BILINGUAL PUBLISHING CO.
Pioneer of Global Academics Since 1984

Journal of International Education and Practice
http://ojs.bilpublishing.com/index.php/jiep/

ARTICLE

Example of a Project to Work the Sustainability Competence in the Subject of Linear Algebra in Engineering Studies

M.I. Garcia-Planas* and J. Taberna
Universitat Politècnica de Catalunya, Departament de Matemàtiques, Barcelona, Spain

ARTICLE INFO

Article history:
Received: 12 November 2018
Accepted: 16 January 2019
Published: 18 January 2019

Keywords:
Sustainability
Project-based-learning
Linear algebra

ABSTRACT

Strength in sustainability is becoming more and more essential for anyone who wants to dedicate themselves to the practice of competent and professional engineering. From the scientific-technical teachings, therefore, the transversal competencies of sustainability and social commitment should be addressed, so that students understand and become aware of the problems of a global world. Using the project-based learning tool (PBL), from a practical case, transversal competencies related to the global issues of the Sustainable Development Objectives (SDG) can be explained and evaluated in a classroom of Engineering or scientific degrees through the subject of Linear Algebra. This project presented is novel since usually, in a class of mathematics, teacher proposes examples in which we can see an attempt to approximate math to essential topics such as sustainability. In this case, the procedure is the other way round; it is about setting as the objective of the course the solution of a problem related to sustainability and adapting the mathematics program so that throughout the course the problem is solved. It is not about looking for application examples of the tools, but looking for algebra tools to solve the problem.

1. Introduction

In 2015, was adopted the 2030 Agenda for Sustainable Development for transform the world and 17 Sustainable Development Goals were fixed. One of the goals is the number four where in its target 4.7 ensures (see Wells[19]), that all learners acquire the knowledge and skills needed to promote sustainable development including education, global citizenship and cultural diversity. On the other hand, all the objectives admit a mathematical approach that allows them to advance in the achievement of the same. Therefore, it is important to introduce these aspects in higher education and the mathematics subjects so that students become aware of them and at the same time, they observe that the knowledge of mathematics contributes positively in the achievement of the Objectives of Sustainable Development (SDG).

**Corresponding Author:*
M. I. Garcia-Planas,
Universitat Politècnica de Catalunya, Departament de Matemàtiques, Barcelona, Spain;
Email: skhawaldeh@aabu.edu.jo

 DOI: https://doi.org/10.30564/jiep.v1i1.317

The University has a basic function to play in implementing the 2030 Agenda for Sustainable Development. It is an essential performer in achieving quality education, but it must also contribute to the training of responsible citizens committed to the local sustainable development and global.

Progressively, universities and other institutions of higher education have been incorporating values and practices of sustainable development in its core teaching and research activities, institutional management and operational systems, even some of them have prepared strategy guides to integrate the learning of the generic competition "sustainability and social commitment" [21]. However, so far they have mainly focused on justifying and reasoning about the need to implement competencies on sustainable development but without taking action.

To break this dynamic and choose one of the objectives of sustainable development, we introduce in an evaluable way the competence of sustainability and social commitment in a subject of the first year of studies of the degree of engineering, in order that from the beginning, students take Awareness of the global problem of sustainable development.

It is clear that having a dedicated course on sustainability does not guarantee the students' full understanding of the sustainable message. Therefore, a solution as already indicated Colombo et al.[4], Allen et al.[1] and Murphy et al.[14] could be to transpose transversely into an existing course unit the sustainability elements on which it is desired to focus.

From the scientific-technical teachings, the transversal competencies of sustainability and social commitment must be addressed, so that students understand and become aware of global problems. Using the project-based learning tool (PBL), from a practical case, transversal competencies related to the global issues of the Sustainable Development Objectives[23], can be explained and evaluated in the classroom.

Crofton[6] indicates that provide education based only on technical knowledge is insufficient to address the complexity of the problems associated with sustainable development. It is also noteworthy that there is a growing demand from students to rethink the content and form of courses taught in engineering degrees, (Trimingham et al.[18]). To deal with all this requires training that helps to contemplate environmental problems and development as a whole.

