and show the work they have done.

Due to the good results obtained after the implementation the e-portfolio, we expect to repeat the experience the course 2015-16.

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AUTHOR BIOGRAPHY

Judit Taberna Torres

Member of the Architectural Graphic Expression Department of Universitat Politècnica de Catalunya from Barcelona (Spain) since 2008. Her area of expertise is architectural photography. The subject that is currently teaching is Drawing in the degree of Architecture. She is a member of the emergent group GILDA and her research field are ICTs as a tool for learning and student assessment.

María Isabel García-Planas

Member of the Department of Applied Mathematics at the Universitat Politècnica de Catalunya from Barcelona (Spain) since 1981. Her works focus on Linear Algebra, and Systems and Control Theory. She has authored more than one hundred articles, and she is a reviewer for several international journals and conferences. Regarding her teaching, she is involved in teaching innovative projects incorporating ICTs in various subjects.

Santiago Domínguez-García

Ph.D. student at the Rovira i Virgili University of Tarragona (Spain). He is a member of the Group of ARGET, and his area of expertise and research is ICT.

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