Some essays over sustainability competence implementation in engineering studies have been reported in recent years, for example, an interdisciplinary Project Based Learning strategy has been applied in the first year of the Integrated Master's degree in Industrial Engineering and Management at University of Minho (Colombo et al.[5]). Nevertheless, there are no essays in which the only subject is Linear Algebra.

This paper presents a proposal of a project to implement the competence of sustainability and social commitment through PBL in the Linear Algebra subject of the first course of the engineering curriculum at any Engineering schools or Sciences faculties that contain this matter in its curriculum.

With the proposed implementation of Project-based Learning, we not only introduce the competition corresponding to the sustainable development objective of a specific goal (in this case, the number 6, although it is possible to prepare projects for each of the objectives (see Garcia et al.[9]), but also address the number 4 one that is related to education. This target is to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". Given that the PBL promotes quality education and supports curricular innovation, it collaborates in consecution of the SDG number 4.

The project presented is novel since usually, in a class of linear algebra; the teacher proposes examples in which we can see an attempt to approximate linear algebra to essential topics such as sustainability but always from mathematical matter. In this case, the procedure is the other way round; it is about setting as the objective of the course the solution of a problem related to sustainability and adapting the linear algebra program so that throughout the course the problem is solved. It is not about looking for application examples of the tools, but looking for algebra tools to solve the problem.

This work is not about introducing the PBL as a teaching method of linear algebra, but to show that its use can be a good method to evaluate the transversal competence of sustainability and social commitment through a STEM subject as well as to help students to reflect on the SDGs.

Integration of sustainability into the curricula of engineering education

Since the World Commission on Environment and Development had presented the "Our Common Future" known as the Brundtland Report[20], to the General Assembly in 1987, the concept of sustainable development has gained increasing interest and attention. Sustainable development is defined as development that meets the needs of the current generation without compromising the ability of future generations. However, the lack of understanding and even misinterpretation of this definition has delayed the implementation of sustainable practices within the framework of Higher Education.

Universities must act as agents of change by promot-

  DOI: https://doi.org/10.30564/jiep.v1i1.317

ing the principles of sustainable development within their institutions and in society. As Barth and Reickmann[2] say, there is no doubt about the role that universities must play in relation to sustainable development, through education and the development of competencies that will contribute to a more sustainable future.

Education for Sustainable Development (ESD) is a learning process based on the principles underlying sustainability. This process encompasses a broad range of experiences and programs. As stated in the Sustainability Education Handbook, published by UNESCO for the United Nations Decade of Education for Sustainable Development (The Manual of Education for Sustainability[22]), ESD is based on five types of learning to facilitate quality education and encourage Sustainable human development. Which are: "learn to know", "learn to be", "learn to live", "learn to do" and "learn to transform oneself and society". Education for Sustainable Development, in its broadest sense, is therefore linked to balanced development, in which it takes into account the social, cultural, environmental and economic dimensions of an improved quality of life for present and future generations.

The ESD is of particular importance in engineering education, which must include social, environmental and economic aspects to training socially responsible engineers, as they are basic in development society. Consequently, engineering education programs should be geared towards sustainability by bearing a part in the competencies between different disciplines, promoting interdisciplinary and sharing values among them to form for a sustainable future.

For this project, we have prepared and developed educational materials that allow working from Linear Algebra, issues related to sustainable development and social commitment. The material must be the basis for the preparation of projects that students must solve to assess this competency to all its dimensions. The competence about sustainable development and social commitment is understood as the ability to know and understand the complexity of social and economic phenomena that are typical of the welfare state: capacity to relate well with globalization and sustainability; capacity to use a stable and compatible technology, economy and sustainability (Guides to develop generic skills in designing degrees).

It will work the first level of achievement that is: systematic analysis and critical global situation, taking into account the sustainability of interdisciplinary and sustainable human development, and recognizing the social and environmental implications of the professional activity of the same field.

The other two levels of achievement that can be considered for undergraduate curricula consist of the following.

For level two: applying sustainability criteria and professional codes of conduct, in the design and assessment of technological solutions,

For level three: considering social, economic and environmental factors in the application of solutions, undertaking projects that tie in with human development and sustainability.

2. Acquisition of Sustainability Competence through the Subject of Linear Algebra

In engineering studies, the subject of Linear Algebra has been chosen as an essential and indispensable tool for anyone who deals with Mathematics, Arithmetic, Functional Analysis, Differential Geometry, Algebraic Topology, among others. In other fields, such as Engineering, Linear Algebra is used for example for the calculation of structures in which the notion of the eigenvalue is relevant. So it is a subject always thought to be applied in the longer term, making it difficult to think of introducing competencies other than those of the subject itself.

However, convinced of the importance of sustainability issues to be introduced from the outset, we have sought ways to make this possible.

Although, many people are convinced that Sustainable Development is completely disconnected with the mathematical reasoning. Nevertheless, they are very connected, and they need each other, and it is essential not only to show this relationship to the students but must work both competencies simultaneously. We will try to relate first-year college level math with one of the goals of sustainable development, concretely we chose the number six goal about clean water and sanitation.

Different mathematical models can be developed, for each one of the Sustainable Development goals. As, for diverse water problems such as the flow of rivers, lakes, reservoirs, drainage networks, supply networks, treatment plants, among others, for various renewable energy issues such as control of wind speed and direction as a means to estimate the region's wind power potential. These mathematical models are developed for better understand cause-effect relationships, to evaluate scenarios and to find alternative solutions to different problems related to the considered topic.

Many of these models are linear or linearized, so they can be treated using Linear Algebra.

2.1 Project Based Learning

Project-based learning (PBL) is a model that organizes the students learning around projects.

According to the definitions found in the PBL manuals for teachers, projects are complex tasks, based on ques-

 DOI: https://doi.org/10.30564/jiep.v1i1.317

tions or challenging problems, which involve students in the design, problem-solving, decision-making, or research activities. They give students the opportunity to work relatively autonomously for extended periods of time, and culminate in realistic outputs or result presentations (see (Jones et al.[11]; Thomas et al.[17], for example).

In a course where learning is based on projects, students apprehend about a topic by working for an elongated period to investigate and respond to a complicated question, challenge, or problem. PBL is an active method of learning which starts by posing questions, problems or scenarios rather than paper-based, rote memorization, or teacher-led instruction that presents facts (see Taberna and Garcia-Planas[16].

This method of learning presents at least the following advantages

Exploit student's autonomy

It allows to work collaboratively.

They come from the interests of the students and are motivators therefore.

They involve the development of core competencies.

Allow the work of different intelligences.

Allow the use of different learning strategies.

But, not all are advantages; we can also find some disadvantages.

They demand a paradigm shift in the way teachers think: we educate how they have educated us.

The concept of educational "level" needs to be redefined. Does the amount of knowledge or the quality of that knowledge matter?

Probably, if the change affects a whole matter or a center, it is necessary to convince the families of the outcome of the project.

They may need more teaching time to achieve the same academic goals.

It may at first confuse students.

Students who are bright or looking for more grades may be uncomfortable in a cooperative work group.

The biggest advantage is that in addition to the skills of collaboration, communication, critical thinking and the use of new technologies, it is possible to include work skills on sustainability. As a result, project-based learning helps students make their learning meaningful and rewarding by connecting them to the real world outside the classroom and generating confidence in the realization of their possible actions.

Then, it is clear that the use of PBL increases the significance of the learning that is, the relevance and the usefulness of what is learned.

For the PBL to be successful, the tasks to be carried out must be explained in detail, giving guides, advice, materials and offer opportunities for students to put them into practice through the tasks and activities proposed in the project.

On the other hand, students should be helped to overcome their tendency to postpone the process of completing the work by properly structuring the course.

2.1.1 How Does Project-Based Learning Work?

Project-based learning, as well as any learning method, requires a lot of planning. After a brainstorming, it begins with the selected idea and the approach of an essential question. Then many content standards will be addressed and devise a plan that will integrate as many subjects as possible into the project (see George Lucas Educational Foundation[10]).

Which can be summarized in the following steps:

- Start with the Essential Question.

The proposed question must be one that will engage the students.

- Design a Plan for the Project.

It is essential to have in mind which content standards will be addressed.

- Create a Schedule.

Design a timeline for project components taking into account:

- What time allotment will be given to the project?

- Will this project be conducted during the entire school day or during dedicated blocks of time?

- How many days will be devoted to the project?

Not forgetting that possible changes to the schedule will happen.

- Monitor the Students and the Progress of the Project.

Maintain control without preventing students from taking responsibility for their work, following these steps:

- Facilitate the process and the pleasure of learning.

- Encourage students to work collaboratively.

- Provide resources and guidance.

- Assess the process by creating team and project rubrics.

- Assess the Outcome.

Evaluate progress and give students feedback on how well they understand the information and on what they need to improve.

- Evaluate the Experience.

Reflection is a key component of learning. Allow for individual reflection, as well as group reflection and discussion.

The proposed question must be one that will engage the students.

Designing the project, it is essential that you have in mind which content standards will be addressed.

DOI: https://doi.org/10.30564/jiep.v1i1.317

2.2 Evaluation by Rubrics

Whenever there is an instruction, it is necessary to evaluate the acquired skills to know if the learning objectives have been achieved.

Evaluate is a process by which one or more characteristics of a student or a group of students are given the attention of the one who analyzes and evaluates their characteristics and conditions according to some criteria or reference points to emit a judgment that is relevant to the student's education.

Any method of evaluation employed must have clear and detailed criteria, which can be translated into parameters from which the evaluators will quantify and provide their assessment.

The methodology that we chose for the evaluation of the project is by rubrics because of it has been shown that the use of rubrics for assessment contributes significantly to improving students' performance.

The rubrics or rating matrices are "scoring guides used in student performance assessment that describe the specific characteristics of a product, project or task at various levels of performance, to clarify what is expected of the work of the Student, to evaluate its execution and to facilitate the proportion of feedback"

In the elaboration of a rubric, it is necessary to include the criteria of evaluation that gather the fundamental elements of the competence; they have to be criteria that offer to the student, with clarity, all the characteristics of the competence to develop[15]. More concretely, at the time of elaboration, it is convenient to take into account some aspects such as

Consider the characteristics of the competencies that have to be evaluated.

Determine accomplishment indicators (Development, originality neatness, creativity, clarity of writing, ability to synthesize, etc.).

Place the acquisition levels on a graduation scale to specify the differences in learning.

Determine the score awarded at each level.

The rubric must be available to students from the moment they call the project to be done. In this way, the students see that there is a system with some objectivity for the evaluation of their work and at the same time can evaluate their progress by consulting this rubric.

2.3 Tools for the Implementation of the Methodology

The progress made by information and communication technologies in recent years has had a significant effect on education and tools such as e-portfolio and others useful for e-learning have appeared; This tools can help improve and complement teaching Traditional in the classroom in many fields, including mathematics. In addition, they make it possible to make flexible the programs of the assignments facilitating the implementation of transversal competences.

In this case, we propose the use of the e-portfolio tool to support problem-based learning (PBL) in the teaching of the subject of Linear Algebra in which the transversal competence of sustainability and social commitment has been implemented.

An e-portfolio is a valuable tool for teaching, learning and assessment. Bear in mind that an e-portfolio is a digital collection of statement joined and managed by a user, usually on the Web. Such electronic evidence includes among others entering text, electronic files, images, multimedia, blog entries and hyperlinks. E-portfolios are a process of showing both the user's abilities and platforms for self-expression, and, if they are online, they can be maintained dynamically over time, (Domínguez-García et al.[7]).

Can be found various online platforms that allow creating a personal e-portfolio in general and educational e-portfolio in particular. Several authors (see (Bri et al.[3]; Domínguez-García et al.[8]) for example), analyse some of these educational platforms to facilitate the decision about which platform will be chosen.

One of the most used platforms is the open source e-Portfolio and social networking web application "Mahara" usually used joining an open source e-learning platform as for example Moodle. Both systems have built-in support for each other in the form of single sign-on and transfer of content or export different types of objects from Moodle to Mahara (API Portfolio) and to import objects from Mahara to Moodle (API repository)

Another open source of e-Portfolio able to be connected to Moodle by means of a plug is "Exabis". This platform permits us to introduce different pictures called categories where each of them gives access to different competencies. It is possible to access to multiple frames and assign different categories.

The Exabis platform is simpler than Mahara however is easier to import and export materials from Moodle.

As is well known, "Google Sites" is a free online application offered by the company Google. This application allows us to create a website in a simple editing a document. Both teachers and students can put in one place texts and images, as well as to include multiple documents. It also allows easy sharing personalized information across the network.

However, one limitation of this application is that the storage space is 100 MB. If the user is member if Google

 DOI: https://doi.org/10.30564/jiep.v1i1.317

Apps it can be expanded to 10 GB.

The tools for working on this platform provide graphic images in a more visually attractive way than Mahara and Exabis, making it more suitable for subjects such as drawing.

However, lately, it is spreading the use of the WordPress platform to create the portfolio for its sensibility in handling.

The use of learning platforms is an excellent tool for a quality education that is the basis for sustainable development, favoring access to education at all levels.

3. Using Case Study Methodology to Approach the Sustainable Water Management Competence

The Agenda 2030 for Sustainable Development (http://www.un.org/ sustainable development/en/), with an ambitious vision, includes seventeen Objectives integrating economic, social and environmental dimensions. Among these, there is the Goal 6: "Ensure access to water and sanitation for all". To achieve its aims is essential training to increase the efficient use of water resources in all sectors and ensure the sustainability of extraction and fresh water supply to cope with water scarcity and reduce the number of people suffering from water shortages.

To approach Sustainable Development Objectives in a mathematics subject, we make a teaching proposal based on projects.

Collaborative learning techniques are incorporated so that the project (that constitutes the core of the matter), be developed in the framework of project-based learning (PBL).

Despite the fact that the project has been implemented in large groups, it would seem natural to have opted for traditional master classes. This kind of courses offers certain advantages over other teaching methods because it is a fast, cheap and efficient method of transmitting information to a large number of students simultaneously. But it is also well known that student attention can only be maintained for short periods of 15 to 20 minutes separated by small spaces of 1-2 minutes in which the students stop paying attention; These periods of concentration are reduced, lasting less than five minutes at the end of a class, (Khan 2012).[12] In spite of everything, the master class has its meaning and can be used, but we think that it should not be the only method used in the classroom. So, we combine master classes with project-based teaching that helps to contribute effectively to the development of both cross-curricular and specific competencies that the subject must face.

The methodology of project-based learning enables different competencies to be worked in a cooperative way and can influence the understanding that a win is not sustainable, leading to the failure of others, which requires replacing competitiveness with cooperation. At the same time, it allows to contemplate environmental and developmental problems as a whole, taking into account their close relationship and the use of Linear Algebra, we can analyse their repercussions in the short, medium and long term.

Different mathematical models can be developed for various water problems such as a flow of rivers, lakes, reservoirs, drainage networks, supply networks, treatment plants, among others. These models are developed to understand cause - effect relationships better, to evaluate scenarios and to find alternative solutions to different problems related to water.

3.1 Project Proposal

This project is designed for a context of engineering school or faculty of science where a course of linear algebra is taught.

The proposal responds to the need to introduce the subject a competence that adds criteria and values consistent with sustainability and responds to the economic, social, cultural and environmental aspects of human development. Concretely, the subject considered is the water because it is a critical resource that has not substituted. Having potable water is a universal human right and is also a key factor for public health. The way we maintain and expand this critical good is a fundamental problem for building an environmentally and socially sustainable world.

This project can be applied in any studies in which contain the subject of linear algebra in its curriculum.

The following project is presented to students:

In a certain country, it is proposed to build a reservoir to regulate the basin of one of its rivers with the objective of satisfying the needs of water for irrigation.

For the realization of the project, the students are given the following data:

Maximum reservoir capacity,

Quantities required for irrigation

Volume to be left to maintain water quality standards for other uses, provided that the water level of the dam plus the weekly contribution by the water of the river, does not reach a minimum that does not allow the exit of water.

The primary objective to be achieved with this project is: "Study the viability of the reservoir" by analyzing

The stability of the reservoir under the given conditions

The sustainability of the reservoir under the same conditions

DOI: https://doi.org/10.30564/jiep.v1i1.317

The stability of the reservoir imposing the variation in the time of the river's contribution to climate change.

The sustainability of the reservoir by imposing the previous condition

It is also intended that the following awareness-raising objectives be achieved:

Make an assessment of the social benefit by counterbalancing the benefits to be obtained by irrigation in the face of social conflict caused by expropriations and the resulting displacement of the inhabitants of the area.

Make an assessment of the problem by extrapolating the case to a large dam.

To solve the project, the student must:

Describe using a matrix equation of the type p(k + 1) = Ap(k), the weekly transition of the probable water units.

2. Express p(k) as a function of p(0)

Starting from a particular amount of water impounded:

Analyze the probability that in two weeks the reservoir will be below minimums.

Critical assessment of the result within the context of the work.

Find out how Linear Algebra will give us a solution to the matrix equation proposed

Apply it to the case at hand

Use the calculations to analyze the situation of the reservoir at the week

k = 10.

Study and analysis of stability and sustainability.

The organized task for PBL is precisely aligned with one of the Sustainable Development Objectives 2030, more concretely with the goal number six "Ensure access to water and sanitation for all". To achieve this aim is essential training to increase efficiency of water resources in all sectors and ensure the sustainability of freshwater harvesting and water supply to address water scarcity by reducing the number of people suffering from water shortages.

With this project not only introduces and evaluates the competence on sustainability but also the social commitment because they must also value the social cost that involves the displacement of people with the uprooting that this entails.

Clearly, the students need to learn a full linear algebra course to solve completely and in a correct form, the project.

3.1.1 Course Planning

Suppose that the subject of linear algebra corresponds to a course of 150 hours of which 40% corresponds to the work done in the classroom and the remaining 60% to work done outside the school. Theoretical classes occupy 25% of the time devoted to the classroom tasks, and complete the time with tutorials and solving the doubts that have arisen for the students. In addition, students work collaboratively on the proposed project related to the academic content of the subject. This accounting has been realized taking into account the European Credit Transfer system, (ECTS). In this system are also assessed the hours that students devote to the self-activity. The computation corresponds to 25 hours per credit, and the subject is valued at six credits. One of the significant advantages of the ECTS credits is that being the unit of measure equal in all the universities of the new European space allows comparing much more efficiently the educational load of the degrees.

We plan, as can be seen in Figure 1, the distinct tasks that must be solved by the students through the different weeks of the course to achieve with success the project.

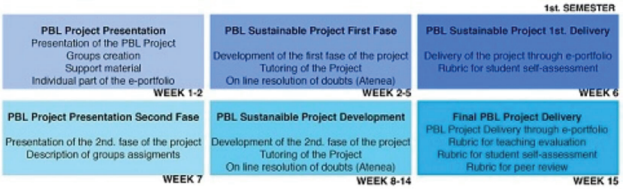

Figure 1. Subject Planning

The plan has been prepared conscientiously having in mind the progress of the lectures in which they are introduced the theoretical support corresponding to the linear algebra subject and that should serve them as the basis for the completion of the project.

Students are given the work plan at the same time that they are notified of the project they are required to complete.

The students are invited to follow the plan as closely as possible so that they can carry out their project progressively and profitably.

3.1.2 Evaluation

When designing a subject one of the fundamental questions that one has to think about is how what and when to evaluate. If we focus the evaluation on the competencies that we want the student to acquire, we can give coherence to the structure, approach and the development of the subject. Keep in mind that they are first-year college students and the first project they face, so it is important to help them plan to avoid failure.

Following Monereo[13], "Say you how you evaluate, and I will tell you how your students learn" the evaluation has a retroactive role on learning and teaching because it modifies the way of learning and educating.

Once we have defined the competencies that we want to evaluate and have designed the methodology to front

 DOI: https://doi.org/10.30564/jiep.v1i1.317

learning for the acquisition of these skills we have to proceed with the evaluation.

As we have indicated in subsection 3.2, the evaluation of the project is done by rubrics.

We have valued the current rubrics, and we have found that they do not provide the required information, for Linear Algebra course, in general, and for mathematics topic including evaluation of transversal competencies as sustainability. So we have chosen to perform new rubrics in such a way that they perfectly adapted to the course, which includes all skills treated, that is evaluated. Table 1 Presents the Part of Rubric Corresponding to the Evaluation of Sustaina- bility.

Table 1. Evaluation of the transversal competency involved in the PBL

Task	descriptors			
Description of the water sustainability problem	NO correct identification 1 point	YES, identifies the problem, but NO properly 2 points	YES, identifies the problem, but something confusing 3 points	YES, identifies the problem, but clearly and accurately 5 points
Analysis of stability and sustainability	Has not been able to perform the study 1 point	Has not been able to analyze stability and sustainability 2 points	Has correctly analyzed only one of the concepts 4 points	Has analyzed the problem correctly 7 points

Sustainability competence is evaluated in each of the evaluation acts, in the examinations appear detailed questions linked to the competencies of sustainability.

The project values the treatment of sustainability in a special way, although in each and every one of the points to be evaluated, this concept is implicit. Also, different aspects of the project are assessed, the ones related to the formal appearance and care in the presentation of the work, the solving process of the project and the self-assessment and peer assessment of the student work. Self-evaluation is a good strategy to increase responsibility and for students to learn to value, criticize and reflect on their learning process and peer evaluation enables students to evaluate peer work and compare work that leads them to improve their realized work.

Due to the good results, we have prepared text with different projects to continue to implement in class (Garcia-Planas et al. [9]).

4. Results

This project has been implemented by the students of the Barcelona School of Industrial Engineering (ETSEIB) from the Polytechnical University of Catalonia (UPC), on the subject of linear algebra during the academic year 2016-17. The results in the process of acquisition of the transversal competence on sustainability and social commitment on the part of the students are satisfactory. Specifically regarding the objective of sustainable development "Sustainable water management" students through project-based learning implemented in the subject of Linear Algebra, have become aware and have been able to address, deepen and disseminate the proposed theme in the classroom through the virtual campus of the UPC.
It is important to emphasize the change of attitude of students with regard to the ones of the previous years.

5. Conclusion

Sustainability is often emphasized as an essential objective of higher education, but more as a principle than at a practical level. This work has shown how it is possible to carry out the implementation of sustainability competence in an evaluable form, in a subject of higher education mathematics.

As a first conclusion, we have that it is imperative that universities in making their curricula take into account sustainable development. Little by little, the high schools are becoming aware but the process is slow and according to which subjects the teacher is less open to including this competence in his subject.

With this work, we have proved that it is possible to implement the competition "Sustainability and social commitment" within a mathematics subject, to address the objectives of the Agenda 2030 on sustainable development.

For this, it has been important to see how cross-sectional looking for real problems, which the student must model, it is possible to evaluate such competence.

In this case the analysis of the sustainability of water management. It is important to emphasize the change of attitude of the students about previous years.

Collaborative learning techniques are incorporated to ensure that the project that constitutes the core of the subject is developed in the framework of project-based learning (PBL).

The presented project has significance since the learning through PBL implies changes in the knowledge structures of the students, modifies them and enriches them since it establishes new connections and relations between them. In the learning process, the student develops a significant relationship between what has been acquired and everything that must be learned and assimilated through the project "connecting" the new information with relevant concepts previously acquired.

The project has contributed to the development of an organizational culture that fosters principles such as meaningful learning, collaboration, responsibility, innovation, mutual help and respect, participation, individual and collective reflection.

References

[1] Allen, D., Allenby, B., Bridges, M., Crittenden, J., Davidson, C., Matthews, S., Murphy, C., Pijawka, D. and Nolt-

  DOI: https://doi.org/10.30564/jiep.v1i1.317

helm, C. (2008). Benchmarking Sustainability Engineering Education: Final Report: EPA Grant X3-83235101-0.

[2] Barth, M., Rieckmann, M. (2012). Academic staff development as a catalyst for curriculum change towards education for sustainable development: an output perspective, Journal of Cleaner Production 26, 28-36.

[3] Bri, D., García, M., Coll, H. LLoret, J. 2009. A Study of Virtual Learning Environments. Wseas Transactions on Advances in Engineering Education, 6 (1), 33-43.

[4] Colombo, C.R., Alves, A.C., van Hattum-Janssen, N., Moreira, F. (2014). Active Learning Based Sustainability Education: a Case Study. Proceedings of the Sixth International Symposium on Project Approaches (PAEE2014) Medellin Colombia.

[5] Colombo, C.R., Moreira, F., Alves, A.C. (2015). Sustainability Education in PBL Education: the case study of IEM-UMINHO. CGIT - Publicaçes em actas de encontros científicos/Papers Conference proceedings 221-228.

[6] Crofton, F.S. (2000). Educating for sustainability: opportunities in undergraduate engineering. Journal of Cleaner Production, 8, 397-405.

[7] Domínguez-García, S., García-Planas, M.I., Taberna, J. (2016). Mathematical modelling in engineering: an alternative way to teach Linear Algebra. International Journal of Mathematical Education in Science and Technology, 47 (7), 1076-1086.

[8] Domínguez, S., Garcia-Planas, M.I., Palau, R., Taberna, J. (2015). Modelling E-portfolio for a Linear Algebra undergraduate course. International journal of education and information technologies, 9, 115-121.

[9] García-Planas, M.I., Taberna, J., Rina, N. (2018). Linear algebra in education for sustainable development [Álgebra lineal en la educación para el desarrollo sostenible]. Barcelona, Spain: Iniciativa Digital Politècnica.

[10] George Lucas Educational Foundation. 2007 Edutopia. How Does Project-Based Learning Work? Tools for understanding the process of planning and building projects. https://www.edutopia.org/project-based-learning-guide-implementation (Retrieved 21/11/2017)

[11] Jones, B.F., Rasmussen, C. M., Moffitt, M. C. (1997). Real-life problem solving.: A collaborative approach to interdisciplinary learning. Washington, DC: American Psychological Association.

[12] Khan, S. (2012). Why Long Lectures Are Ineffective. Time Ideas. Retrieved from http://ideas.time.com/2012/10/02/why-lectures-are-ineffective/

[13] Monereo, C. 2009. Evaluation as a tool for educational change [La evaluación como herramienta de cambio educativo]. In PISA as an excuse. Rethink the evaluation to change the teaching [En PISA como excusa. Repensar la evaluación para cambiar la enseñanza]. Barcelona: Graó, pp. 15--31.

[14] Murphy, C.F., Allen, D., Allenby, B., Crittenden. J., Davidson, C., Hendrickson, C., Matthews, H.S. (2009). Sustainability in Engineering Education and Research at US Universities, Environ. Sci. Technol., 43 (15), 5558--5564.

[15] Taberna, J., Domínguez Garcia, S., García-Planas, M.I. 2016. The use of tic for an evaluation in competences in higher education [El uso del tic para una evaluaci\'on en competencias en la educaci\'on superior]. XIII Fecies

[16] Taberna, J. Garcia-Planas, M.I. 2016. Project-based teaching: an alternative way to teach Linear Algebra [Enseñanza basada en proyectos: una forma alternativa para enseñar Álgebra Lineal]. Proceedings IN-RED 2016 - II Congreso Nacional de Innovación Educativa y de Docencia en Red INRED UPV, 826-839.

[17] Thomas, J. W., Mergendoller, J. R., Michaelson, A. (1999). Project-based learning: A handbook for middle and high school teachers. Novato, CA: The Buck Institute for Education.

[18] Trimingham, R., Lazzarini, B., Pérez-Foguet, A., Noble, N., Boni, A., Sierra Castañer, M., Mongera, F., Zolezzi, G. (2016). Integrating the Global Dimension in Engineering Education: Experiences from a Collaborative Project. In Teaching Education for Sustainable Development at University Level, Book Chapter, Springer, Switzerland, pp. 175--190. doi: 10.1007/978-3-319-32928-4_12

[19] Wells, P.J. (2017). UNESCO Higher Education Priorities within the context of the Sustainability Goals. CHEA International Quality Group, Washington D.C. https://www.chea.org/userfiles/Conference%20Presentations/2017-ciqg wells. pdf

[20] Comisión Brundtland (1987) Report of the World Commission on Environment and Development Our Common Future.

[21] Guides to develop generic skills in designing degrees. Retrieved May 22, 2017 from https://www.upc.edu/ice/ca/innovacio-docent/publicacions_ice.

[22] The Manual of Education for Sustainability. United Nations Decade of Education for Sustainable Development (2005-2014). Retrieved january 20, 2017 from http://www.urv.cat/media/upload/arxius/catedradesenvolupament sosteni ble/Informes%20VIP/unescetxea-manual_unesco_cast_education_for_sustaina bility_manual.pdf

[23] Sustainable development goals. 17 goals to transform our world. Retrieved on January 15, 2017 from http://www.un.org/ sustainabledevelopment/es/

 DOI: https://doi.org/10.30564/jiep.v1i1.317